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STATES' INDUSTRIAL TECHNOLOGY PROGRAMS

HEARING

BEFORE THE

JOINT ECONOMIC COMMITTEE CONGRESS OF THE UNITED STATES

ONE HUNDRED SECOND CONGRESS

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WEDNESDAY, SEPTEMBER 30, 1992

CONGRESS OF THE UNITED STATES,
JOINT ECONOMIC COMMITTEE,
Washington, DC.

The Committee met, pursuant to notice, at 9:30 a.m., in room 2359, Rayburn House Office Building, Honorable Lee H. Hamilton (Vice Chairman of the Committee) presiding.

Present: Representative Hamilton.

Also present: Dorothy Robyn and Mark Forman, professional staff members.

OPENING STATEMENT OF REPRESENTATIVE HAMILTON, VICE CHAIRMAN

REPRESENTATIVE HAMILTON. The Joint Economic Committee will come to order.

The purpose of today's hearing is to discuss the report of the Carnegie Commission on Science, Technology and Government entitled *Science, Technology and the States in America's Third Century*.

State support of economic development through subsidies and regulation goes back to the colonial days, and the Morrill Act of 1862 established our system of land-grant institutions and thereby carved out an important role for states in science and technology. More recently, states have defined a new economic role for themselves through support for technology initiatives that rank from venture capital funding to manufacturing extension. These state initiatives to foster technological innovation are important in their own right; in addition, they are seen by many as offering lessons for the formulation of national policies.

We are fortunate to have with us today three experts on states' management of technology to promote economic development and other policy objectives affecting health, energy and the environment. The Honorable Richard Celeste was Governor of Ohio from 1983 to 1991. As governor, he chaired the National Governors' Association Committee on Science and Technology. Governor Celeste also created Ohio's nine Thomas Edison Centers, a public-private partnership to enhance the State's existing strengths in materials, manufacturing and biotechnology.

Walter Plosila is the President of the Suburban Maryland and Montgomery County Technology Councils. He was previously Deputy Secretary for Technology and Policy Development in Pennsylvania. In that capacity, he created Pennsylvania's Ben Franklin Partnership, which has been called a model state program for stimulating technology commercialization.

Edward Hudgins is Deputy Director for Economic Policy Studies at the Heritage Foundation. He is heading up a new project there on State Strategies for Fiscal Responsibility and Economic Growth.

We are delighted to have each of with you us this morning.

Governor, we will begin with you and move it across the table.

Before opening it up for questions, I wanted to say that Senator Sarbanes, who is Chairman of the Joint Economic Committee, does have an opening statement that he wants submitted into the record, and that is done without objection. And he would also like to express a very special word of welcome to Walter Plosila of Maryland, one of the witnesses, of course. Senator Sarbanes points out he has made very meaningful contributions to state technology programs in Maryland.

[The written opening statement of Senator Sarbanes starts on p. 29 of Submissions for the Record:]

REPRESENTATIVE HAMILTON. Governor, please proceed.

STATEMENT OF THE HONORABLE RICHARD F. CELESTE, FORMER GOVERNOR OF OHIO; AND CHAIRMAN, CARNEGIE COMMISSION TASK FORCE ON SCIENCE, TECHNOLOGY AND THE STATES

MR. CELESTE. Thank you, Mr. Chairman. I want to express my appreciation to you and your colleagues for this opportunity to testify before the Joint Economic Committee and to share with you some of the highlights of the report entitled *Science, Technology and the States in America's Third Century*.

I would also like to thank the Carnegie Commission on Science, Technology and Government, its co-chairs, Bill Golden and Josh Lederberg, the President of the Carnegie Corporation, David Hamburg, and especially the members of the task force whose efforts gave shape to this report before us today.

Walt Plosila served on that task force, and also with us, Mr. Chairman, is Graham Jones, the Executive Director of the New York State Science and Technology Foundation, and chairs the Science and Technology Council of the States.

Also David Robinson, who directs the work of the Carnegie Commission in this field, was a tremendous help; and I express my appreciation to him.

Mr. Chairman, I would like to submit my prepared statement for the record and summarize its key points for you, if I may.

REPRESENTATIVE HAMILTON. Without objection, that will be done. Proceed.

MR. CELESTE. Also, I would like to make copies of the report available to all members and staff who would like to have one.

Since World War II, during the era we think of as the Cold War, the Federal Government really set and dominated the national research agenda. National defense and, more recently, the space race had first call on a large share of our resources. But as the Cold War has ended, new issues and concerns vie for national attention and resources—economic competitiveness particularly, but education, environmental protection, public health and others.

Unlike national defense and space, these are issues of shared concern and urgency with our states. In fact, the nature of these issues often necessitates a more flexible and less centralized response.

The genius of our federal system is the balance the founders struck between federal and state authority and initiative. Our report urges that we restore that balance in America's Third Century.

Rebalancing our federal system, if you will, requires that we identify roles for each level of government which play to its strength and contribute to a

most efficient and effective overall national effort. And we believe that state governments bring a capacity for organizational entrepreneurship and diversity of experience and approach and a refreshing ability to move quickly, which are essential characteristics in responding to the challenges of the new national agenda.

These qualities need to be mobilized not in isolation, but in partnership with the Federal Government, with the private sector and with academia.

Our task force found in the best of the states' industrial technology programs models of the kind of cooperation with industry and research universities that is required to meet the full range of our national challenges. For example, state industrial technology programs have created systems which engage businesses, especially small firms on their own ground, with the private sector setting the investment priorities.

These programs, with narrowly defined roles for state government, bring innovation in terms of new technologies and new management skills, as well, to businesses in a manner which encourages its immediate application.

University researchers are usually engaged as full partners in these programs. In sum, these state-crafted systems seek not to create more bureaucracy, but to engage all available assets within the states in a cooperative, flexible and focused contribution to the states' economic well-being and thereby to the Nation's global competitiveness.

Mr. Chairman, we believe these models of innovation, responsiveness and diversity suggest ways in which to respond to many of our Nation's other pressing challenges. The sort of cooperation that I have described, combining the efforts of individual states and reaching out to include the Federal Government, would provide significant new capabilities in addressing the needs of our citizens for health care, educational improvement, environmental protection, as well as economic development. In fact, this cooperation, what we have described as inventing new partnerships, will be vital if the Nation is to take full advantage of our wealth of science and technology.

The task force urges Congress to adopt the following changes in federal policy in order to fashion new partnerships between the states, the Federal Government, and especially the private sector:

States should be represented at the decision-shaping levels of policy development within federal agencies. The national strategy for using federal technology to the private sector should build on the foundation that many states have already laid.

And finally, states should be full partners with the Federal Government in defining the new missions and redesigning the operations of federal science and technology institutions, especially the federal laboratories.

We also urge the states to take a number of steps to improve both their capacity as participants in national initiatives and their ability to meet their responsibilities within their own jurisdictions.

We recommend that each governor should designate a science and technology advisor. Each state should have an independent science and technology advisory body. Each state, through its advisory body, should develop and periodically update a vision of how science and technology will help the state meet its strategic goals. And each state legislature should have access to a standing source of objective science and technology analysis.

Moreover, we believe that the states should form an interstate compact which would enable them to coordinate their science and technology activities and to speak with a single voice on behalf of states to federal agencies and in national councils. All too often, it is difficult for the heads of federal agencies, even the President's science advisor, to reach out and enlist thoughtful perspectives from state government, because there is not a high-level forum in which the states are able to express themselves.

Finally, we urge that the states, working through this new national arrangement and in close cooperation with the Congress and the President, plan and convene a kind of a national summit on science and technology goals, and seek to identify a shared agenda for the new partnerships which must characterize America's third century if our Nation is to flourish.

Mr. Chairman, thank you again for inviting me. I certainly welcome your questions as we go through.

[The prepared statement of Mr. Celeste, along with Study, starts on p. 30 of Submissions for the Record:]

REPRESENTATIVE HAMILTON. Thank you for getting us off to a good start. This is going to be a difficult day. We have a vote, and I am going to have to excuse myself for a few minutes. I will get back as quickly as I can, and when I do, we will take up with your statement, Mr. Plosila. It will take me about 10 minutes.

We stand in recess.

[Recess:]

REPRESENTATIVE HAMILTON. The Committee will resume its sitting. Mr. Plosila, please proceed.

STATEMENT OF WALTER K. PLOSILA, PRESIDENT, SUBURBAN MARYLAND/MONTGOMERY COUNTY TECHNOLOGY COUNCILS

MR. PLOSILA. Thank you, Mr. Chairman. I would like to summarize my testimony and augment what Governor Celeste already covered.

In the 1980s, we saw state governments undertake a number of innovative efforts. Much of this, of course, was in the economic development arena, but indeed states have in the last 20 years become much more important players in both the development and delivery of a whole range of services. Justice Brandeis talked about states undertaking novel social and economic experiments. And, in fact, today we have something like 400 small business incubators around the country.

We have a majority of states with industrial technology extension services. We have probably a majority of states with some kind of matching grant programs. And, in addition, we have governors and state legislatures much more interested in the whole area of science and technology than has been the case, at least since the 1960s.

One important component of the 1980s legacy is that states have recognized that science and technology itself is a very important part of not only their economic vitality, but also in terms of the necessity of science and technology advice for their decisionmaking, whether it is elected officials or senior appointed officials. And the state experience of the past decade or more suggests, indeed, that states are becoming full partners in a range of areas that necessitate more state-federal collaboration and cooperation.

In addition, the national economy itself faces a couple of issues that I think make it an opportune time for the state-federal partnership to be more fully developed. One is the whole issue of defense conversion. And the second is the issue of the future of our national laboratories. I use these simply as illustrations of why state-federal cooperation in science and technology is important.

In the case of defense conversion, I cite a couple of examples in my testimony of situations we faced in Pennsylvania where we had major Fortune 500 companies basically close down completed R&D infrastructure projects. If the state had not intervened with our universities and the private sector, those infrastructure improvements would no longer be in place. Reuse of the Harmarville facility, formerly with Gulf Oil at the University of Pittsburgh, provides for now as a contract research center, an EPA hazardous waste research center, incubator, and several other activities.

In the case of Bethlehem Steel, it made plans to dispose of its Home Research Lab and park adjacent to the Lehigh University campus in Bethlehem, Pennsylvania. Rather than the land being broken up into small parcels, the Commonwealth partnered with Lehigh University to provide a matching $10 million grant for Lehigh to acquire several buildings and acreage—an entire established research park. This facility is now home to one of NSF's Engineering Research Centers; an incubator; and firms participating in the matching grant program of the Ben Franklin Partnership.

But in both those cases, the Federal Government was really not a player in those decisions for reuse or reconversion as it now faces defense conversion, and a new role for national labs. We need both a macro and a micro perspective, and the state input at the national level can help accomplish that.

The Carnegie Commission report suggests a number of recommendations both to the national and state level. In terms of the state-federal partnership itself, though, I would highlight three points of that state-federal partnership in terms of implementation actions. One is, in fact, the idea of an interstate compact. This is something that is somewhat different than the usual discussions about science and technology. But the fact is, if the national government is to look at the state governments and utilize and develop a complementary agenda with them, we would suggest the Education Commission of the states as an appropriate model for science and technology application as well, and we ought to look at that as a future effort, of course, as an interstate compact that requires joint actions of the states with the blessing of the Congress.

The second suggestion in there be a summit on how science and technology efforts contribute to national goals, much like the educational summit. As we face these issues on defense conversion and national labs and so forth, it is clear that we do not have a general idea how we are going to accomplish that. Such a summit could help address that.

A third area I would cite is to get a state-federal partnership in science and technology. The Government-Industry-University Roundtable that Governor Celeste is intimately involved with has issued a separate report which I commend to your attention. This report talks about how we can look at the criteria for a state and federal partnership. That supplements this report before you.

In any event, we on the Commission Task Force felt that there is much to be learned by the states and Federal Government working much closer together. A compact is one way to accomplish that.

The last point I mention quickly is that there are a number of recommendations for the states themselves, the legislatures and governors, to address. As a former research director of a state legislature and as a former planning director in one state and associate state planning director in a second state, I can vouch for the need for the expertise and technology advice that this report suggests.

I would, however, note that just as Congress has designed its science and technology advisory system to reflect its needs with OTA and OSTP. Similarly, I would say, the task force also suggests that the approach at the state level be a flexible and adaptable one to each state's needs and circumstances; that there is not a national model or approach that every state should adopt, but really it should reflect the needs of each state. Having worked in several states in senior positions, I think that suggestion is a wise one, if in fact the advice is going to be listened to and used in decisionmaking.

With that, I simply commend the report to your attention and would be happy to answer any questions.

[The prepared statement of Mr. Plosila, together with attachment, starts on p. 106 of Submissions for the Record:]

REPRESENTATIVE HAMILTON. Thank you Mr. Plosila. Mr. Hudgins, please proceed.

STATEMENT OF EDWARD HUDGINS, DEPUTY DIRECTOR FOR ECONOMIC POLICY STUDIES, HERITAGE FOUNDATION

MR. HUDGINS. Thank you very much. I want to thank the Committee for the opportunity to testify today. I want to thank the Carnegie Commission for calling attention to what I consider to be an important issue—actually two issues. Number one is science and technology policy, and number two is the role of the states in developing and implementing such policy.

One set of recommendations in this report that I found to be quite valid, and I want to endorse, is the idea of a science advisor or a board of advisors for the state governments.

Now, many states already have something in place, though I think that the report's recommendation of updating or creating a new institution at the state level is very important. Aside from the reasons already given, I want to call attention to a problem that has been growing, in the last decade certainly, that this would help to overcome, and that is the politicization of science.

What we find, unfortunately, and especially at the federal level, is agencies basically either manipulating facts, holding back reports and so forth for political gains or political aims. For example, the national acid precipitation assessment program—NAPAP—was a 10-year, multi-agency program—which included EPA, I believe, the Energy Department, and many others—to look at the effects of acid rain on lakes and streams. The result of that study was to find that acid rain has very little effect on lakes and streams, though it has other adverse effects.

The Administration knew the content of this report, and yet they pushed ahead with certain provisions of the Clean Air Act, knowing that this might

potentially contradict the findings of the report, which was released after the Clean Air Act provisions went into effect.

Another example is found in the transportation area. Donald Stedman, a professor of chemistry at the University of Denver, found in his research that something like 10 percent of the cars cause over 50 percent of the pollution, and not being satisfied with simply that bit of knowledge, he invented a device called the Stedman device which works like a radar gun. It takes a picture of what is coming out of the tail pipe and the license plate of the car. Needless to say, this opens up a lot of possibilities for local enforcement of clean air regulations.

The Environmental Protection Agency in Washington has known about this and yet has failed to push this, I think, in part, for political reasons.

My point is this. Having 50 states with science advisors or advisory boards allows just the kind of competition and knowledge and information that I think is going to be good for addressing policies of the environment, transportation, and many other policies; that is, if EPA in Washington or if some other agency in Washington is not giving the proper attention to certain facts, perhaps some of the states that would stand to benefit would give proper attention.

So I think the idea of the 50 competitors, as it were, in knowledge is a very good idea, and I think it would help to deal with this problem.

I do have several caveats about the report, things that I think the Committee should take into account when formulating policy. When we look at science and technology policy, we have to ask what exactly are the goals and where exactly does the market fail, if at all, to help forward these goals? And the report points to competitiveness and the need for states to do more in this area. It points to the need for better advice in the area of so-called "public good," such as the environment and transportation.

The national economic policy really attempts to be most important in determining what businesses, what the private sector can do, whether they have the funds and the flexibility to do research, basic research, to cooperate in such research, or whether they don't. And that really, I think, is the most important focus.

Where focus is on technology, again, often policy is more important. I give the example of the transportation area. I have done some work in that area, and have gone to a number of very interesting conferences and so forth. There is a group called Transportation 2000 in Denver, Colorado, which puts on conferences, bringing together people who develop new transportation technologies to discuss transportation problems.

The interesting thing about the conferences is, much of the discussion is not on the technologies, but on which ones are really the most economically efficient. So it is not just a matter of developing the technologies, but saying which ones really work, which ones don't.

I like to make the analogy with foreign assistance, and I am quite familiar with your report from several years ago, I do a lot of work in this area. One of the things that is now recognized in the foreign assistance area is the need for appropriate technologies, a big project, a big multi-million dollar tractor might not be as good as a hand plow in some areas. Particularly in transportation, HOV lanes may be far better and far less costly than a modern subway or

monorail or something incorporating technology. So I think we ought to have that kind of balance.

I also note that the private sector is moving more into cooperation in basic research and certainly in competitiveness, and proliferation in joint ventures and strategic alliances in the last few years is an example. Apple and Sony in 1991 formed a joint venture to produce laptop computers. IBM and Seimen's in 1991 have put together a joint venture to produce a 16 megabyte chip. Ford and the Excel Corporation, which produces glass, are now in a joint venture.

I can name a number of others where corporations are getting together and looking at how to share costs and how to share risks in technology development. I think it is a very promising development in the last couple of years.

Therefore, in light of this, there are, again, a few caveats I would like to make about what could come out of the report in terms of policy. First, is a warning against science pork. And in the last couple of years, the use of pork-barrel spending in academia has come to light. I think that the Space Station and NASA is a primary example of what I would call science pork, where, yes, they can say we are building a station and surely we can do something with it. The question is, is this the most useful way of spending our scarce resources, $40 billion on a Space Station?

If you ask most scientists whether a station is need, they usually say no. They say, we can do the experiments on less costly mini-stations; we don't need a station to return to the moon or go to Mars, and so forth. And yet, obviously, politics has driven, in this case, the allocation of resources for technology rather than real needs.

And this is something that I have a lot of concerns about, and in a sense that argues for more of a competition between the 50 states and argues against too much of a close cooperation between the Federal Government and the state government. I fear that this could simply lead to an extension and even more larger division of the pork.

Finally, one other thing I would like to call attention to, the report does discuss program evaluation, but I think it needs a lot further discussion on that. The report notes that attempts to evaluate the effectiveness of programs has had a lot of problems in the past. Many states would look at a program and say, well, does it provide jobs within the next three to five years, or are there other visible results that we can measure? Now, many states feel that the timeframe is more like 10 years, perhaps 15 years, and this does raise a concern.

The report suggests that perhaps certain factors can be used, as it were, as "surrogates" to determine whether the program is effective or not. Leverage, for example, the participation of the private sector in the case of a joint venture; and I think this is an honest attempt to come to grips with this issue. However, I would urge a much deeper examination of this problem.

Again, what I fear here is the sort of situation I like to call the Small Business Administration syndrome; that is, if you take public money and give it to a business, is there is a fairly good chance that they will produce something of value? The question is, again, whether this is the best use of public resources, and whether this leads simply to the proliferation of more programs and giving away more money, which in the end leads to a very large budget deficit.

In summary, I think the Carnegie Commission report is a good and honest attempt to address certain issues that have not gotten the public attention they deserve, both science and technology policy, and especially at the state level. And I would like to see the debate and discussion of this issue continue in the future.

Thank you very much.

[The prepared statement of Mr. Hudgins starts on p. 115 of Submissions for the Record:]

REPRESENTATIVE HAMILTON. Mr. Hudgins, thank you for your comments and testimony. Let's open it up now for questions.

One of the curious things to me is that if the Federal Government was doing what state governments are doing, we would be accused of an "industrial policy." And "industrial policy" has become a bad word in many ways over the past few years. As a matter of fact, we don't even use it. We changed it to technology policy. But states have been routinely active in lining up the private sector and the state government to advance economic interests. So what is happening at the state level would be shocking if it were to be proposed at the federal level.

Why is "industrial policy" a bad word at the federal level and a good word at the state level?

MR. CELESTE. Mr. Chairman, if I may, it is probably because we don't use it at the state level. We simply go right ahead in pragmatic ways. I think if I look at the programs I am familiar with, there are several characteristics of the states' response to the economic crisis, which has generally given birth to these initiatives.

In the first place, very few states have created any kind of large new bureaucracy. They have tried to operate through existing state agencies to a large degree. Many of these initiatives are within the department of economic development or some generally preexisting framework.

Second, the states have tended to look to the private sector to set the priorities. In other words, if I can use Ohio as an example, when we created the Thomas Edison Program, we tried to identify existing strengths and to require the participation of businesses and universities in a cooperative fashion before any state funds were available. And all of those state funds had to be matched by private resources, and over time those programs were sustained largely, not exclusively, but largely with private-sector funds. So that the driver of the initiative really was those places where there were strong capabilities within the business community that needed additional access to research.

In fact, it is interesting because Mr. Hudgins mentioned what is happening with the development of joint ventures and strategic alliances within the private sector. In many respects, the state technology initiatives represent public-private joint ventures, or public-private strategic alliances, in which the initiative or the priority-setting was largely in the hands of the private sector, at least where they have been durable.

REPRESENTATIVE HAMILTON. I will come to you on the larger question, but when you talk about priority-setting by the private sector, what do you mean? They determine what the research is, they determine what the direction of the technology center is; is that right?

MR. CELESTE. They participate very directly in the management of the technology center and identify, usually on an annual basis, areas for generic

research which will be shared by all of the corporate members, let's say, of the Edison Welding Institute, which was cited by Mr. Plosila in one of his articles.

REPRESENTATIVE HAMILTON. Do these technology centers become captive of the private interests?

MR. CELESTE. I would say that there is an interesting balance usually struck between the interests of the research team, those who are assembled and participating in the research, many of whom have an interest in moving from basic insights into tests for the development phase of that new knowledge, and the interests of the corporate members which are much more driven by immediate commercial interests and needs.

REPRESENTATIVE HAMILTON. How do you assure that the state government simply doesn't pick up the research budget for the private company?

MR. CELESTE. In the first place, the states don't put all that much money in. I think in the case of Ohio, we probably never provided more than $18 million in the course of a year as a total for eight or nine centers, matched by a much larger number from the private sector. We tried to treat that as separate from what we were investing in basic research through the university system. And I think that is a very important point that often isn't emphasized in these discussions.

REPRESENTATIVE HAMILTON. Let's go back to the original question and let the other witnesses come in here.

Mr. Plosila?

MR. PLOSILA. First of all, I think part of the problem with industrial policy at the national level is its concern with picking winners and losers. The state programs primarily, as Governor Celeste indicated, are not picking winners and losers, but in fact, in many cases, it is a joint effort of the university and a private company in which they both have to agree. The university has to agree that there is in fact an academic merit and research merit in what they do, and the industry has to put up its money and figure they are going to get something back in return.

So these kinds of programs tend more to be ways to build new relationships than they are to displace existing relationships.

REPRESENTATIVE HAMILTON. Is the product of that research available only to the company that participate——

MR. PLOSILA. It depends on the way the centers are organized. Some of the Ohio centers, for example, will have generic research available to all members. In other cases, in other states, the programs will be sponsored for that company. The ownership stays in the university.

REPRESENTATIVE HAMILTON. So it can vary?

MR. PLOSILA. Right.

The other point I would say about industrial policy at the national versus state level is that many times the state investments, as Governor Celeste also indicated, are relatively small in dollar amounts, but they are designed to fill gaps in the private sector for a temporary time period, to change private-sector behavior.

Most parts of the United states have a problem with seed venture capital, right now. There isn't enough money available for small, young, growing companies. What we have done in Pennsylvania is leveraged, with $3 million in public money, $40 million in private money to create privately managed seed

venture funds, getting banks and university endowments and utilities and individual investors to put money into early stage investments.

REPRESENTATIVE HAMILTON. That private money would not have come forward——

MR. PLOSILA. Without the seed money. In and out, 10 years later, those private, managed funds are out raising new funds without any public money.

In addition, the public money was an investment that came back to those Ben Franklin Centers for further R&D. So it was investment, not a grant. That is a change in private-sector behavior for the long haul, with a little bit of public intervention to address the problem in the short term.

REPRESENTATIVE HAMILTON. Mr. Hudgins.

MR. HUDGINS. I think there are very serious problems with industrial policy, certainly at the national level. If you think back to the discussion in the 1970s of whether the government should have funded development of the supersonic transport, it is good that we didn't; otherwise, we would have a big money loser on our hands.

The high-definition television controversy was similar, and interestingly enough, American companies seem to be leapfrogging the Japanese just because we didn't put funds into what might have been a dead-end alley or an alley that was not the most productive.

I think that the one difference is that if you keep these kinds of experiments at the state level, they may have very similar problems. But I would rather have 50 laboratories out there trying it, and that way if North Carolina comes up with a formula that works, for example, then the other states can copy North Carolina. If another state comes up with something that turns out to be nothing but pork barrel spending for businesses or for academics, the other states can learn.

So I think that is one of the differences between the federal and the state level.

REPRESENTATIVE HAMILTON. Do you take the position that it is okay for the state governments to do these things, but not the federal?

MR. HUDGINS. Well, I am a native of Maryland, and I would probably have objections to Maryland spending money of that sort if I thought that it wasn't necessary. I mean, it is something that should be debated.

REPRESENTATIVE HAMILTON. I mean, conceptually, though——

MR. HUDGINS. Conceptually, I have problems with it. I am open to the idea that, for example, the Government might act as a facilitator. For example, maybe in a state where an examination might find it is very difficult for businesses to cooperate, to get together, to pool their resources, perhaps a state will come up with a research enterprise zone plan that, in a sense, tries to pave the way and allow businesses and academics to get together, and perhaps provide that facilitation.

REPRESENTATIVE HAMILTON. But the idea that they were talking about, these research institutions where you mingle private and public money and manufacturing extension, you don't buy that?

MR. HUDGINS. I have serious problems with it because I would ask the question of, first, why doesn't the private sector do this?

There was an interesting study done—it was released in December 1984—"Innovations in Industrial Competitiveness at the State Level" by

Edward Reagan, who was, I believe, Treasurer of New York state at the time, and Bruno Mahler, a businessman from Wisconsin. This was part of the President's Commission on Industrial Competitiveness. One of the things the study did, and some of the associated studies, was to try and examine what are the problems of taking basic research, doing it, and bringing an end product, for example, to the market. That was very interesting because much of what they found was that it was government policies. And they actually recommended, I believe, more of a government facilitating role, trying to simplify licensing processes and things of that sort.

REPRESENTATIVE HAMILTON. I told you we were going to have a lot interruptions today, and we have another one. I apologize to you for that. While I am gone, I will ask our associates here to check with you on your schedules for the balance of the morning so that I don't unnecessarily detain you.

I am sorry for all these interruptions, but we are voting with a vengeance as we conclude our, we hope, session here. One of the charges often made is that the university industry alliances primarily help the universities and not the industry. So I want you to speak to that, if you would, please.

We will stand in recess.

[Recess.]

MR. CELESTE. Mr. Chairman, could I go back for one moment to the intriguing industrial policy question, to mention two things? One, to my surprise and quite coincidentally, the directors of three of the Edison Centers are here, meeting with the Ohio delegation.

There are two other aspects of state initiatives that I think are worthy of note. First, there is no guaranteed lifetime to any of these state initiatives, and part of this is because they are so driven by their business relationship. And if it isn't proving out, if there isn't a real benefit in terms of the marketplace, most of these initiatives will not last for a long period of time. That may be a difference between state government and the Federal Government.

REPRESENTATIVE HAMILTON. Have you actually seen some stop?

MR. CELESTE. Yes, in the case of the state of Ohio, one center was put out of existence in the very early round of appraisal, and others may be in the future.

The other point is that with small businesses, as economic activity becomes more and more knowledge based, more businesses have a hard time sustaining a substantial research program. Therefore their ability to participate in some kind of shared access to state-of-the-art research and to find a way to deploy that in their small enterprise can be enormously valuable.

So many of the participants in these centers are small businesses who cannot afford high-level research and yet recognize that new knowledge is vital to them in their business, and they need both the research and a training aspect so that this can be shared with their work force.

REPRESENTATIVE HAMILTON. The centers do not become captured by the big business interests in the state, that has been your experience?

MR. CELESTE. In my experience, that has not been the case.

MR. PLOSILA. Mr. Chairman, if I can just comment, having worked for about 33 states and their technology programs——

REPRESENTATIVE HAMILTON. Thirty-three?

MR. PLOSILA. Yes, at one time or another. Ohio and Pennsylvania tend to have a much more balanced portfolio of small, medium and large——

REPRESENTATIVE HAMILTON. Which of the 33 states have the best program?

MR. PLOSILA. I can't answer that question. But the point is that when a lot of the state programs began in the early 1980s, they were somewhat captured by the universities, and many of the universities thought that these were programs, much like federal programs, for basic research. And those programs that didn't evolve—a number did over time, but many did not do tech transfer—those that continued to have industrial affiliate relationships with a few large companies and did only basic research—technical assistance to small and medium ones have had a lot of trouble with the state legislatures. Those are the ones who have had their funding reduced or deleted.

Those that are responsive to the marketplace, to companies, in meeting needs have done relatively well, even in this recession, without major cutbacks in many states.

REPRESENTATIVE HAMILTON. But it is true, is it not, that these state universities are powerful figures in a state, and they have a lot of clout. They have got a lot of clout with the Governor. I mean, is there some risk to this?

MR. PLOSILA. Let me say that in Pennsylvania, they have 128 colleges and universities involved in the Ben Franklin Center. So it is not just a Penn state program or a large research university program.

Number one, we require them to compete with each other. Penn state was not very happy when they ended up last in the competition for two or three years, and did try in indirect ways to go back to the old approach of how they got their money. It did not work.

REPRESENTATIVE HAMILTON. Mr. Hudgins is very worried about pork, science pork, and he cited some federal examples.

MR. HUDGINS. Most of these are federal examples, yes.

REPRESENTATIVE HAMILTON. How do you respond to his concern?

MR. PLOSILA. I think what the states have generally done is look at their comparative advantage, where they have strengths, and try to use these programs to focus somewhere where there is an industry constellation of forces and university expertise where the programs have worked.

I am not saying there aren't programs where the universities simply said they wanted more money to do what they have normally done. The ones that have been successful are ones where there have been a group of companies driving the agenda and the activities. And in those cases, industry isn't any happier than anyone else about "pork"—quote, unquote—and they are not going to put in three or four times the public money in leverage if they think this is simply that kind of project.

REPRESENTATIVE HAMILTON. How do you handle the problem of equity? Maryland has four biotechnology centers.

MR. PLOSILA. Six.

REPRESENTATIVE HAMILTON. Why do you need six of them? North Carolina has located some of its business incubators in rural areas.

MR. PLOSILA. Since I have written about this subject, I should comment. There is this tendency in universities in the United States to have every teaching hospital become a biotech center. We have something like 80 biotech centers in 29 states. And that probably is way too many. One of the things

the interstate compact idea, which is in this report, would help address is encouraging more information-sharing, more knowledge-sharing. And maybe in a collaborative venture, there is a need, as Mr. Hudgins noted, for some competition, but I also believe in cooperative competition; and there also is a need to encourage states and regions to work together.

On the whole, however, if you look at where the state programs are focused and the research, most of it is in advanced manufacturing, helping existing firms modernize and be competitive, use technology, whether it is robotics or CADCAM or sensors to help improve their manufacturing processes; and that is what we see in the Ohio centers, as an example. I think half the Ohio centers are in the advanced manufacturing area.

REPRESENTATIVE HAMILTON. Governor, you must have had some experience with this distribution problem. You are going to get enormous pressures, aren't you, as a state leader? You have to spread these things around.

MR. CELESTE. You do get enormous pressure. I think in the case of Ohio we were fortunate. We had a clear set of goals at the outset, which helped us to evaluate proposals as they came in.

Second, we required a competitive and peer review of the proposals, and we didn't fund every proposal that came in. We turned down proposals from some distinguished institutions. Case Western Reserve wanted to be the university partner in a polymer center. The University of Akron wanted to be a university partner in a polymer center. There were separate proposals. We said we cannot afford, as the state of Ohio, to create two centers that compete with each other.

If we are going to have something which is nationally credible, you need to find a way to come in together and build on your strengths. And in the case of one of two biotechnology centers—Ohio is more modest than Maryland—the center in Cleveland took four years to get funded because it was consistently rejected by the panel of reviewers in Columbus who said, you are not involving all of the participants who need to be involved.

So I think you have to have clear goals at the outset. You have to say that in order to justify an investment, this must meet the test of national and international quality. And that is a test that is going to be judged by academic peers and by business leaders, who both have been represented on the panels that made the decisions.

REPRESENTATIVE HAMILTON. What about labor?

MR. CELESTE. Labor was involved, and they had an interest in ensuring that every center had a training component to it. In talking about these Edison Centers, when we talk about science and technology being moved to the marketplace, it is not enough simply to have a new set of knowledge that is going to affect the design of a product or a manufacturing process. People who will do this need to be trained in that. So training becomes an important component.

REPRESENTATIVE HAMILTON. Labor and management in Ohio and Maryland have both been very supportive of these; is that an accurate statement?

MR. PLOSILA. Pennsylvania.

REPRESENTATIVE HAMILTON. Pennsylvania?

MR. CELESTE. Yes.

MR. PLOSILA. Very much so.

REPRESENTATIVE HAMILTON. A couple of years ago, we had testimony in this Committee about Michigan's manufacturing extension program. And then a new governor comes in and knocks it out altogether. So, do you have a problem with stability here? Is this an off-again-on-again kind of thing?

How about your successors, Governor?

MR. CELESTE. My successor has been very supportive of the Edison program.

MR. PLOSILA. In Pennsylvania, the program is still funded six years after I left, at $21 million.

REPRESENTATIVE HAMILTON. Still going?

MR. PLOSILA. Still going.

MR. CELESTE. But I might say, Mr. Chairman, the concern is one that the task force did acknowledge, and one reason for wanting to have a commitment to an advisory body on science and technology is to help provide a frame of reference for sustaining these kinds of investments over time, a body that isn't simply a partisan body.

REPRESENTATIVE HAMILTON. Now, you had the Ohio Tech Transfer organization?

MR. CELESTE. That is right.

REPRESENTATIVE HAMILTON. You set it up, and your successor knocked it out; is that correct?

MR. CELESTE. It actually was in the throes of childbirth or in its infancy when I became governor. It was set up by my predecessor, and we worked to build on his efforts. I think that——

REPRESENTATIVE HAMILTON. It has now been knocked out?

MR. CELESTE. I think "downsizing" is a better description. The state of Ohio, like many states, Mr. Chairman, has had to suffer through the constraints of a budget which——

REPRESENTATIVE HAMILTON. Of course, experimentation is one of the aspects of this, isn't it? Not all of them are going to be home runs.

MR. CELESTE. Several of the Edison Centers have become part of what I would call a technology extension effort.

MR. PLOSILA. Mr. Chairman, if I could just supplement that. This report also talks about staying power of the federal players as well as the state players. And those of us involved at the state level have also had the ups and downs of federal funding and federal stops and starts. So it also works at the federal level.

REPRESENTATIVE HAMILTON. I wanted to ask you about this interstate compact idea. That is not something that, I guess, we at the federal level are all that familiar with. But your report calls for the development of these interstate science and technology compacts. How do you go about that? How do you structure that?

MR. CELESTE. Perhaps, I should make a distinction, Mr. Chairman. There are interstate cooperative efforts that don't rise to the level of being formally an interstate compact.

REPRESENTATIVE HAMILTON. A compact is a contract, isn't it?

MR. CELESTE. It is really a contract, and it requires action by the Congress to be recognized. As an example of interstate cooperation, the Great Lakes

Governors' Council undertook a cooperative effort in the area of dealing with toxic substances in the Great Lakes. In the states that the Governor decided to recommend to their respective states an appropriation to create a trust fund, which we did, the six states put together $100 million, the revenue from which is used to address toxic cleanup needs in the states. That was never done formally as a matter of interstate compact.

What the task force has in mind is something akin to the education commission of the states, which is an interstate compact, and brings together all of the states, governors, legislative leaders, to focus on a specific area of concern.

REPRESENTATIVE HAMILTON. For example?

MR. CELESTE. In this case, we would imagine an organization that focuses on science and technology policy to create an arena in which we identify opportunities for cooperation, in which we share best practice, and in where we try to hammer out a common approach to policy so that we can speak with a coherent voice to the Federal Government and to federal policymakers.

One of the reasons I think that the states aren't as effective a partner as we ought to be in federal initiatives is, it is very hard for you as a concerned member of Congress to hear a state perspective. You hear different people speak at different times. But if we are to really mobilize the best of what we know in science and technology and put it to work in a partnership between the Federal Government and states——

REPRESENTATIVE HAMILTON. Give me some examples. How does this work? Dream up an example here for me. You would have an interstate compact doing what?

MR. CELESTE. Let me give an example. I would think an early agenda item for such a commission, or such a compact, would be to talk about what states can do to help refocus the work that is going on at the federal laboratories. These labs have a very intimate impact on the communities in which they are located. While they may be dealing with nationality problems, they have often a local flavor.

Now, already some states have taken the initiative. The state of New York has a consortium built around work that is being done in Cold Spring Harbor with federal labs, state universities, and businesses. In California, there is an effort now to look to the federal laboratories and their work in the transportation area, to see how this can be geared into states' interest in transportation.

But as of today, the states have no way to speak to the Department of Energy, the Department of Defense, other agencies who fund the federal labs, to say, here is our interest as state governments, and here is how we would like to participate with you as a partner.

And I can see such a compact addressing that sort of an issue. It might address expectations of the Congress and federal agencies with something like the small business innovation research program, or in a variety of other areas.

REPRESENTATIVE HAMILTON. Mr. Plosila or Mr. Hudgins, do you have any comments on this interstate compact idea? Mr. Plosila, you have worked a lot in different states. Have you had any experience with the compact idea?

MR. PLOSILA. Interstate compacts were basically established in the United states partly for regional issues. But increasingly Congress and the states themselves have come forward to create national groups of compacts—the ECS being one more recent example. The reasons for this seem to be

because they need a source of independent knowledge to address standards, to address innovation, to address common problems or needs.

And I think some of the work going on in educational reform now around the United states really came about from the work of ECS over the last 10 to 15 years in which they have helped educate the elected officials in legislative and executive branches, not just at the state levels but at national levels as well.

The importance of science and technology issues in defense conversion and federal labs are only two examples. But increasingly in our society what we do is affected by science and technology. So environmental issues is another area. The cleanup of defense installations is another example. There are a number of areas in which they are going to require collaborative efforts at the state and national levels. A compact can provide a common place for which the states together can play a role, which I think Congress and the Executive branch would appreciate, in the sense of having a place to go without having to talk to 50 different folks.

Interstate compacts, however, are not a panacea, and really only those states that sign up are members, so all states don't necessarily sign up. And Congress itself has to approve the compact itself, legitimize it.

REPRESENTATIVE HAMILTON. Let me ask you this question. One of the phenomena that confronts the states now is this business of smokestack chasing, where you get a lot of competition among states to locate a certain industry or facility. Would a compact, for example, likely have a clause in it that would prohibit that kind of thing? Is that feasible, or is that off the wall?

MR. CELESTE. Mr. Chairman, having tried to get an agreement among just six Great Lakes states and their governors to forego smokestack chasing and having failed, I would say that it would be very difficult to get such a clause into any compact. It would create a forum, however, where a discussion of that—particularly around science facilities and the kind of pork issue that Mr. Hudgins raised—could be addressed in, I think, a responsible way, and, again, addressed among peers with an opportunity to share the outcome in important forums.

There are several other debates going on in Washington right now about the deployment of science and technology for the benefit of society. The National Science Foundation is looking at its mission and whether to refocus it in certain ways. The National Institutes of Health is doing the same thing as they develop a strategic plan. There is no mechanism today for the voice of state governments to be heard in that discussion.

REPRESENTATIVE HAMILTON. Mr. Hudgins, do you want to comment on this area?

MR. HUDGINS. Yes, just a couple of remarks.

Policy innovations do often occur at the state level, whether it is choice in education, welfare reform or whatever. As you move up the ladder, so to speak, and try to get consensus, it is much more difficult. This is where I see a serious limit to compacts.

In regional agreements, whether it is on pollution or water and public utilities—these kinds of things—very practical ends are involved. But when you start talking about something beyond, that it is very difficult.

Perhaps, the states could have some consensus on what kind of flexibility they want from the Federal Government, okay? Or they could, perhaps, have

a consensus on seeking to have certain powers returned to them. And I am looking, for example, in the environmental area. This is an area where you may find something like that, where the states say we can handle a lot of the problems associated with the environment better if you give us more flexibility. Perhaps, a unified voice in that area would be useful.

But in terms of science and technology, except perhaps for conversion of the federal labs, I find it difficult to imagine exactly what kind of a compact they would have. I see serious limits to these sorts of agreements.

I might add, one of the problems also is that in this country, business turnover is among the highest in the industrialized world. I think David Birch, from MIT, his studies of businesses and jobs finds that we have something like 6 or 8 percent turnover in our jobs and businesses every year. If we look at the Fortune 500 today and five or ten years ago, you find a lot of turnover.

So you do have this problem as well when you have business partnerships even at the state level with the Government, as a lot of those businesses, you know, in the market probably should fail, and the resources go somewhere else. And as you move up the chain, it is even more difficult to get a consensus and get the businesses tied in.

MR. CELESTE. Mr. Chairman, just to give one other illustration of where I think a forum of this kind could be valuable—whether it is created under an interstate compact or in some other fashion.

A strategy of many federal agencies in recent years has been to insist on matching funds from state governments or local communities in many of these science and technology initiatives. This can become a way of pitting state governments and localities against each other and rewarding the place with the most wealth. That isn't necessarily the best way to make these decisions. And I think there is a real concern on the part of many of the policymakers and states focused on state science and technology initiatives to frame an understanding about matching funds that recognizes flexibility, that rewards quality and not simply who has got the money and things of this kind.

So I want to suggest that the forum can go beyond simply a decision about recommendations of what is the future of national labs to deal with issues of this sort, which affect the nature of the partnership between the Federal Government and states and the way we do our business most productively.

REPRESENTATIVE HAMILTON. Let me ask you this. There is a feeling, I think, among many, since the American competitive position in the world is such a dominant concern of Americans—and will be a dominant concern going into this next decade—that the Federal Government is going to become more involved in these types of policies than has been true in the past. Mr. Hudgins may not like that, but it may develop in that direction.

And if you look at it from the standpoint of the Congress, you can clearly see pressures in that direction. Now, if that happens—we won't argue the merits of it—but if it happens, what does that mean with regard to states, and with what you are arguing for today? If the Federal Government moves into a technology policy, or whatever we call it, and we begin to set up manufacturing and research centers and the rest of it, what does that do to the state role? Is that going to diminish the state role, or increase it? How would you see that developing?

MR. CELESTE. Mr. Chairman, my sense of the discussions in our task force were, first, we anticipate what that direction is likely to be, that the Federal

Government will desire to invest in R&D for economic competitiveness as we move away from the major preoccupation with defense investment in R&D, and a recognition that our national security depends very much on our economic competitiveness.

I think the conviction of the task force is clearly that, to do that wisely, the Federal Government needs to think in terms of partnerships with the states, that the states have been active on the frontiers, that we have been very flexible and diverse in what we have pursued. And I can give you some examples of problems that arise when the Federal Government acts without taking into account state initiatives.

There was considerable discussion about NSF investments in the early days, in engineering centers that would duplicate, in many respects, work that was already invested in by a particular state, in the way of a similar engineering center focused on particular areas or problems. And the conclusion we have reached, I think, is that if we work together, we can leverage limited resource——

REPRESENTATIVE HAMILTON. This is not a zero sum game.

MR. CELESTE. It is an opportunity to go well beyond a zero sum game.

REPRESENTATIVE HAMILTON. You said there are six biotechnology centers in Maryland?

MR. PLOSILA. Yes.

REPRESENTATIVE HAMILTON. Why have you got that many? Isn't that a big waste?

MR. PLOSILA. Actually, as I understand what happened, it was a University of Maryland initiative. And on their own basically, without industry involvement, and really without much state oversight, they decided that they wanted to cover all fields of biotechnology and simply added centers over time. The state now——

REPRESENTATIVE HAMILTON. You said there were some 80 in the country?

MR. PLOSILA. Right.

REPRESENTATIVE HAMILTON. Is that good to do that?

MR. PLOSILA. What is happening, however, as Governor Celeste indicated earlier, is that when there isn't the private-sector interest and the state governments don't see results, they are pulling money out of these things, so there will be less centers over time. It is the laboratory of democracy argument; which is, when people experiment, you tend to duplicate activities, and there is a consolidation period in which you bring things back together.

I think what is happening with many of these things when they first got into the technology arena, they all wanted to be part of it. Now, I think there is much more a look at where the private-sector money is, and what the benefits of these things are. But I don't think——

REPRESENTATIVE HAMILTON. Can you give us any help on these intense fights that we have in the Congress on federal research projects? You get a superconducting super collider. What do you do about that? How do you reduce the——

MR. PLOSILA. We have this on a micro level in Pennsylvania, because every research university wants to create multiple centers. It is the nature of the beast. What we said was, in fact, if you wanted to get state support, you had to get private-sector commitment, dollars in hand, at least equal to the public

money you are asking for. You had to apply the funding toward development projects, not simply for basic research. You had to show a tech transfer component.

We had six criteria we applied to each of those centers. And some of them still got federal money, but we did not put state money into them because they did not meet our state and local priorities, which were primarily on economic development. We are using research as a way of helping commercialization. That same phenomenon is now happening throughout the country with a lot of state efforts asking the questions and seeing, in fact, if those investments are worthwhile.

And I would argue that, in fact, the states have a little bit more experience at this, in many respects, than the Federal Government, because I can cite to you 10 states that have cut centers. There are at least 10 of the 44 states that have cut one or more of their centers in the last two or three years. That is rather unheard of for university-based research centers to get defunded, but, in fact, it is happening because states are asking these questions.

This relates to the question Governor Celeste is responding to; that is, if the national government is more involved in competitiveness issues, what does that mean in terms of the state and local role. I think if we are going to be successful in competitiveness issues, we are going to have to have approaches that are somewhat more decentralized than the approaches we did during the World War II and post-World War II period. We are going to have to have efforts that involve the private sector.

And I think the state programs tend to be more downstream, to be more applied, involve more industry than more traditional programs. If we are going to have federal intervention, these programs are going to be responsive to what industry needs. They need to be responsive to what our competitiveness problems are. If we try to operate these out of a national approach, I think we are asking for failure from the start because they are not responsive to the customer, the client. They are not responsive to the particular needs of the different areas and regions of the country.

And so, the state-federal partnership we are going to need more than ever in science and technology, not less, because of the nature of what we are going to be intervening on, which is technology diffusion, manufacturing modernization will require close relations between the private sector and the customer, which state and local governments, just by the nature of where they are, can accomplish.

REPRESENTATIVE HAMILTON. Did you want to make a comment on that?

MR. CELESTE. I wanted to comment specifically, Mr. Chairman, on the big science issue and the competition for that.

It seems to me that, again, if there were an opportunity for the leaders of 50 states—governors and legislative leaders—to think about how one arrives at a decision to locate a major big science project, once there is a determination from the Congress and the President that this is a project that is in the national interest, I think it would be helpful to have their input in the process.

For example, it may be important to say, as part of our evaluation, we want to see built into each proposal cooperation among the states within a region. No big science project should belong to a single state alone. It ought to rest in a region, and it ought to be justified because of the region's commitment to that effort.

There is a real temptation to tie such a decision to which state is going to put the biggest pot of money together. That isn't going to guarantee that it will be put in the best place. I think that there will be in the future some big science projects that require an investment from this country. Even today, we are debating whether those costs should be internationalized in some fashion.

REPRESENTATIVE HAMILTON. You know, Mr. Hudgins was concerned about the space station. They sprinkle those contracts around every state in the country. So I have people calling me from Indiana and telling me that I have to support the space station because it is important to such-and-such a business or such an institution.

The business of spreading contracts around is a highly sophisticated business today, and it is done for the purpose of gathering political support. And it is very effective. There is no doubt about it.

That is not exactly on point of what we are discussing here, but it is a phenomenon that has become very impressive from the standpoint of a politician in this institution. How these projects that you hear about, all of a sudden you find all kinds of connections with your state on it.

Okay. Let's get on with some other things now.

MR. CELESTE. Mr. Chairman, did you want to return to the university business alliance issue?

REPRESENTATIVE HAMILTON. I do. But let me ask you this. When you set up these centers—I will let you go into that because the whole purpose of this is to let you talk about what you want to—but when you go into these state centers, where does the opposition come from, and how much is the opposition in Maryland and Pennsylvania and Ohio, politically speaking?

Let's look at this as politicians for a moment. How much significance do you get for that? And, once you establish them, does that opposition fade away on you, or does it remain and intensify?

MR. CELESTE. The two criticisms or the two concerns that were raised in the early stages of the Edison program were: Why didn't we get a center? In other words, you have some local opposition.

REPRESENTATIVE HAMILTON. This county gets it, and that county didn't get it.

MR. CELESTE. Toledo did not get a center. Dayton did not get a center. Youngstown did not get a center. Why does Cincinnati have two centers? Why does Athens, Ohio, have a center, and we don't have one in Toledo or in Dayton?

REPRESENTATIVE HAMILTON. That is not opposition on a conceptual basis.

MR. CELESTE. No. It is assuming that if it is good, we should have one, too.

So there is a lot of work that has to be done to persuade a community that the only way you can have an investment of this kind is if you can identify an area of sufficient strength and focus, that you can begin to exert some real national leadership. Because that was the test we used. Can these centers become recognized national leaders in their area of expertise?

REPRESENTATIVE HAMILTON. But almost by definition, then, don't the rich get richer?

MR. CELESTE. Well, no, not necessarily. We have the director of the Edison Welding Institute here. I don't think anyone had welding on the horizon

when we talked about this, that there was really a very advanced technology aspect to it; and yet it proved to be the case.

Cleveland was not a big winner in the early days. There was one center there in advanced manufacturing, and they felt, somehow, that certainly that didn't match what their interests were.

The second source of concern is one that arises over time, and that is, we tend to sell these programs on the basis that they are going to be good for our economy. Now, as politicians we translate that into jobs, and we have elections in a two-year or four-year cycle. Where are the jobs in two years or four years? I tried very hard to make it clear to members of the legislature and the public that these were long-term investments. We should look at them in 5-, 10-, and 20-year time increments.

But we went through an evaluation early on to begin to look at were these really beneficial to the private-sector participants? Did the businesses that were paying members of these centers believe that they were getting something of value? Could they identify specifically what it was?

Similarly, did other constituencies like organized labor see a value in this? An example would be——

REPRESENTATIVE HAMILTON. Do they now support them?

MR. CELESTE. Yes, they do.

An example would be the Cleveland advanced manufacturing program, in the early stages, received not a request for a generic research but a very specific proprietary problem. The Ford engine plant in Brook Park—a part of Cleveland—had a specific problem where a machine was constantly breaking down, and they could not figure it out in the plant. They went to the advanced manufacturing program, and within a relatively short period of time, the skills that were available—academic, experienced, and so on—were brought to bear, and that problem was solved, and in a way that allowed for a very important manufacturing process to continue.

It was fortunate that that happened in the early stages of the center because it helped everyone to understand the ways in which this transfer of knowledge could be directly beneficial.

REPRESENTATIVE HAMILTON. One interesting aspect of your response is that in the initial stage when you proposed these centers, you did not get a lot of opposition; is that correct?

MR. CELESTE. That is correct.

REPRESENTATIVE HAMILTON. Mr. Plosila?

MR. PLOSILA. First of all, in the early 1980s, the centers were university-based. Increasingly, the centers are becoming nonprofit based. So I think the U.S. centers are evolving much more into being a mixture of industry and university nonprofit than they are university-based centers. So I just wanted to put that out there as to what is happening.

REPRESENTATIVE HAMILTON. In that instance, does that mean a small business in Ohio, or somewhere, which has a welding problem, they can come to that center?

MR. PLOSILA. I won't try to cover everything, but among the services to their members is technical assistance to those firms. They provide a limited amount of technical assistance to their member companies, wherever they are located.

REPRESENTATIVE HAMILTON. If the firms are not members, are they shut out?

MR. PLOSILA. It depends on the center. That one I can't comment specifically on. Most of them can do contract work, but it is at a much higher rate than for a member.

MR. CELESTE. Mr. Chairman, if I might, just as a point of interest, the Cleveland advanced manufacturing program is the only nonprivate-sector entity to get a Q-1 award from Ford for quality work.

MR. PLOSILA. In terms of your question about opposition and so forth, around the country there are four different oppositions that comes up, and it depends on the program. One is small firms that feel shut out of the early programs because they could not afford the membership costs.

And the second problem is that when they tended to be basic research centers, university researchers aren't noted for deliverables and timeframes. But that is partly a definitional problem. It depends on what kinds of centers you have. The centers not designed for that, obviously, can't provide that kind of service.

The second area tends to be parts of universities are upset because their area wasn't selected for the focus of the center. Or some parts of industry will be upset because what they are interested in was not selected.

I might say that, generally, areas are selected where there is an equal amount of support of both industry need and university expertise. Where you have joint centers or where you have an industry-driven center, it tends to be industry-focused on what they are interested in.

In Pennsylvania and Ohio, we had labor support. In other parts of the country, we have had problems from time to time. Although, I think, generally, labor organizations recognize that if we don't use technology to modernize, there won't be any jobs. It is not a question of elimination of jobs; it is a question of retaining some jobs. So there is much more support on the technology-infusion side. But that has been a problem in some cases.

And then the final group is legislators. Governor Celeste mentioned in terms of looking at short term versus long term, but also looking at what the benefits are. Again, there was a communication problem in a number of states where the university would say that they wanted to help economic development— that meant better quality workers—whereas, the legislator meant jobs. So there has been a real communication problem that I think, hopefully, will get worked out.

REPRESENTATIVE HAMILTON. We have over 1,300 university research centers in the country today, and some of those have been in existence for some time. They are associated with 450 universities. Can we draw any experience from those? Is it clear that they are contributing to economic growth? Have there been any studies of these centers? I am not talking about any one particular one. I am talking about the big picture. And in terms of jobs, that is usually the bottom line.

MR. PLOSILA. Carnegie-Mellon has a study funded by the Ford Foundation, which is underway now, which is surveying to find out, in fact, what these centers do. It is a very comprehensive survey. We will know more about centers out of this study than anything I have seen to date.

REPRESENTATIVE HAMILTON. When is that going to be ready?

MR. PLOSILA. Shortly. Your staff may know more than I do. I have lost track by now. But this study should help inform us.

In terms of anecdotal information or state-by-state information, it depends on the kind of state you are talking about.

I did some work for Utah and Utah's Centers of Excellence, which are based in the university. Number one, they graduate centers They are only in the program for five years, and the centers actually graduate from the program.

Number two, the cost per job is something like $7,000. Utah is a very entrepreneurial state. They have lots of spin-offs. They have something like 69 biomedical firms alone in the Salt Lake City area which came out of university intellectual property or university faculty.

So, in that kind of program, they clearly are showing a cost benefit ratio that is very good. It is a small program—$2 million a year in state money.

REPRESENTATIVE HAMILTON. One of the criticisms, of course, of government generally is that we set things up and then we never follow up and see if it continues to perform. For example, in the programs you are familiar with, is there an ongoing, rigorous oversight to see if they continue to perform like they are supposed to perform, or do you set them up and forget about them?

MR. CELESTE. Mr. Chairman, I think that those centers which have been created specifically within the economic development framework are subject to pretty substantial oversight, both in the legislative arena and from an administrative point of view. As we have indicated, at least one of these centers has been defunded, so I think there is an effort to look at them critically.

I think, if you look more broadly at university business collaboration, this is an arena that bears examination. Mr. Plosila mentioned a study that is under way in conjunction with the Ford Foundation. If I can put on another hat, I chair something called the Government-University-Industry Research Roundtable. We are deeply interested in the future of the academic research enterprise and the relationship between business, industry and the university in the research arena.

We are bringing together a dozen university-industry partners for discussion in the latter part of October to focus on what makes a good collaboration: To what degree do we really understand and do two partners really have the same expectations of each other?

Even today, with all of what we invest through these centers and in other ways in research, that aims to have a valuable impact on business. What business really wants from the university, more than anything else, is highly trained personnel who can come out and join them in their business. If the centers are productive, that is an added benefit from the standpoint of many of these university-business partnerships.

MR. PLOSILA. The Carnegie Commission Task Force Report does call for evaluation to be given more attention. And one of the things the interstate compact could do is help, in fact, look at how to develop standards.

And this is actually something of benefit to NSF and other federal agencies. I have been on a number of groups in the last couple years which determined that the Federal Government itself has trouble evaluating science and technology investments, not just the states. But if you look at what the states have been trying to do in looking at their science and technology investments, they have far exceeded what generally the federal agencies have done up to

now. Not that it is perfect, but they have at least been trying to find ways to do it.

The compact would be of benefit to both federal and state partners in the sense of having a place to try and figure out how we can do a better job of measuring and evaluating these investments.

REPRESENTATIVE HAMILTON. Mr. Hudgins, did you have a comment?

MR. HUDGINS. The only thing I will add is that I think it is a crucial question about how you evaluate these programs. And, again, from the experience at the federal level, we know that the follow-up is not particularly good. I think that, in a sense, it does argue, if we are going to do these experiments, it is better to do them at the state level. That way, if Ohio does something everybody universally agrees works and they have their standards and criteria out there, then we can say, fine, here is something that seems to be useful, and perhaps the Federal Government can learn from what the states have done.

And, conversely, if many of my fears come to fruition where there are serious problems with these, where the state governments literally have to make a choice between continuing to fund a program, with no foreseeable benefits to the states, or, for example, covering the education budget or cutting the budget for police, then, fine, the people of the state and the state legislators can have a good, rousing debate over that very issue.

REPRESENTATIVE HAMILTON. Is there any problem of foreign corporations coming in and getting undue advantage from these things? We have 496 foreign corporations that now have a research relationship with 41 research universities in this country. Does that come up on your radar screen at all? Is that a concern, that our universities are turning out research, and the foreign corporations are going to be the ones that take advantage of it and benefit from it?

MR. CELESTE. Mr. Chairman, the answer is, yes, it comes up on the radar screen. It comes up very clearly. And I will give you a specific example.

I have mentioned the Edison Polymer Innovation Corporation. This has a number of corporate members focused in Northeast Ohio because of the Akron-Cleveland interest in polymers. Two of the corporate members of this center were Sohio—a major oil company— and Firestone—a major tire company. One based in Cleveland, the other in Akron.

These are major corporate members of the center, very active participants. Well, Sohio is now BP. Firestone is now Bridgestone. They are the same companies in many respects, but they are now foreign-owned companies.

The view of the board of the center is, they are entitled to fully participate in the center on the same terms—not better terms, not worse terms—but on the same terms as any other companies with investments there, and they will be full participants.

And, indeed, for these centers to really provide state-of-the-art knowledge to their businesses, the centers themselves have to think internationally. Thus, the Edison Welding Institute in Columbus has a partner relationship with the Welding Institute in Great Britain, which is providing an international insight, that they can call on for the benefit of members of that effort in Central Ohio and throughout the state and really throughout the Midwest.

It is extremely difficult today to draw meaningful boundaries around who are the beneficiaries of research as we move it to market. And the real challenge, it seems to me, is many U.S. companies are still less interested in

knowledge coming out of university research or other research centers than are foreign companies who come here and stay attentive to this.

I have been told that, for example, twice as many Japanese companies make inquiries to the federal labs for published research results than do U.S. companies. And half again as many German companies approach federal labs for information as to U.S. companies. So part of the goal of these centers is to actually stimulate interest in communications with U.S. firms in a way that is going to help them be competitive.

But I don't know that we can guarantee a national advantage by trying to create boundaries that will say, somehow this knowledge is off limits to, quote, a foreign company.

REPRESENTATIVE HAMILTON. Why can't we say, if you are going to benefit from the fruits of research at Ohio state University, then you are going to manufacture in Ohio?

MR. CELESTE. Actually, we seek to do that. Another aspect of the Edison effort is seed money for firms that spinoff, and that develop out of new knowledge. And part of what we try to do is to build the contract relationship that keeps those jobs in Ohio.

It is extremely difficult when the Edison Animal Biotechnology Center in Athens spins off a company, and it is a private company in which they own an interest. And that private company, as it goes from venture capital to the next stage of its development, is acquired by a firm based in Princeton, New Jersey. And they say, we want to move the base of this company to New Jersey. We will try to keep jobs in Ohio, but it is extremely difficult to make sure that happens.

Part of it is that we just have to understand that the turnover is moving so fast, we have to help our companies be flexible and quick in their ability to respond to changed market conditions.

REPRESENTATIVE HAMILTON. Mr. Hudgins?

MR. HUDGINS. It is true that foreign corporations are always looking for advantages over here. I note that one of the primary users of the Freedom of Information Act are foreign firms often trying to get information about American businesses. It is not usually reporters trying to find out what is happening in the Government.

But, in a sense, that calls our attention back to the strategic alliances and joint ventures that I mentioned earlier. American firms seem to be getting more sophisticated in driving a harder bargain with these kinds of agreements than they did in the past.

The Apple-Sony agreement, for example, I believe was agreed to in 1981, means that the Apple computer company will have access to certain manufacturing procedures and miniaturization technology that they need. The Sony people will have access to our laptop designs, and they presumably will come out with a product which both can market in their own countries. Or the LSI Logic Corporation agreement with Sanyo to produce semiconductors for high-definition television. In that agreement, the American firm will gain manufacturing technology that they don't have already. The Japanese firm will gain design information. Hopefully, both will become more competitive.

And maybe that is something you might want to look at as a model, are the two companies both benefiting? I would assume that they are. And, in this

case, you can document where Apple or where the others gain by having an agreement with foreigners.

REPRESENTATIVE HAMILTON. Do states take an equity position in companies that associate themselves with these centers?

MR. PLOSILA. It varies by state and by program. The states have what are called matching grant programs where they fund projects, say, between a faculty member and a company. In most cases, most of them require a royalty payback and a fee to the university.

REPRESENTATIVE HAMILTON. Does the state become a shareholder?

MR. PLOSILA. In the venture capital program I talked about in Pennsylvania, the state is a shareholder. In the Ben Franklin Challenge Program, the Ben Franklin centers get equity for their investments.

REPRESENTATIVE HAMILTON. Suppose the state regulates that industry? Is there a conflict of interest?

MR. PLOSILA. It is like the Federal Government. The right hand doesn't know what the left hand is doing sometimes.

REPRESENTATIVE HAMILTON. Easy there, now.

MR. PLOSILA. A number of states have tried to encourage their securities' commission to have a more active playing field for technology start-ups. I don't think there is a real conflict problem there.

REPRESENTATIVE HAMILTON. Do states put pension funds into these operations?

MR. PLOSILA. Yes, not into the centers. When we talk about state technology development programs, we are talking about eight or ten different varieties there. One of those varieties is matching grants. Another is incubators. Another is centers. A fourth is venture capital.

In venture capital, there are two kinds of state interventions. One is where the pension funds invest generally in privately managed venture capital funds. In Pennsylvania's case, the state invested 1 percent of its pension assets in venture capital funds, and they were so pleased with that that they have just doubled it to 2 percent. Ohio is one of the first states to actually do this.

Michigan has put 5 percent of its pension fund money into venture capital. The funds invested in generally are not geared to one state. They are geared to regions or to multi-state kinds of investments, with an effort to help the states they are in. But their primary responsibility is to their pension holders, as fiduciary responsibility. And you have, as I say, 25 states with some kind of a pension investment. You have another 17 states with some kind of seed venture capital investment, not necessarily the same thing.

REPRESENTATIVE HAMILTON. You are very familiar with this Ben Franklin partnership, right?

And, Governor, you have referred several times to the Edison centers. Are these among the best examples of the kinds of programs that we are talking about in the country today?

MR. CELESTE. If you want my unbiased opinion, the answer is yes.

MR. PLOSILA. The Corporation for Enterprise Development is a nonprofit group that studies state economic development, which just gave its awards, I think, to six programs in the country. These were two of the six.

REPRESENTATIVE HAMILTON. What were the other four?

PREPARED STATEMENT OF CELESTE

Mr. Chairman, members of the Committee, thank you for inviting me to testify on the Carnegie Commission report: *Science, Technology and the States in America's Third Century*. As you know, this report was prepared by the Commission Task Force I chaired on Science and Technology and the States. I would like to commend my fellow Task Force members for their commitment and compelling work: Bill Baker, Arden Bement, Erich Bloch, Lawton Chiles, Dan Evans, Bob Inman, Graham Jones, Frank Mosier, Walt Plosila, Donna Shalala, Luther Williams, Linda Wilson and Chuck Young. Additionally, Chris Coburn did an excellent job as Task Force staff director. The outstanding Carnegie Commission staff included its Executive Director, David Robinson, Maxine Rockoff, Jonathan Bender and David Kirsch. Additionally, we were well supported by a number of other people including Harvey Brooks, Duncan Brown, Tom Moss and Jeanette Aspden.

Finally, I would like to express my heartfelt gratitude to the entire Carnegie Commission and especially its co-chairmen Bill Golden and Josh Lederberg as well as the Corporation's President, David Hamburg.

Since the Second World War, the federal government has taken the dominant role in applying science and technology to national needs. Over this period, the Cold War made national Security tile prime consideration, and it is the responsibility of the federal government to protect the nation against military threat. More recently, three broad trends have combined to offer new national challenges and to demand new ways of organizing the responses. These trends are the growing national importance of science and technology; the increasing strength of the states in managing these assets; and the end of the Cold War, with the consequent release of resources, especially human resources, once devoted to defense. The opportunity is to devise fresh new responses to many national challenges, among them the reform of education, the preservation of the environment, the promotion of economic competitiveness, and the provision of health care.

These issues are largely domestic, and major aspects of all of them traditionally fall within the purview of the states. In addition, the past 20 years have seen increasing devolution of many of these responsibilities from the federal to the state level.

As this Committee knows better than most anyone, effective responses to these challenges will place a premium on flexibility, efficient distribution of resources, and organizational entrepreneurship in place of the centralized, coordinated response that was appropriate to the challenges of the Cold War. New partnerships of federal and state government, academic research, and private industry will be needed, and building these partnerships will require changes in our systems and institutions of government at both levels. Many of these changes are well under way. Some have yet to begin.

In previous hearings, this Committee has received descriptions of how many states, in their industrial technology programs, have demonstrated the ability to achieve the necessary flexibility and responsiveness, working closely with industry and academic institutions. While these efforts are still relatively small on a national scale, their structures provide models of government-industry partnership that can be extended to the federal government, and that can help shape responses to other great national challenges.

Our report stresses that the central issue is how to determine the most effective roles of federal and state government. The two should be assigned their roles not on the basis of which level raises (and spends) revenues, but according to their relative effectiveness in a given situation, including their effectiveness in catalyzing private-sector action. Determining the appropriate balance in a particular case will require an unprecedented degree of communication and cooperation, with consultation about needs and priorities and timely sharing of information about programs of potential joint interest.

Ensuring effective communication and cooperation will require new advisory and policy development mechanisms. Whether they are helping shape national science and technology priorities or addressing closer-to-home problems of the environment, health care, education, energy, and economic development, states must have ways of gathering knowledge, of learning from one another, and of putting their ideas and priorities forward in national science and technology forums. We believe, new scientific and technological advisory organizations will be needed at three levels:

- Within states, today's formal and informal advisory bodies will become more significant, and their charters will have to be reshaped to include the development of broad policy positions, integrating knowledge from many fields and from all available sources, including especially the private sector. States will need well-defined mechanisms for mobilizing science and technology expertise to meet strategic goals.
- Interstate organizations will be needed to support information exchange, interstate cooperation, regional collaboration, and the development of opportunities for cooperation with the federal government and with industry.
- States will need to become more heavily involved in federal policy deliberations, both for setting broad priorities and for designing programs that share state and federal resources. The states will need to be represented on federal advisory committees at all levels, from the highest national policymaking councils to the individual laboratory. They will need to work toward a partnership whose influence reflects their potential contributions and needs.

In creating this new partnership, the nation will draw on the vision of great predecessors: the Founders, who defied the initial balance of state and federal powers; the authors of the Morrill Act of 1862, who melded scientific and technological innovation with education in the state Land Grant institutions; and Vannevar Bush, who forged a strong and durable link between government and science after the Second World War. Another opportunity for a new relationship between government and science and technology is at hand: the Cold War is ending; old assumptions about the world are being put aside, and new truths are emerging. In a changed and changing world, science and technology are increasingly central to effective democracy and economic prosperity. By grasping this opportunity for renewal, the nation can increase its industrial competitiveness and meet the challenges of education, health care, environmental protection, and other vital domestic concerns.

The Commissions report makes eight major recommendations, grouped into two areas: shaping policy with states and shaping national policy.

Shaping Policy Within States

1. Each governor should have a designated science and technology advisor. Governors *are increasingly called upon to make decisions that have scientific and technological dimensions. However, they generally lack staff sources of science and technology advice and assessment.*

Each governor's science and technology advisor should act as a focal point for advice on the full range of scientific and technological issues that a governor faces, including health care, environmental quality, telecommunications, and science and technology for economic development. The science and technology advisor should serve on the governor's executive advisory team, as a trusted source of objective advice, integrating the views and knowledge of experts in academic institutions, industry, and elsewhere throughout the state and the nation. This official would have several important functions:

- Bringing knowledge of science and technology to bear at the highest level of decision making in the state
- Helping the governor respond quickly to emergencies by assembling the appropriate experts

- Serving as liaison with the science and technology community in industry, federal agencies, and universities

2. Each state should have an independent science and technology advisory body. *No state has the benefit of a sufficiently well organized process for developing broad, comprehensive positions on issues that involve science and technology, such as economic development, health, and environmental protection. Sound decisionmaking about major public issues requires such a process.*

Such a group, with members representing all elements of the science and technology community in the state, should be charged with providing broad views on key policy challenges. With its help, the governor, legislature, and the public would be able to engage science and technology leaders from throughout the state in their efforts to respond to technological change and promote technological competence. The group would also provide continuity and institutional memory, bridging political cycles.

The group should be independent and representative, and should have access to the science and technology community. In some states, an existing organization, such as a state academy of science, might serve this advisory function.

3. The proposed state advisory body should develop and periodically update a vision of science and technology's role in meeting the state's strategic goals. *Partnership between government, industry and academia requires consensus about broad Issues. Few states have a formal process for developing such views.*

A critical responsibility of the advisory group is to provide the framework in which the major components of the states S&T community can convene, discuss, and forge consensus. This consensus then forms the basis of direct and compelling communication to the executive and legislative branches of state government. The consensus supports S&T-related policy and programs and also enhances the state's ability to work in partnership with industry, federal agencies, universities, and other states. The advisory body would also provide the forum for consideration of the very complicated issues of state S&T policy: performance evaluation, distribution of resources, and practical goals.

4. **Each state legislature should have access to a standing source of objective analysis of science and technology** *Issues. Legislators have even less access to sound science advice than governors.*

The legislative advisory body might be legislative staff or a standing panel in a university of a state academy of science. It should maintain links to national science and technology resources, such as the U.S. Congress's Office of Technology Assessment and the National Academy of Sciences. In some states, size or resource limitations might mean that the same advisory body could serve both executive and legislative branches; in other states, separate bodies may be practicable or desirable.

Shaping National Policy

5. The states should form a new organization to coordinate their science and technology activities and to speak **for the states in national science and technology councils.** *When necessary, states must be able to speak with a single voice to shape national policy. The current interstate organizations for developing science and technology positions are Inadequate to the task of developing, analyzing, and expressing unified policy positions.*

The recommended group must have the standing and the analytical capacity to develop credible broad priorities and recommendations for the states as a body, and to be heeded by federal agencies. A formal interstate compact, underpinned by state and federal enabling legislation, would have these characteristics. The Education Commission of the States may be a suitable model.

The group would have several main functions. First, it would serve as the focus for continuing exchanges of views with senior federal decision makers in both the legislative and executive branches. In the current administration, for example, it would make regular contributions to the priority-setting proceedings of the White House's Federal Coordinating Council on Science, Engineering, and Technology (FCCSET).

Second, it would develop reliable sources of information to support policy development. Precise statistics on state science and technology investments and their outcomes would help the setting of broad natural or regional priorities and in the management of individual state programs. It should also have the ability to analyze state and federal policy options. Finally, the organization should serve as a point of access and information for federal officials, Congress, the news media, and the public.

6. **States should become partners in defining the new missions and operations of federal science and technology institutions (see page xx).** *Many federal technology programs are undergoing radical change, as the nation adjusts to the reduced threat to its security. Some of these programs and institutions offer resources that could be applied to other important national needs. States can help give direction to search for a new mission, through the networks of industry and universities that most have established in their technology programs.*

In seeking new industrial missions for federal programs in technology development and diffusion, care should be taken that these successor activities serve the interests of state and federal government as well as industry. The new interstate compact recommended earlier should be involved in these deliberations. In addition, representatives of the state should be appointed to the advisory committees of the federal executive and legislative branches, on which they are poorly represented now.

7. **Any national strategy for diffusing federal technology to the private sector should build on the foundations that states have already Laid.** *States, using their knowledge of local conditions, have developed channels for using technology to companies, especially the small- and medium sized ones that are most difficult to reach.*

Policymakers at all levels should recognize the value of states as natural interfaces between government and industry, and should take advantage of state programs of technology transfer and diffusion. A national partnership, encompassing industry and all levels of government, should be cultivated.

8. **Through the recommended new coordinating and policy development organization (the interstate compact), states should work** with **federal agencies to plan and hold a national summit on science and technology goals of common concern.** *To make the most of defense conversion and other emerging opportunities, a new federal-state partnership to apply science and technology to national goals is urgently needed. A broadly chartered gathering of all key leaders would promote wide discussion and action on these issues.*

The summit meeting, to be attended by the President, cabinet officials, governors, and members of Congress, would identify common interests and concerns of state and federal governments, industry, and universities and develop a joint agenda. Prominent among these interests would be the sharing of access to science and technology resources, such as federal laboratories.

Mr. Chairman, thank you again for inviting me. I am open for questions.

SCIENCE, TECHNOLOGY, AND THE STATES IN AMERICA'S THIRD CENTURY

SEPTEMBER 1992

A Report of the

CARNEGIE COMMISSION
ON SCIENCE, TECHNOLOGY, AND GOVERNMENT

The Carnegie Commission on Science, Technology, and Government was created in April 1988 by Carnegie Corporation of New York. It is committed to helping government institutions respond to the unprecedented advances in science and technology that are transforming the world. The Commission analyzes and assesses the factors that shape the relationship between science, technology, and government and is seeking ways to make this relationship more effective.

The Commission sponsors studies, conducts seminars, and establishes task forces to focus on specific issues. Through its reports, the Commission works to see that ideas for better use of science and technology in government are presented in a timely and intelligible manner.

Additional copies of this report may be obtained from the Commission's headquarters.

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FOREWORD

State governments have long been users and generators of scientific and technological information. Since World War II, however, the states' involvement in science policy has been overshadowed by the rapid expansion of the federal role, first in defense and later in space and health research.

With the end of the Cold War, the economy, the environment, education, and health care will rise to the top of the American agenda. These are all areas in which states have traditionally played a major role. As the nation moves to address these issues, both the federal government and the states will have new roles to play, and their relationship will be redefined to meet the demands of a new era. In order to fulfill their responsibilities, the states must continue to increase their competence in science and technology. New kinds of partnerships, both between states and among states, the federal government, industry, and academia, will be necessary if the nation is to confront the problems and seize the opportunities that the future will bring.

This report examines the achievements of the states in managing science and technology and recommends ways in which they can join with industry and the federal government to address the domestic issues of the 1990s and beyond. The report focuses in depth in one area of policy that is well developed in many states: government–industry partnerships to support the development and diffusion of industrial technology. These programs may be models for cooperation between government and the private sector in other areas. They may also show the way for federal–state partnerships that best exploit the complementary strengths of the two levels of government.

To ensure the effectiveness of the new partnership with the federal government and industry, the report proposes the establishment of an interstate compact to help the states themselves decide what policies work best in a decentralized and variegated nation. This compact will enable states to work more easily with the federal government so that, together, they can help reshape the relationship between science, technology, and government in our rapidly changing world.

Science and technology are central to nearly every issue of government policy today, and governors and legislators need sources of impartial, expert, technical advice and analysis. The report recommends that states increase their own technological competence by availing themselves of the best possible S&T advice at the highest levels of government. In particular, governors should have easy access to S&T information. Governors need a designated science advisor who has access on a regular basis to the best scientists, engineers, and physicians in the state.

We wish to thank the members of the Task Force on Science and Technology and the States and particularly its chair, Governor Richard Celeste, for their outstanding work.

William T. Golden, Co-Chair
Joshua Lederberg, Co-Chair

PREFACE

This report of the Carnegie Commission on Science, Technology, and Government was prepared by the Task Force on Science and Technology and the States. The Commission was established in April 1988 to assess the mechanisms by which the federal government and the states incorporate scientific and technological knowledge into policymaking processes. The Commission formed the task force in 1991 to study a key level of this nation's government that, in earlier studies of the Commission, had been examined only tangentially.

The task force held its first meeting September 9–10, 1991, in Middleburg, Virginia. Subsequent meetings were held March 15–16, 1992, in Deerfield Beach, Florida, and May 14, 1992, in Washington, DC.

The task force was chaired by former governor and Advisory Council member Richard F. Celeste. The task force members were William O. Baker, Arden L. Bement, Erich Bloch, Lawton Chiles, Daniel J. Evans, B. R. Inman, H. Graham Jones, Frank E. Mosier, Walter H. Plosila, Donna Shalala, Luther Williams, Linda S. Wilson, and Charles E. Young. Christopher M. Coburn was the staff director for the task force. Commission staff members who worked with the task force and contributed to the development of the report were David Z. Robinson, Maxine L. Rockoff, Jonathan Bender, and David M. Kirsch. Thomas H. Moss also assisted the task force. The task force is grateful to Harvey Brooks for his interest and invaluable insight. The final report was drafted by Duncan M. Brown, and the manuscript was edited by Jeannette L. Aspden.

The report is endorsed by the task force and was approved by the Commission at its June 1992 meeting.

SUMMARY AND RECOMMENDATIONS: MEETING THE CHALLENGES OF AMERICA'S THIRD CENTURY

Since the Second World War, the federal government has taken the dominant role in applying science and technology to national needs. Over this period, the Cold War made national security the prime consideration, and it is the responsibility of the federal government to protect the nation against military threat. More recently, three broad trends have combined to offer new national challenges and to demand new ways of organizing the responses. These trends are the growing national importance of science and technology; the increasing strength of the states in managing these assets; and the end of the Cold War, with the consequent release of resources, especially human resources, once devoted to defense. The opportunity is to devise fresh new responses to many national challenges, among them the reform of education, the preservation of the environment, the promotion of economic competitiveness, and the provision of health care.

These issues are largely domestic, and major aspects of all of them traditionally fall within the purview of the states. In addition, the past 20

years have seen increasing devolution of many of these responsibilities from the federal to the state level.

Effective responses to these challenges will place a premium on flexibility, efficient distribution of resources, and organizational entrepreneurship in place of the centralized, coordinated response that was appropriate to the challenges of the Cold War. New partnerships of federal and state government, academic research, and private industry will be needed, and building these partnerships will require changes in our systems and institutions of government at both levels. Many of these changes are well under way. Some have yet to begin.

Many states, in their industrial technology programs, have demonstrated the ability to achieve the necessary flexibility and responsiveness, working closely with industry and academic institutions. While these efforts are still relatively small on a national scale, their structures provide models of government–industry partnership that can be extended to the federal government, and that can help shape responses to other great national challenges.

The central issue is how to determine the most effective roles of federal and state government. Their roles should be developed not on the basis of which level raises (and spends) revenues, but according to their relative effectiveness in a given situation, including their effectiveness in catalyzing private-sector action. Determining the appropriate balance in a particular case will require an unprecedented degree of communication and cooperation, with consultation about needs and priorities and timely sharing of information about programs of potential joint interest.

Ensuring effective communication and cooperation will require new advisory and policy development mechanisms. Whether they are helping shape national science and technology priorities or addressing closer-to-home problems of the environment, health care, education, energy, and economic development, states must have ways of gathering knowledge, of learning from one another, and of putting their ideas and priorities forward in national science and technology forums. New scientific and technological advisory organizations will be needed at three levels:

- Within states, today's formal and informal advisory bodies will become more significant, and their charters will have to be reshaped to include the development of broad policy positions, integrating knowledge from many fields and from all available sources, including especially the private sector. States will need well-defined mechanisms for mobilizing science and technology expertise to meet strategic goals.
- Interstate organizations will be needed to support information exchange, interstate cooperation, regional collaboration, and the develop-

ment of opportunities for cooperation with the federal government and with industry.

■ States will need to become more heavily involved in federal policy deliberations, both for setting broad priorities and for designing programs that share state and federal resources. This should include representation on federal advisory committees at all levels, from the highest national policy-making councils to the individual laboratory. States and the federal government will need to work toward a partnership that reflects their potential contributions and needs.

In creating this new partnership, the nation will draw on the vision of great predecessors: the Founders, who defined the initial balance of state and federal powers; the authors of the Morrill Act of 1862, who melded scientific and technological innovation with education in the state Land Grant institutions; and Vannevar Bush, whose seminal report forged a strong and durable link between government and science after the Second World War. Another opportunity for a new relationship between government and science and technology is at hand: the Cold War is ending; old assumptions about the world are being put aside, and new truths are emerging. In a changed and changing world, science and technology are increasingly central to effective democracy and economic prosperity. By grasping this opportunity for renewal, the nation can increase its industrial competitiveness and meet the challenges of education, health care, environmental protection, and other vital domestic co .is.

FINDINGS AND RECOMMENDATIONS

Shaping Policy within States

■ **Each governor should have a designated science and technology advisor** (see pages 24–27). *Governors are increasingly called upon to make decisions that have scientific and technological dimensions. However, they generally lack staff sources of science and technology advice and assessment.*

Each governor's science and technology advisor should act as a focal point for advice on the full range of scientific and technological issues that a governor faces, including health care, environmental quality, telecommunications, and science and technology for economic development. The science and technology advisor should serve on the governor's executive advisory team, as a trusted source of objective advice, integrating the views and knowledge of experts in academic institutions, industry, and elsewhere throughout the state and the nation. This official would have several important functions:

- Bringing knowledge of science and technology to bear at the highest level of decision making in the state
- Helping the governor respond quickly to emergencies by assembling the appropriate experts
- Serving as liaison with the science and technology community in industry, federal agencies, and universities

- **Each state should have an independent science and technology advisory body** (see pages 26–27). *No state has the benefit of a sufficiently well-organized process for developing broad, comprehensive positions on issues that involve science and technology, such as economic development, health, and environmental protection. Sound decision making about major public issues requires such a process.*

Such a group, with members representing all elements of the science and technology community in the state, should be charged with providing broad views on key policy challenges. With its help, the governor, legislature, and the public would be able to engage science and technology leaders from throughout the state in their efforts to respond to technological change and promote technological competence. The body would also provide continuity and institutional memory, bridging political cycles.

The group should be independent and representative and should have access to the science and technology community. In some states, an existing organization, such as a state academy of science, might serve this advisory function.

- **The proposed state advisory body should develop and periodically update a vision of science and technology's role in meeting the state's strategic goals** (see pages 26–27). *Partnership between government, industry and academia requires consensus about broad issues. Few states have a formal process for developing such views.*

A critical responsibility of the advisory group is to provide the framework within which the major components of the state S&T community can convene, discuss, and forge consensus. This consensus then forms the basis of direct and compelling communication to the executive and legislative branches of state government. The consensus supports S&T-related policy and programs and enhances the state's ability to work in partnership with industry, federal agencies, universities, and other states. The advisory body would also provide the forum for consideration of the very complicated issues of state S&T policy: performance evaluation, distribution of resources, and practical goals.

■ **Each state legislature should have access to a standing source of objective analysis of science and technology issues** (see page 27). *Legislators have even less access to sound science advice than governors.*

The legislative advisory body might be legislative staff or a standing panel in a university, a state academy of science, or another institution with broad scientific and technological capability. It should maintain links to national science and technology resources, such as the U.S. Congress's Office of Technology Assessment and the National Academy of Sciences. In some states, size or resource limitations might mean that the same advisory body could serve both executive and legislative branches; in other states, separate bodies may be practicable or desirable.

Shaping National Policy

■ **The states should form a new organization to coordinate their science and technology activities and to speak for the states in national science and technology councils** (see pages 27–28). *When necessary, states must be able to speak with a single voice to shape national policy. The current interstate organizations for developing science and technology positions are inadequate to the task of developing, analyzing, and expressing unified policy positions.*

The proposed group must have the standing and the analytical capacity to develop credible broad priorities and recommendations for the states as a body, and to be heeded by federal agencies. A formal interstate compact, underpinned by state and federal enabling legislation, would have these characteristics. The Education Commission of the States may be a suitable model.

The group would have several main functions. First, it would serve as the focus for continuing exchanges of views with senior federal decision makers in both the legislative and executive branches. In the current administration, for example, it would make regular contributions to the priority-setting proceedings of the White House's Federal Coordinating Council for Science, Engineering, and Technology (FCCSET).

Second, it would develop reliable sources of information to support policy development. Reliable statistics on state science and technology investments and their outcomes would help both in the setting of broad national or regional priorities and in the management of individual state programs. It should also have the ability to analyze state and federal policy options. Finally, the organization should serve as a point of access and information for federal officials, Congress, the news media, and the public.

■ **States should become partners in defining the new missions and operations of federal science and technology institutions** (see pages 47–50). *Many federal technology programs are undergoing radical change, as the nation adjusts to the reduced threat to its security. Some of these programs and institutions offer resources that could be applied to other important national needs. States can help give direction to the search for a new mission, through the networks of industry and universities that most have established in their technology programs.*

In seeking new industrial missions for federal programs in technology development and diffusion, care should be taken that these successor activities serve the economic interests of state and federal government as well as industry. The new interstate compact recommended earlier should be involved in these deliberations. In addition, steps should be taken to increase state representation on the advisory committees of the federal executive and legislative branches.

■ **Any national strategy for diffusing federal technology to the private sector should build on the foundations that states have already laid** (see pages 38–46). *States, using their knowledge of local conditions, have developed channels for diffusing technology to companies, especially the small and medium-sized ones that are most difficult to reach.*

Policymakers at all levels should recognize the value of states as natural interfaces between government and industry, and should take advantage of state programs of technology transfer and diffusion. A national partnership, encompassing industry and all levels of government, should be cultivated.

■ **Through the recommended new coordinating and policy development organization (the interstate compact), states should work with federal agencies to plan and hold a national summit on science and technology goals of common concern** (see page 46). *To make the most of defense conversion and other emerging opportunities, a new federal–state partnership to apply science and technology to national goals is urgently needed. A broadly chartered gathering of all key leaders would promote wide discussion and action on these issues.*

The summit meeting, to be attended by the President, cabinet officials, governors, and members of Congress, would identify common interests and concerns of state and federal governments, industry, and universities and develop a joint agenda. Prominent among these interests would be the sharing of access to science and technology resources, such as federal laboratories.

I
HISTORIC DECISIONS

History occasionally offers this nation an opportunity to renew its institutions. In the past, there have been two such turning points in the relationship of government with science and technology. The first, the enactment of the Morrill Act of 1862, created the land grant colleges, whose "leading object" was to teach subjects related to agriculture and "the mechanic arts," or technology. The second watershed was Vannevar Bush's historic 1945 report, *Science—The Endless Frontier*, which held that "Science is a proper concern of government."[1] That report opened a chapter in the federal government's relations with science that will never be closed. The National Institutes of Health, the Office of Naval Research, and the National Science Foundation were founded as a result of the proposals made in that report. Thanks to the undoubted success of those agencies, and others that followed, many Americans—and probably most scientists—today view the funding of basic research as a natural role of government, nearly as fundamental as any of the functions enumerated in the Constitution.

In 1945, however, such a role was revolutionary. Bush's position was opposed by many experts, and his proposals were debated heatedly by Congress for years. The proposals matched the revolutionary times: one war, in which applied science had played an heroic role, had ended. Hopes were high that science could be equally heroic in peacetime, revealing the workings of the universe, conquering disease, reducing poverty, and solving a wide array of social problems. A darker side of that revolutionary period was the world's gradual descent into what became known as the Cold War; here the hope was that science and its applications would hold world war at bay. In both cases, those hopes have been rewarded.

THE FEDERAL-STATE BALANCE, PAST AND FUTURE

The historic balance of federal and state government, devised by those who founded the Republic, will respond to these revolutionary changes. For two generations the balance in the realm of science and technology has been heavily weighted toward the federal government. This balance was appropriate to the task that dominated the national agenda, namely responding to the challenges of the Cold War. However, with the end of the Cold War, the demands of national security have lost their primacy. Today's challenges—better schools, more efficient and accessible health care, refurbished public infrastructure, a cleaner environment, and firms that are more competitive in world markets—require the striking of a new balance. All demand national responses, but these responses cannot be the nearly exclusive province of one level of government, or, indeed, of the public sector. They require partnerships between the public and private sectors and between federal and state governments. While the balance will vary depending on the issue at hand, it will generally involve the states more deeply and intensely than at any point in the past half century. These adjustments will require changes in our systems and institutions of government, both federal and state. Many of these changes are well under way. Some have yet to begin.

The balance of federal and state roles is a great issue. But the founders of our nation devised this balance with sufficient flexibility to offer scope for self-renewal. Working together, we can evolve a vision of the future to match our opportunities.

NEW ROLES FOR THE STATES

In the late 1940s, the debate revolved around the appropriateness of a new federal role in research. This time it involves new roles for the states, too,

in maintaining the national capability in science and technology and in pursuing industrial excellence, environmental quality, health care, education reform, and other domestic goals. The states are growing strong and sophisticated enough, many believe, to take a greater, more independent role in pursuing these peaceful but still fundamental national goals.

The states have developed these strengths through decades of confronting issues with science and technology implications. The Morrill Land Grant Act of 1862 produced a strong federal–state partnership that built great universities, universities that became a vital source of technology. In particular, the agricultural extension system carried the benefits of research to the end of every farm road in the nation. Over the years, problems of agriculture, resource management, and transportation, as well as higher education and graduate research, gave the states further experience in managing and exploiting science and technology.

Higher education has been a major channel for states' contributions to the nation's science and technology needs, through education, research, and public service. It continues to offer important opportunities for investment and for cooperation with the federal government. However, the task force saw a comprehensive review of this subject as beyond its scope.

The past two decades have added challenging issues of environmental planning, health care, energy, and a new model of technology-based economic development based on cooperation between industry and government. As a result of this experience, the states are well prepared today to take a more active role in meeting the nation's domestic needs. Their traditional domestic concerns have become the national concerns of the 1990s.

As a model for developing responses to these national concerns, the task force focused on one of them: the application of science and technology to economic competitiveness. Meeting this challenge will require a balanced national response with significant roles for the states and the federal government, as well as the private sector. The nation cannot rely on the heavily centralized structure used during the Cold War. That challenge, which demanded a single tightly coordinated response, was greatly different from today's.

States, in their industrial technology programs (see Chapter 2), have demonstrated decentralized structural approaches that can ensure the rapid responses, efficient distribution of resources, and organizational entrepreneurship that today's national challenges and those of the future will demand. While these programs are still small on a national scale, their decentralized structures and their close cooperation between government and industry give them a natural role in any national effort to improve industrial competitiveness. Experience gained by states in promoting their own industrial competitiveness can be extended to enhancing the nation's industrial competitiveness in a changing world.

States compete with one another for some kinds of resources (notably the siting of large employers). They are learning to cooperate as well in developing the economic and educational infrastructure through which regional and national growth can take place. While healthy competition will continue, in itself it cannot guarantee future economic success.

Industrial competitiveness is only one of the great challenges facing the nation. On such issues as transportation and health, several states have undertaken bold initiatives—for example, fundamental changes in access to health care and new mass transit programs designed to yield economic and environmental benefits. A balanced federal–state response to the challenge of industrial competitiveness will set an example that will help shape responses to other national challenges. The central issue is how to determine the optimal roles of federal and state government. These new roles should be based not on which level raises (and spends) revenues, but on which level is most effective at specific tasks, including catalyzing private sector action.

States and the Private Sector

The private sector has a significant stake in the resolution of many of the issues targeted by the federal–state partnership. This means that the private sector will be involved in the partnership in a new way. The key understanding on which the state programs have been built is that it is in the private sector that the program outcomes accrue—it is here that new jobs and new wealth will be created.

Access to industry is the state technology programs' greatest strength. These programs are joint activities of government, industry, and academia to promote technology development and technology transfer and to share experience of markets and economic conditions. Through these activities they provide channels to the market for the products of academic and public sector research programs.

For these reasons, the federal–state technology partnerships will involve the private sector in nearly every program decision, from the technology emphases of joint research centers to the nature of training and education programs.

Science and Technology Advice for the States

The states have recognized a growing need for scientific and technical advice as they are increasingly forced to address issues that would, a few years ago,

have presented almost unimaginable technological complexity. In addition to the problems of industrial competitiveness, these issues include environmental protection and health care, which have been shifted by federal action to the states. Many complex policy problems lie at the intersections of these issue areas.

Some states have arranged for high-quality advice, but often only as an afterthought or in response to emergencies. In other states, decision makers have no single reliable source of such information and must depend on informal sources. Good sources of advice enable decision makers to interpret scientific and technical information from agencies and advocacy groups, to balance conflicting claims, and to weigh alternatives objectively. Without such advice, governors and legislators must interpret scientific and technical information using criteria such as familiarity or trust in the agency or group advocating the position, the packaging of the information, or its perceived relationship to other technical issues. It is critical that states develop their own systems, especially at the gubernatorial and legislative levels, to ensure the flow of advice from the broad science and technology community into the state government at its highest decision-making levels.

A NEW FEDERAL ROLE

The framers of the Constitution of the United States defined the new nation in the balance between the 13 states and the new federal republic. During the Cold War, that balance was heavily weighted toward the federal government. Recent developments on both the international and domestic scenes, however, require a balance closer to the original. That balance will no doubt shift again as states and the federal government join in various ways to respond to the challenges of the 1990s and the next century.

A new federal–state partnership will require the federal government to play a new role, very different from the one it has been forced to play for the past 50 years. In the case of economic competitiveness, new federal leadership roles have begun to take shape. The White House's Federal Coordinating Council for Science, Engineering, and Technology (FCCSET) has suggested a policy of federal funding for applied research in areas such as high-performance computing, biotechnology, and advanced materials and processing.[2] The National Science Foundation (NSF) and the U.S. Department of Commerce have established programs of research in "precompetitive" or "generic" technologies.[3]

These initiatives may be viewed as the first expressions of a new direction for federal policy, which could serve as the basis for the transfor-

mation of the federal–state partnership. The nation must go much further if it is to achieve its domestic goals, from reinvigorating the economy to improving access to health care. A firm partnership must be based on shared interests, shared information, and clearer ideas of the respective roles of state and federal government.

Federal research and development programs command resources of technology, personnel, and facilities that should be valuable assets for the nation. Indeed, for many years federal agencies have sponsored an extraordinarily large proportion of the nation's research and development, including industrial R&D, but success in bringing the results of government-sponsored R&D to the marketplace has been spotty. States can help increase the return on this huge investment, especially through their partnership programs with the private sector.

The defense conversion process now beginning represents a fundamental transition for the United States, industrially, technologically, and culturally. While federal and state governments must join with industry to effect this transition, the federal government will clearly be the leading government partner, because it established and funded the multitrillion-dollar defense effort. But to conduct defense conversion as an exclusively federal program, to treat it like national defense programs themselves, would be a fundamental error. Converting the defense base into a civilian industrial tool requires engaging industry in new and innovative ways throughout the United States. The private sector cannot be effectively galvanized from a single point in Washington, DC. Its involvement must reflect the diversity of the U.S. industrial base and the rapid change it is now experiencing. States bring indispensable assets to the partnership, in the form of industrial contacts and local knowledge.

S&T AND THE STATES: GROWING CAPABILITIES, GROWING NEEDS

The evolving federal–state partnership must have the flexibility and responsiveness to recognize and pursue new opportunities. Both parties must commit themselves to sharing in the benefits of the partnership's initiatives. States have already created varied programs to further this role. Many, for example, have well-established programs in precisely the technology-related areas only now being identified as national priorities, such as biotechnology, advanced materials, computers, and communications. This capability complements the technological competence that states have been forced to develop as they assume program responsibilities from the federal government in areas

such as the environment, energy, and health care.[4] Many of these new state responsibilities have strong science and technology implications.

States have been building the capacity for this partnership for many years, beginning nearly a century before Vannevar Bush's 1945 call to national renewal through science, with the 1862 Morrill Act. That act created a historic federal–state partnership that helped states establish their Land Grant institutions and defined their vital interests in research and technology. Since then, states have built, staffed, and equipped universities. They have funded research in agriculture, resource conservation, education, transportation, and other areas of state responsibility (some states have even funded basic research). They have supported higher education in the sciences and engineering, to improve their business environments and research capabilities. Since the 1970s, they have assumed new obligations for science- and technology-intensive missions such as environmental enforcement, health care financing, and education reform—often as a consequence of new federal requirements.

In the early 1980s, several industrial states, suffering a deep and intractable manufacturing recession, formed new partnerships with industry and academic researchers, aimed at building economic strength through the development and deployment of technology. These grassroots programs were so successful that they have been widely replicated throughout the nation. States share research costs with industry, award grants to technology-oriented firms, and offer technical advice and business services to industry. States rely on industry to make technological investment decisions. Most of the programs are funded under economic development programs, but some, such as Texas's $30-million-a-year Applied Technology and Research Fund, are supported through higher education systems.[5] They depend heavily on universities for research, and this dependence has led to the strengthening of academic research in fields relevant to industry. The great public universities—legacies of the Morrill Act—have been a mainstay of these programs.

As a rule, the programs give industry the deciding vote in investments: initiatives are supported only if industry signals its commitment by providing significant cost-sharing. In this way, states avoid putting themselves in the position of trying to "pick winners." Success depends on maintaining close ties with industry, to help reveal both broad economic opportunities and specific company needs. With their new technology programs, National Academy of Sciences president Frank Press has said, the states "recognized the missing link that weakens our innovative strength," displaying "a greater awareness of the way the world is going than you find in many places in Washington."[6,7] In the aggregate, writes another observer, the state programs are "probably as close to an industrial policy as we will see in the U.S."[8]

Science and technology in state government goes far beyond industrial competitiveness. It is a nearly pervasive element in the daily decisions of state policymakers and program managers. In many policy areas, such as radioactive waste management, utility regulation, and health care strategies, the scientific and technical aspects are recognized in decision making. In other fields, such as the empirical analysis and behavioral research underpinning social policy, they are not so clearly recognized. Only a few states have set out deliberately to create systems of technical and scientific advice to support decision making. Even in those states, the advisory systems are specialized, generally with a focus on industrial technology activities, with little scope to integrate and interpret information across wider ranges of issues. Arrangements for advice should become more formal and better integrated, as the advantages of technology advisory bodies are more widely recognized. (See Chapter 2 for a detailed discussion of this central issue.)

REDEFINING AMERICAN FEDERALISM

From this process of renewal and redefinition will emerge a new partnership between the federal government and the states. States will play increasingly important roles in the national science and technology system. As they interact more and more with that national system, they will need to work both individually and collectively to develop and influence national policy. The states themselves, with their industrial and academic partners, must take the initiative in this effort to redefine American federalism, for only through a true partnership of federal and state governments, with the full involvement and support of the private sector, will this effort succeed.[9]

2

STRENGTHENING THE STATES' CAPACITY TO USE SCIENCE AND TECHNOLOGY

To be effective in their new partnership roles, states will need new advisory and policy development mechanisms. Whether they are helping to shape the national debate or addressing closer-to-home problems of the environment, health care, education, energy, and economic development, states must have ways of gathering knowledge, of learning from one another, and of putting their ideas and priorities forward in federal science and technology deliberations. New scientific and technological advisory organizations will be needed at three levels:

- Within states, today's formal and informal advisory bodies will become more important, and their charters will be reshaped to give states well-defined mechanisms for mobilizing science and technology expertise from government, industry, and academic institutions to meet strategic goals.
- Interstate organizations will be needed to support information exchange, interstate cooperation, regional collaboration, and the development of opportunities for federal–state cooperation.

- States will become more heavily involved in federal policy deliberations, both in setting broad priorities and in designing programs that share state and federal resources. The states will need to be represented on federal advisory committees at all levels, from the highest national policy-making councils to the individual laboratory. They will need to work toward a balance of influence that reflects their potential contributions.

One challenge of the emerging partnership will be for state programs to retain their valued flexibility and creativity—and their ties to industry—while at the same time maintaining stable relations with other agencies at both federal and state levels. To achieve this balance, states will need leadership and vision. The states' federal partners will need to make due allowance for states' diversity and innovativeness, seeking joint objectives rather than imposing rigid requirements. On the most fundamental issues of federal–state relations in science and technology, states need to work toward consensus, even while fostering diverse points of view in many areas of policy. In this way, states can bring their full political strength to national policy deliberations.

SCIENCE AND TECHNOLOGY ADVICE FOR GOVERNORS AND LEGISLATURES

In the past decade, governors have increasingly required reliable science and technology advice, on topics ranging from solid waste disposal to materials science and manufacturing. Science and technology are now part of everyday decision making in each state. The 1980s saw a shift to the states of responsibilities previously considered federal, including many aspects of environmental management and health care. These reallocations of responsibilities coincided with the increasing complexity of traditional state issues and the burgeoning movement to promote technology-based economic development. As these responsibilities have mounted, the old informal state-level channels of communication with the science and technology community (university and business leaders, cabinet officers, and so on) have become more organized and, in many states, have focused on strategic questions, and new sources of advice are being developed.

Advice for Governors

Governors, in particular, often face competing claims, whose resolution requires science and technology advice that is reasonably independent of the

narrow interests of a given industry or of a set of state and federal agencies. Every governor needs a trusted advisor in his or her inner political circle who can help synthesize the scientific and technical aspects of policy issues into concrete options. Several kinds of conflict that may involve science and technology issues arise in every governor's work:

- Conflicts between agencies. The state department of transportation, planning a highway, assures the governor that wetland protection measures are adequate. The natural resources department disagrees. Both cite scientific and technical analysis in support of their positions. What is the best decision?
- Citizens' safety and health concerns. A citizens' group petitions the governor on the safety of a nuclear reactor. The owner claims adherence to federal standards to show that the reactor is safe. Are federal standards actually being met? If federal standards are being met, are they adequate?
- Conflicts with other states. One member of a regional low-level radioactive waste compact agrees to provide the region's waste site. The site, near the border of another member state, raises citizen concerns in that second state. The first state argues that geological and other analysis was sufficient. The second state's governor must decide how valid the safety concerns are and what options are available under prevailing environmental standards and existing contracts.
- Conflicts with federal agencies. State investigators find violations of environmental law at a federal research or defense production facility. What are the risks associated with those violations? What legal options are available?

In most states, the first formal state advisory bodies were established in the 1960s, with funds from the U.S. Department of Commerce's State Technical Services (STS) program. (New York formed its own advisory unit in 1963.[10]) Many states used STS funds to create science and technology commissions and advisory offices, to help policymakers address issues such as pollution, solid waste disposal, and energy. The program was canceled in 1969.[11]

In another initiative to help states address the growing number of problems that involved science and technology, Congress in 1977 authorized the National Science Foundation to establish the State Science, Engineering and Technology (SSET) program. SSET was intended to support state legislatures and governors in their efforts to develop and implement S&T plans. In all, 49 governors and 42 legislatures applied for and received SSET planning grants. The planning stage ended in 1979, but federal funds for implementation grants never materialized. Of the state organizations charged with overseeing the planning, only two, the New York State Science and

Technology Foundation and the North Carolina Board of Science and Technology, still exist today.

The new wave of advisory organizations now being established, however, is not the result of federal perceptions of state needs; rather, the states themselves have taken the lead. Each state has arranged for science and technology advice in its own way. In the areas of health and the environment, governors generally rely on directors of the responsible departments for advice. Sources of advice on technology for economic development are far more varied; a recent National Governors' Association (NGA) study places them in four categories[12]:

- Science advisor. A few states have formally designated science advisors, who generally report directly to the governor and are expected to mediate between the governor, the legislature, the science and technology community, and often the public and news media. State science advisors often serve also as directors of technology development agencies.
- Program director. Many states have housed their technology programs in economic development or commerce departments. In that case, the governor usually relies on the cabinet official responsible for that organization for science and technology advice.
- Independent organization. Many states have created independent organizations to plan and carry out their technology strategies. These bodies have boards made up of senior representatives from industry, academic institutions, and government, and are largely state-funded. The states maintain a degree of control, usually by appointing specified members to the boards.
- Informal network. Almost all governors rely on networks of varied contacts throughout their states for advice, whether or not they have a formal advisory apparatus. In a few states such informal channels are the sole source of advice, sometimes supplemented by special committees established to consider specific issues.

The precise form of the advisory organization aside, few governors have a single source of advice that can interpret and focus information from across the range of relevant scientific and technical fields. This lack of a single point of contact with the science and technology community raises concerns about the management of individual programs and about the cooperation among different state programs. For example, few governors are equipped to consider health care reforms in light of their impact on state economic development strategies. Rarely do environmental and health policy leaders work together to address problems of joint concern.

To the extent that a state intends to formulate long-term policy,

to work with other states, or to interact with federal agencies, it will need increasingly formal and comprehensive advisory resources. Each governor should be able to call on a single reliable and well-defined mechanism that can transmit the knowledge and views of the broad science and technology community, in academic institutions, industry, and government.

Advice for Legislatures

Legislatures need advice, too. At the federal level, Congress established the Office of Technology Assessment in 1972 as a source of technical advice independent of the Executive Branch. State legislators have small staffs and generally serve part-time. As states assume a greater role in national science and technology policy deliberations, legislatures will increasingly be called upon to make important decisions in this realm, and they are likely to need legislative science advice offices. Several of the larger states have already established such organizations. The not-insubstantial costs of setting up and maintaining an office or an advisory body might be borne better by sharing these services with other states, either regionally or through a national network.

The very nature of legislative bodies imposes different requirements on the provision of scientific advice. In the executive branch, there is ultimately a single decision maker, but in legislatures there are many, and they are divided by party affiliation, regional interests, committee assignment, and personal idiosyncrasy. Given these factors, and others, ensuring that state legislators have access to adequate scientific and technical information and advice is a complex and challenging task. Some states may find a joint executive–legislative advisory mechanism practical; in others, the two functions can be separate.

INTERSTATE CHANNELS OF COMMUNICATION

States began to establish interstate channels of communication on technology matters in the early 1980s, as the success of North Carolina's pioneering program became obvious. They have maintained and strengthened these channels since, generally using the National Governors' Association as the forum for discussions.

In 1981, the NGA Task Force on Innovation was established under the leadership of Edmund G. (Jerry) Brown of California and William Milliken of Michigan. The first attempt at a network of governors' offices, it produced

a seminal report that reviewed state activities aimed at encouraging technological innovation.[13] The task force was later chaired by Governors James Hunt of North Carolina and Richard Thornburgh of Pennsylvania. In 1985, it was succeeded by the NGA Working Group on State Initiatives in Applied Research, initiated and chaired through 1990 by Governor Richard Celeste of Ohio. This group continues in operation as the Science and Technology Council of the States, chaired by Governor Mario Cuomo of New York. As of 1992, every state is represented on the Council.[14,15]

The NGA remains vital for exchanges of information and development of alternatives in the area of science and technology. Through the Science and Technology Council of the States, governors have helped each other refine their approaches to technology-based development and have begun to make their voices heard nationally on these issues.

Yet the national effectiveness of this organization is limited by its reliance on consensus and its part-time nature. A dedicated institution that can set priorities and follow them through over a period of years is needed; such an institution would also provide analytical support to state decision makers. The goal is to create a national science and technology focal point for states as they confront new challenges. Only in this way will states be able to act as true partners in promoting national economic competitiveness. That goal argues for an effective and professional independent organization that can serve as a locus for discussions, collect and disseminate information, provide interpretation and analysis, and maintain a strong corporate memory. Such an organization should bring together all the important parties to state programs, including representatives of industry, legislatures, universities, and nonprofit research organizations. An interstate compact, with a statutory basis in both state and federal law, may offer the appropriate combination of persistence, independence, and inclusiveness. Such an organization should also lend itself to interacting with federal agencies, programs, and policymakers, by providing a single source of information and access to state technology leaders.

HARMONIZING FEDERAL AND STATE ACTIVITIES

Federal–state cooperation requires the two levels of government to share information about goals, while leaving room for states' diversity and innovation. It will require a growing volume of two-way communication. States will have to communicate their needs and priorities directly to federal agencies in many fields of science and technology, with regard to many different federal and state programs. Federal programs will need to consult states about programs of potential joint interest. For this process to be successful, states

Box 1. Early Attempts at Cooperation

Before the 1980s, moves to harmonize federal and state science and technology activities were few and ineffective. Federal programs were expanding, as federal agencies assumed wider roles in the economy. States had little to tell federal agencies, and the agencies had little incentive to listen.

The short-lived Intergovernmental Science, Engineering, and Technology Advisory Panel (ISETAP), established by federal law in 1976, was charged with identifying technical problems important to states and localities, and directing federal aid to their solution. Frank Press, President Carter's Science and Technology Advisor, commented in 1977:

> If science and technology are to benefit our people more effectively, a better R&D partnership must be established between the Federal Government and the States, counties, and cities. Properly designed and directed toward State and local needs, federally supported R&D could help to protect regional and local environments, reduce demands on energy and various natural resources, and improve delivery of State and local services. . . .
>
> Governors, mayors, state legislators, and country and local officials have far better ideas of the problems and the needs of their communities than do Washington officials. They should have more of an input into the decision making that results in Federal R&D budgets in the civilian sector.

The panel, with an impressive roster of federal, state, and local officials, was co-chaired by the President's Science Advisor and a governor. It was abolished in 1981, with the change in administration, before it could become a force for cooperation.

will require an organization that can promote at the federal level the priorities and policies developed by the states in their interstate science and technology deliberations.

In an attempt to meet this need, the Intergovernmental Science, Engineering, and Technology Advisory Panel (ISETAP) was established in 1976 (see Box 1). ISETAP was intended to involve state and local governments more deeply in federal science and technology strategies and programs. It reported to the White House and was co-chaired by the President's Science Advisor. The organization devoted its first few years to workshops and other activities aimed at identifying high-priority problems. It was abolished in early 1981, before it could embark on the next stage: addressing those problems.[16]

Several general criteria should be considered in creating the new national partnership and establishing state–federal program cooperation:

- The program's position on the research and development spectrum. Research near the "basic" end of the spectrum is likely to be the re-

sponsibility of the federal government, and work at the more "applied" end, that of the states and industry. There is considerable overlap, however.

- The program's national or local scope. Benefits of national scope may deserve federal support. More localized benefits are likely to be of interest to states.
- The potential benefits of the program to the state and federal partners. Once a decision has been made to cooperate, the extent of involvement in a program should reflect the benefits that each partner expects to realize from it.[17]

For these criteria to be met in practice, states and federal agencies will need to discuss their relations frankly and freely. The appropriate forum for these discussions remains to be created. The National Governors' Association—through the Science and Technology Council of the States—is today the most prominent forum for governors wishing to affect national science and technology policy. While vitally important, the group is effectively a committee, and its organization is too informal to allow it to exert consistent influence on policy.

Another valuable but limited channel of communication is the National Research Council's Government–University–Industry Research Roundtable (GUIRR), composed of senior federal research officials and representatives of industry and universities. In 1988 GUIRR established a subcommittee on federal–state dialogue, which has tried to promote increased federal–state understanding in science and technology initiatives.[18] The group, however, is barred by its charter from actively advising government.

Shared Goals, Shared Investments: Federal–State Cooperation in Education

One promising example of state–federal cooperation in pursuit of comprehensive change in a field with science and technology implications is the National Science Foundation's Statewide Systemic Initiative (SSI) program of education grants (see Box 2). SSI awards federal funds to states over periods of several years, in return for the states' agreement to pursue education goals that they set themselves (so long as the goals meet certain minimum standards). SSI is significant for three reasons: it recognizes the diversity of the states, it entails a long-term joint commitment of federal and state agencies in pursuit of shared goals, and it allows substantial flexibility in the design of each specific state–federal relationship. These features suggest the hallmarks of successful federal–state relationships in other areas involving science and technology.

Box 2. NSF's Statewide Systemic Initiative: Honoring the Diversity of the States

The National Science Foundation's Statewide Systemic Initiative (SSI) is a program of competitive grants to states, intended to give all students a better chance to acquire the skills and mental habits of mathematics and science. Described by NSF as an experiment in intergovernmental cooperation, SSI brings federal and state government together in pursuit of joint goals. It capitalizes on states' diversity by building on existing state programs and meeting state-defined needs.

Each participating state develops its own "coordinated action plan" for improving elementary and secondary math and science education. Before NSF will review the plan, it must be endorsed by the governor as well as the chief state school officer and the commissioner for higher education.

NSF offers states great latitude in selecting their own approaches. A state may designate a university, a private organization, or a state agency to apply on its behalf. The action plans are tailored to the specific resources and needs of the states.

NSF grants (of up to $2 million a year) are awarded for periods of five years. The first year's awards, in 1991, were made to 10 states (Connecticut, Delaware, Florida, Louisiana, Montana, Nebraska, North Carolina, Ohio, Rhode Island, and South Dakota). A second round of grants was announced in the spring of 1992.

NSF hopes that these relatively small grants will encourage the participating states to focus more clearly on math and science education and make fundamental improvements in teaching.

In addition to the five-year grants, the SSI program will offer technical assistance to all states interested in improving their science and mathematics education.

Nevertheless, SSI is at its core a federal program. States are free to compete for grants or not, but the program's educational standards are imposed by NSF, and states had no influence on the fundamental program design. It should be considered, not as a model for future cooperative activity, but as a step in the right direction.

Need for Information

A productive partnership will depend on a full understanding by each party of the other's activities. Federal agencies have sometimes failed to consult states about projected activities, as noted earlier. The lack of information on state science and technology initiatives is also an obstacle to harmonizing state and federal policies. Federal and state policymakers and program managers, for example, do not have accurate, current data on the goals or out-

comes of the state industrial technology programs (these programs are discussed in Chapter 3). They may find it hard to identify whom to contact, or even where to obtain basic information. Under these conditions, cooperation is obviously difficult.

Good information is scarce largely because the state programs are so diverse and adaptable. The programs pride themselves, after all, on their flexibility and entrepreneurial nimbleness. They were founded, and are supported, with varied goals, and their design varies accordingly. The powers and degrees of centralization of the agencies that operate the programs also vary. While flexibility and variety are generally considered signs of vitality, they can also be barriers to mutual understanding. An illustration of this effect is the fact that neither states nor analysts of the programs have arrived at consistent definitions of such basic terms as "research," "technology transfer," and "seed capital," which are often used to designate state programs intended to improve industrial technology.[19,20] (This problem of taxonomy is also seen in federal technology programs, where it raises similar problems in program evaluation.)

Some observers believe that most of the available studies of state programs overemphasize aggregate state-level data. These studies attempt to total the sums states spend on various categories of activities, such as research centers or technical extension services, without investigating the different activities associated with such spending. For true cooperation, state and federal policymakers need much more precise information on the activities and outcomes of state programs. NSF researcher Lawrence Burton has called for detailed, state-by-state data on "technology resources and relationships," rather than simple spending totals.[21] To mount the kind of comprehensive study that would produce such data, however, would require leadership, and sufficient funds.

Staying Power

Each participant needs to assess the other's capability to maintain a long-term commitment. For instance, many federal programs have been characterized by short-term considerations; more recently, however, emphasis has been placed on longer-term commitment. Federal policymakers also must make judgments about the state programs' political stability (and thus their reliability as partners). Among the difficult questions that need answering is whether political support in a given state is solid enough to warrant long-term commitments by the federal government or private industry. State officials, it should be emphasized, need similar assurances from the federal side. In both cases, these commitments are subject to political cycles.

The stability that a strong state commitment can bring to a federal program is illustrated by the experience of the NSF Science and Technology Center in Advanced Liquid Crystalline Optical Materials (ALCOM), established at Kent State University in Ohio in 1990 under an agreement calling for cost-sharing by the state. Adjustments in the NSF budget reduced the federal share for the first year and the shortfall called into question the center's viability. The state of Ohio, however, came forward with its full share, so that the ALCOM center could begin operating immediately at nearly full capacity.[42]

Similarly, a steady federal commitment can stabilize state programs. The Statewide Systemic Initiative education reform program of NSF, with its five-year funding cycle, is a promising attempt at promoting sustained state efforts in the field of education.[43]

NEW FUNDING ARRANGEMENTS

Better federal–state cooperation in health, environment, economic competitiveness, education, and other science- and technology-intensive areas demands better-organized funding. The expected reordering of priorities and reallocation of responsibilities will probably not require additional appropriations; rather, efficient reallocation of current resources and optimal distribution of roles are called for. In order to achieve this level of efficiency, state and federal governments must plan and budget for national needs together, seeking opportunities for joint investments.

The most pressing need, perhaps, is for secure streams of revenue to fund state–federal partnerships. Some programs to convert federal defense-oriented laboratories to civilian purposes could be largely self-funding. For example, state centers or extension programs might assume the technology transfer functions now performed by federal laboratory personnel, so that no net increase in federal spending would be required.

In other cases, where additional funds are needed, it may be desirable to engage the public directly in providing long-term support for some state science and technology programs, for instance through bond referendums. State governments often use such mechanisms to finance capital expenditures. Some states, such as New Jersey, have gone further, with special bond issues dedicated to science and technology investments. The advantage to the state, in addition to stable long-term funding, is a clear signal of taxpayer support.

New principles are also needed to govern federal–state cost-sharing in joint projects. Cost-sharing requirements at present are unilaterally de-

termined by federal program directors, to meet short-term program budgeting needs. This practice can be wasteful, and it does not promote real cooperation. A cost-sharing system that deploys resources optimally and divides tasks according to established federal and state roles would be better than one that auctions off federal programs to the highest-bidding states. The current system's short-term advantages to federal agencies are so great, however, that change will not come without a high-level policy decision, perhaps arrived through a formal state–federal agreement, or perhaps in Congress.

GROWING NEED FOR PROGRAM EVALUATION

The development of new forms of partnership, new institutions, and new funding sources requires new accountability. This need will grow as investments increase and as costs are more frequently shared with other levels of government and with industry. States and federal agencies will need better management information about the goals and progress of their programs, both individually and in the aggregate. Industrial and academic participants will also require information.

To satisfy these demands, the art of program evaluation must improve and evaluation will need to be carried out more widely and more consistently (see Box 3). All parties will need to collect more precise data on their investments and the outcomes of those investments. To ensure that such data are meaningful, a more accurate and consistent classification of activities will be needed.

Meeting these requirements will be challenging, and sophisticated and expensive research programs will be called for. Even if such research is successfully completed, program participants have little or no incentive to perform the necessary data gathering, which they may see as a time-consuming and expensive distraction with little impact on operations, unless evaluation methods so improve that they have perceptible benefits to individual organizations.

Until then, less sophisticated measures can be useful. Most of the state programs have made progress in their evaluation methods. In the 1980s, for example, legislators often demanded that the new state industrial technology programs demonstrate quantitative "results," sometimes in the form of estimates of numbers of new jobs or companies created, in the relatively short term. Such criteria have long been applied to traditional economic development programs. Technology-based economic development, however, cannot be measured in such terms in the short run. It is a process that may

Box 3. The Art of Program Evaluation

Program evaluation has been a challenge for state technology initiatives and the many new similar federal initiatives. Some early programs tried to justify themselves by claims of jobs or businesses created. It soon became apparent, however, that, as in any research program, benefits are difficult to measure, especially in the short term. The full cycle of innovation takes place over periods of years or decades.

Accordingly, more informative evaluation measures have been developed. Evaluations have used such measures as "leverage" of industry and federal dollars and enhanced high-tech industrial development, as well as "process" measures such as numbers of firms involved or numbers of grants made. States have used diverse means of program evaluation, ranging from straightforward self-evaluation to sophisticated reviews by outside experts.

According to David Mowery of the University of California, program evaluation has several general limitations. First, it is virtually impossible to measure a program's impacts on economic development, because many other factors (such as macroeconomic changes, tax policies, and investments in education) are also at work during the program's course. Second, one cannot construct a "counterfactual case," to test what would have happened without the program. Finally, some states place too much weight on the attraction of high-technology facilities as measures of success, when these facilities may or may not be contributing to state economic development.

Evaluations are growing more sophisticated. Today, they are likely to be carried out on a regular cycle, to include measurements of progress in terms of explicit goals, and in general to use longitudinal data. Outside experts are more frequently called on, to avoid conflicts of interest and ensure meaningful results.

One of the most ambitious evaluations has been that of Ohio's Thomas Edison Program, which arranged for a review of its technology centers by a committee of the National Research Council. The review committee pointed out that the program's diversity makes it impossible to use a uniform set of evaluation procedures even within the state. Additional difficulties include the long time horizons of the state investments and the impossibility of controlled experiments to test contrary cases. "The only realistic evaluations are qualitative," the NRC said in its report, and the Edison centers must be judged by "evidence of networking, a broad base of industrial and academic support, the willingness of larger companies to invest money and of smaller companies to invest time, and clearly defined missions and programs aimed at regional economic development."

show lasting results only over periods of a decade or more, and whose progress must be measured by more subtle and sophisticated means.[24,25]

Evaluation requires measures based on both near-term and ultimate goals. A few initial payoffs from state research and development investments may appear in the first 5 years, but only after 5 to 10 years can the first meaningful returns from those investments be discerned, and then only in the

case of the most successful investments. After 10 to 15 years, sponsors can expect to have measurable results in the form of clear economic impacts. In programs emphasizing immediate diffusion of technology, such as industrial extension programs, results may be observable much more quickly.

To date, most state technology programs and similar federal initiatives have been assessed according to measures of "process variables," such as rates of participation by industry. Industry's willingness to continue paying membership fees in state-sponsored technology programs may be a better market test of effectiveness than any artificially constructed assessment measure.

One academic observer, Irwin Feller of Pennsylvania State University, writes that the state programs "would appear to offer a 'natural' testbed for comparative analysis, for they offer a distinctive array of the organizational forms, mechanisms of support, technologies, and industrial sectors needed to transform emerging theoretical perspectives into effective and efficient operational programs." [16] From the standpoint of technology policy, he adds, the programs should be seen as "a set of working hypotheses," whose outcomes should be carefully evaluated. Feller argues elsewhere that, "although state advanced technology programs . . . are cast as 'experiments,' most current or prospective evaluation activities lack even a modicum of experimental design."[17] Most federal technology programs share the same defect, he adds. The remedy is to include evaluation in the program design, so that performance data will be adequately collected and analyzed.

AMERICA'S THIRD CENTURY: PARTNERSHIP AND RENEWAL

The genius of the American federal system, displayed again and again in its first two centuries, is a capacity for self-renewal. The institutions of our government have survived war, panic, and depression. They have been elastic enough to encompass the enormous territories added as the frontier pushed West. They have welcomed wave after wave of immigrants, and offered all of them access to power. Today is no different. The system is responding to the revolutionary times not by retrenching, but by offers of partnership to meet human needs.

The federal–state technology partnership is not new. It dates at least from the Lincoln administration, when the Morrill Act granted federally held resources to the states on a grand scale, for each to deploy in its own way to achieve agricultural abundance and the general advance of technology. The Land Grant institutions that resulted were major sources of new technology for much of America for many decades. The federal assumption of responsibility for basic and defense research after the Second World War

was another fruitful phase of that partnership, which helped carry society forward.

Today we are offered the opportunity to renew the partnership, entering into a new compact that will lead to a more dynamic economy and better lives for the nation's citizens. The states have shown the way, by forming their own partnerships, engaging citizens and companies and academics in support of technology development and diffusion. With their growing technical skills and their creativity, the states are testing diverse responses to the nation's domestic challenges. They have strong and direct incentives to find effective, low-cost solutions to an array of human needs: health care, education, environment, energy, and economic competitiveness.

To achieve these goals, the nation will need better ways to manage science and technology at all levels. It will be necessary for state leaders to keep developing their methods for assessing technology-dependent issues and their institutions for coordinating and evaluating programs. The states will also need new means of working with other states, regionally and nationally. Federal and state governments must form cooperative relationships with each other and with industry, bringing to bear the complementary strengths of each party.

The 1990s can mark the opening of a new chapter of renewal in the history of America. States can devise new mechanisms for taking advantage of technological change and for collaborating with other states. They can also create and nurture a new partnership with the federal government that will guarantee to all Americans the benefits of science and technology.

3
A NEW MODEL: STATE INDUSTRIAL TECHNOLOGY PROGRAMS

The best-developed examples of public–private partnership in the nation are the varied state programs that have been established to promote the development and application of industrial technology. These programs involve the states with industry and academic researchers in long-term programs with shared goals and shared decision making. Such cooperation will provide an important model for structuring national responses in other science- and technology-intensive areas, such as health care, environmental protection, and education. In these areas, and others, the complementary strengths of the two levels of government, joined in productive partnership, will enable the nation to address the pressing issues that confront it now and in the future.

ROOTS OF THE STATE TECHNOLOGY PROGRAMS

The state technology programs have their roots in a desire to reproduce the concentration of high-technology development in Silicon Valley and Boston's

Route 128 (though in neither case was this development the result of conscious government policy). Led by its innovative governor, Luther Hodges, North Carolina pioneered the state role in technology-based economic development, beginning in the 1960s; Governors Terry Sanford and James Hunt continued this emphasis through the 1970s. Their investments in education and in the Research Triangle Park complex, encompassing the state's major universities, were aimed at raising living standards in what was then one of the poorest states in the Union. The initiatives were striking successes. By 1985 North Carolina had attracted billions of dollars in new investment, created hundreds of thousands of new jobs, and brought its unemployment rate to two percentage points below the national average.[18]

Meanwhile, other states had followed North Carolina's lead, driven by the widespread industrial recession of the early 1980s and a continuing withdrawal of the federal government from the civilian economy. Pennsylvania Governor Richard Thornburgh founded the Ben Franklin Partnership. Ohio Governor Richard Celeste proposed a public–private system of R&D grants and research centers, later christened Ohio's Thomas Edison Program. Other economically depressed states followed suit, with their own industrial R&D and technology diffusion programs. By 1988, 45 states reported more than 250 technology-based development initiatives, with annual expenditures of $550 million.[19]

Private–public partnerships are pervasive in state government. The state technology programs in particular are distinctive for their partnerships of industry and academic research. These programs tend to give industry a prominent role in decision making, through industry advisory boards, cost-sharing, and other devices, so that programs live or die with industrial participation.

HELPFUL FEDERAL INITIATIVES

The federal executive branch opposed direct federal aid to industrial R&D in the 1980s. Nevertheless, when the new state technology programs were taking shape and providing hundreds of millions of dollars of aid to support industrial R&D, several federal initiatives were helpful. Among the more important are the following:

- The University and Small Business Patent Procedure Act of 1980 (PL 96-517) granted universities greater control over licensing of patents resulting from federally funded research on their campuses.

- The Stevenson–Wydler Technology Innovation Act (PL 96-480), enacted in 1980, required all federal laboratories to mount industry-oriented technology transfer activities, and established a central source of information on federal laboratories' technology.[30]
- The Small Business Innovation Development Act of 1982 (PL 97-219) established the Small Business Innovation Research (SBIR) program, which sets aside a small proportion of federal research funds for small business.[31]
- The Federal Technology Transfer Act of 1986 (PL 99-502) authorized cooperative R&D agreements between federal laboratories and other entities, including state agencies.
- Presidential Executive Order 12591, signed April 10, 1987, directed agency heads to help transfer technology to the marketplace, and granted title to innovations growing out of federally funded research to the institutions that performed the research.[32]
- Clarification by the Federal Trade Commission of certain antitrust provisions, beginning in the early 1980s, made industrial research consortia (including state-sponsored ones) feasible. The National Cooperative Research Act of 1984 (PL 98-462) confirmed the antitrust protection.

These measures gave states access to new resources, including federal research funds, R&D results, and expanded intellectual property rights.[33] Many states have used these resources as incentives to encourage industry to participate in state-sponsored academic research centers and other technology initiatives.

CHANGING THE LANDSCAPE OF DECISION MAKING

While not accounting for a very large share of total U.S. research investment in dollars, state technology programs are in many ways the thin edge of a large wedge. States, with their industrial and academic partners, have a flexibility, diversity, and knowledge of local and regional conditions that federal agencies cannot match. Their small investments can therefore be focused accurately to promote technological advances that yield important returns in industrial strength. Successful state programs bring about structural change in the relations between government and industry, between industry and universities, and even between state and federal agencies. In this way, they make possible new research and development alliances and broader research opportunities.

Over the past four years, state spending on applied science and

technology programs appears to have been on the order of $1.2 billion (see Appendix A). This figure is restricted to state funds and does not include the matching funds that are typically required. With matching funds considered, total spending has probably exceeded $2 billion. Eleven states have spent more than $50 million each on the programs from FY90 to FY93.

Additional science and technology spending by states, on colleges and universities, on basic research, and on science and technology for regulatory and mission agencies may total in the hundreds of millions, but it is difficult to determine an exact figure.

These sums may not seem significant in the context of a national research and development enterprise, public and private, that spends more than $150 billion per year. State science and technology investments, however, have several features that amplify their effectiveness:

- The state programs are tightly focused on the specific goal of technology-based economic development.[14]
- The investments are highly "leveraged." That is, states use them as incentives to enlist industry and universities in the programs, which are supported by significant industry cost-sharing in both cash and kind.[15]
- State programs often build on research that has received substantial federal funding.
- The state programs have a flexibility that would be difficult, if not impossible, to obtain in a federal program. They can shift their objectives swiftly and smoothly to meet changing conditions. For example, many seem to have met recessionary pressures on their budgets by shifting toward nearer term goals more certain of economic payoff, such as industrial extension services, and away from longer term research programs (see Appendix A). The director of New York's technology program, which is oriented strongly to long-term research, said in early 1991 that, while not abandoning longer term work, "like a Wall Street fund manager, we will move our investments away from risk toward more likely payoffs."[16]

The state programs have reshaped competitions for national facilities, such as Sematech and the Superconducting Super Collider. They have made it easier for states to make strong, timely proposals by giving them the capacity to manage science and technology programs, as well as enabling them to form supportive constituent groups. (By the same token, state programs can be vulnerable to bidding wars in federal competitions, when awards hinge excessively on bidders' cost-sharing offers, rather than on strategies, policies, priorities, or substantive capabilities.)

The states are significant, then, not because they have assumed responsibility for an appreciable fraction of the nation's R&D. Their claim

to national significance is instead that they are changing the landscape of decision making for science and technology initiative, and reshaping federal–state relationships. Not the least of their significance is the potential they hold as partners for the federal government.

There is a remarkable solidarity of interest among the academic, corporate, and government institutions that participate in the state programs. Universities have revised their patent policies, and in some cases their mission statements, to emphasize economic development goals.[37] (As mentioned above, patent reforms have given universities substantially more control over licensing and other forms of commercialization of federally funded research on their campuses.) University faculty are becoming accustomed to moving easily between "theoretical" and "applied" issues, and industry leaders are acquiring a greater appreciation of the value of long-range research.[38] Industrial research is increasingly a matter of long- and short-term projects, carried out through strategic partnerships with academic research. Governors and legislators have discovered that the alliances made in the technology programs have political advantages in other areas, such as education reform.[39]

One student of the state technology programs writes, "if state advanced technology programs are successful in fostering new alliances, they can have important impacts beyond those associated with the specific projects supported by state dollars or job-creation outcomes."[40] By lowering "the future cost of collaborative relationships," he says, the programs may promote "increased rates of technological innovation and human-resource capital formation that do foster increased rates of state economic growth." In doing so, he adds, they may improve the competitiveness of U.S. business in the fields of technology selected for emphasis.

To ensure that the nation reaps the benefits of these programs, federal and state agencies will find it necessary to work together to plan and implement technology investments. To do so, they will need better information about each other's activities, and better means of cooperation.

Recent Federal Cooperative Technology Programs

In the past there have been some attempts at promoting federal–state cooperation, but their success has been limited, at best. Today, truly cooperative technology investment programs are extremely rare. The only federal science and technology program designed with cooperation in mind is the National Science Foundation's new State/Industry–University Cooperative Research Centers program, a small experiment with joint decision making in research funding. States are responsible for initial selection of proposals, and the National Science Foundation makes the final awards, through a

standard review process. Costs are shared equally by NSF, state, and industry. In 1991, the first year of the program, six centers were funded, with four-year NSF grants of between $100,000 and $300,000 per year; several more grants are expected in 1992.[41]

The Commerce Department's Clearinghouse for State and Local Initiatives, established under the Omnibus Trade and Competitiveness Act of 1988, is intended to be a force for coordination, but has not pursued that goal vigorously. The act gives the clearinghouse broad responsibilities for gathering and disseminating information about state initiatives, establishing liaison relationships, and finding and recommending ways for federal agencies to support state initiatives. However, according to its former director, the clearinghouse, in the Department's Technology Administration, has accomplished little of its mandate beyond developing and operating a computer database of state and local programs.[42]

The new partnership needs to draw on the lessons of the past. One such lesson may be learned by recalling the first round of awards in the NSF's Engineering Research Center (ERC) program, which is an illustration of the federal failure to discuss its plans with the states. The program, which involves industry and universities in joint research, was one of the federal government's main economic competitiveness initiatives in the 1980s. Although valuable as a means of promoting development and diffusion of technology, it was formulated almost entirely in the White House Science Council during the early years of the Reagan administration, with little or no advice from the states.[43]

The lack of consultation resulted in some apparent duplication of effort. For example, in the mid-1980s, without even notifying the state of New York, much less consulting with it, NSF sited an Engineering Research Center in telecommunications in New York City, where the state had already established a center with substantially the same mission.[44]

Some have argued, in support of NSF procedures, that federal and state roles must be distinct, and that too close a coordination of programs can harm both. The federal ERCs were awarded in an open competition without geographic or institutional limitations, they say, while state centers are often sited with such considerations strongly in mind, to help a particular region's industry or improve the geographic balance of science and technology resources. In the case of the duplicate telecommunications centers, they add, New York City, as the nation's telecommunications hub, has the necessary infrastructure to accommodate this kind of activity, so there is no undue redundancy. Nonetheless, better means of sharing information would have helped the state make the most of its investment, and would probably have helped the NSF, too. (The NSF has since significantly modified its approach and is a leader among federal agencies in emphasizing cooperation with the states.)

INFORMAL COOPERATION

Some informal cooperation does take place. The Manufacturing Technology Centers of the National Institute of Standards and Technology (NIST), for example, although they are awarded in open competitions, tend to be sited near existing technology centers. (This practice makes good sense, because the NIST centers have grown out of the technical extension programs pioneered by states, and because the states provide significant matching funds for these centers.) It should be noted, however, that the rules of these competitions are rigidly dictated by NIST and are not the result of consultation between NIST and the states.

Informal cooperation is also beginning to occur at the higher levels of policymaking. The National Science Foundation, for example, has established a state liaison position in the NSF Office of Legislative and Public Affairs and has publicly encouraged efforts by states to cooperate with federal science and technology programs. NSF recognized the state efforts as a new element in the national science policy establishment through the public statements of senior agency staff and through technical advice on such issues as peer review and technology center criteria. It also commissioned a recent major study of the states' R&D investments (see Appendix A).

MECHANISMS OF COOPERATION

A new partnership to spur U.S. economic competitiveness and to improve the health and welfare of citizens and their communities is emerging. At its roots is the concept of cooperation between the federal and state governments, with the involvement of the private sector. In the short term, a combination of need and opportunity motivates action. The most obvious short-term benefit is efficiency, through better sharing of resources. Less obvious, but arguably as real, are the benefits of synergy: innovation can be enhanced by the effort to find common purpose with another party (see Box 4).

Successful cooperation stems from clear understanding by each participant of the others' capabilities and of the roles that each can best play. In support of industrial technology, for example, the federal role is to provide the nation's research base in the sciences and generic technologies and to invest in national infrastructure such as research institutions, equipment, and instrumentation. States are responsible for building university research facilities, equipping them, and maintaining the necessary faculty, as well as for regulating and funding precollege education and vocational training; an important emerging state function is supporting technology activities that are close to the product development phase. Industry is responsible

Box 4. State–Federal–Industry Synergy: A Case Study

State and federal research programs can combine with industrial resources to produce a healthy synergy. In the Edison Polymer Innovation Corporation (EPIC), Ohio joined with industry to make its wealth of academic polymer research more easily accessible to industry.

EPIC is one of Ohio's largest state technology centers. Established in 1984, it takes advantage of the internationally known polymer research programs at Case Western Reserve and the University of Akron, and of the Cleveland–Akron corridor's industrial strength in polymer technology. With a pool of researchers numbering more than 400, EPIC represents one of North America's greatest concentrations of scientific and technical capability in polymers.

Later, the two universities joined with Kent State University (with its fine liquid crystal chemistry program) to seek an NSF Science and Technology Center. EPIC provided seed money for the proposal. Its industrial associates participated in the NSF site visit, to show the strength of its industrial ties. Thanks to this joint effort, the Center for Advanced Liquid Crystalline Optical Materials was established in 1990, with initial federal funding of $1 million per year. Industry, state, and federal funds will total $18 million over 5 years.

Industry and state and federal agencies have continued building on these gains. In 1991 Case and Akron proposed a polymer composite center to the NSF State–Industry–University Cooperative Research program. The state endorsed the proposal, committing itself and, through EPIC, its industry each to match the NSF funds, dollar for dollar. The Center for Molecular and Microstructure of Composites began operation in 1991. Over the first 4 years, funding from federal, state, and industry sources will total $5 million.

for designing, manufacturing, and marketing products, conducting sector- or company-specific research in the sciences and technologies, and keeping its work force well trained.

A partnership to spur U.S. economic competitiveness might thus be based on a division of roles in which the federal government supported research near the basic end of the spectrum, while the states and industry supported applied research and development of more direct interest to industry. It should be recognized, though, that the research and development process does not conform to such neat distinctions. In some cases, such as defense and biomedicine, the federal government has traditionally supported R&D along most or all of the continuum from basic research to applications, because it was the customer for the ultimate product, or because it viewed that product as of special national importance. (It is worth noting that commercial applications of the resulting technologies—aircraft, computers, and drugs—are among the most competitive of U.S. industries in world markets.)

State technology programs, too, blur traditional distinctions between

R&D stages. Through them, according to a leading practitioner, university faculty are becoming accustomed to moving easily between "theoretical" and "applied" issues, and industrial research is seen increasingly as a "portfolio" of long- and short-term projects conducted in both university and industry labs.[45]

At a minimum, true cooperation in such an environment requires state and federal officials to be well enough informed about each others' activities and goals to share resources, such as laboratory facilities. An effective partnership will depend on the involvement of all partners at the earliest project definition stage, and not after plans are completed. Partnership does not mean one partner presenting a final plan, or even a project that has already begun, to the others, leaving them with only two options: acquiescence or nonparticipation. States should be involved in defining individual projects that are expected to have industrial impact at some stage, as well as in designing new programs to create centers intended to aid industry.

Closer, more comprehensive cooperation is possible. States and federal agencies, for example, might engage in continuing consultations on their plans, with shared strategic goals.[46] For such consultations, states would need a seat at the federal table around which these priorities are set and broad funding decisions made. In the current administration, priorities in a number of important areas of research are set by the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET), a White House advisory committee.

More generally, federal executive and legislative agencies could make greater efforts to appoint members from the states to their science and technology advisory committees. There are hundreds of these bodies, and many are highly influential. States are poorly represented on them, even in areas—such as industrial technology—where the state perspective is vital.

The institutions to foster federal–state exchanges and to create the desired partnership in policy development do not exist today. Among the steps that might be taken to foster such cooperation are to create a system of joint advisory and consultative bodies and gather accurate data to help determine how state, federal, and industry investments can be matched most effectively. Building on these shared institutions, states should sponsor a national summit meeting on science and technology, at which governors would join the President, members of Congress, business, academic, and labor leaders, and others to discuss common problems and begin developing a state–federal–industry science and technology agenda. States must also build mechanisms to communicate among themselves and with the federal government. Without such efforts, federal and state agencies will continue to operate independently, with little cooperation, and sometimes at cross-purposes.

4
TOWARD A FULL PARTNERSHIP

A NEW BALANCE OF COOPERATION

Carrying out the nation's post–Cold War agenda will require a new balance of cooperation between federal and state governments. Both parties will need to make efforts to share resources and decision-making authority. The ultimate prize is nothing less than a renewal of our republican institutions, with new national goals and a new balance of federal and state roles.

Tightly coordinated joint planning is not advisable. Rather, a cooperative effort to exploit the two parties' complementary strengths will be needed, bolstered by a variety of new institutions to make consultation easier and more productive. These new institutions might include new sources of science advice for governors and legislators, joint policy development channels for the states, and federal–state forums for discussing priorities.

The appropriate division of roles in science and technology between federal and state governments is a vital issue that demands attention at every

level. A broad new division of roles may be evolving, as states assume important responsibilities in areas that have heretofore been considered federal responsibilities.[47] The only certainty is that federal–state partnerships will continue to increase both in number and in significance.

The states have taken important first steps, steps that exemplify in many ways the kinds of partnerships that will be necessary. They have developed their own entrepreneurial industrial technology initiatives with industry and universities; these initiatives in the aggregate are a strong force for national economic competitiveness. To widen the circle of renewal, these partnerships must be extended to the federal government, and to other fields of endeavor, beyond industry.

Federal and state governments must assume their fundamental new roles deliberately. A good example of the forces demanding a bigger state role in decision making can be found in the question of the future of the federal defense laboratories. Managers and policymakers envision civilian missions for these institutions, often in commercial research and development. These billion-dollar federal labs will not easily adapt to the pursuit of fast-moving commercial technologies, because playing such a role successfully requires detailed appreciation of industrial activities and needs; this must be reflected throughout the laboratories' operations. States, with their networks of industrial contacts and established programs of technology diffusion, can help the laboratories and businesses communicate about their mutual needs and resources. The state of New Mexico, in a move in this direction, has entered into a three-year agreement with the Air Force Space Systems Command's Phillips Laboratory, in which state personnel will manage the lab's technology transfer activities. New Mexico's industries will gain improved access to aerospace, laser, propulsion, and other technologies.[48] Such initiatives are likely to be increasingly common in the future.

In such state–federal cooperative ventures, state agencies should be involved early in the planning process, while new mission statements are being developed for the labs, and not as an afterthought. Otherwise, their contributions may be limited to supplying incremental funds (for example, through federal cost-sharing program requirements), and both the states and the nation will be poorer. Opportunities for synergy of the kind described in Chapter 3 will be lost. States, as a matter of self-protection, must—and will—insist on participating in the setting of the federal R&D agenda, as it moves away from its strong emphasis on defense.

More generally, if the nation is to turn federal technology resources to civilian purposes, states should participate in setting goals and investment strategies (see Box 5). The states have a long tradition of local market and business development, as well as long experience of engaging multi-

Box 5. Cooperation in National Competitions

Many recent federal competitions have required that part of the costs be borne by the recipient institutions. In principle, cost-sharing is a healthy and necessary expression of commitment and cooperation. But states sometimes find themselves bidding against one another until only one is left with the costly prize. The desire for cooperation with the federal government thus leads to competition between states. Overemphasis on cost-sharing has short-term gains for federal agencies but often decreases actual opportunities for cooperation.

The Superconducting Super Collider and the National Magnet Laboratory are well-known federal competitions that hinged on cost-sharing. The practice has become increasingly pervasive, with similar requirements imposed in many smaller programs. New York's success in winning the competition for a National Earthquake Engineering Research Center was interpreted as a consequence of the state's agility in quickly committing $5 million in annual matching funds. Federal agencies have even demanded state cost-sharing in individual research proposals.

Joint planning and shared participation in projects of common interest make for more solid support and a more profitable partnership. For example, the Manufacturing Technology Centers of the National Institute of Standards and Technology have been sited to take advantage of existing state technology centers. NSF's experimental State–Industry–University Cooperative Research (SIUCR) centers are sited according to joint decisions with states. But such cooperation is the exception, rather than the rule.

sectoral support for S&T programs in industry, agriculture, health and welfare, environmental protection, and other areas that are coming to dominate the national agenda. Their growing technical sophistication and their unique relationships with industry and universities suit them for full partnership.

A GREAT AND HISTORIC OPPORTUNITY

The nation has a great and historic opportunity to mount fresh new responses to many national challenges, while renewing and reinvigorating its republican institutions. But taking advantage of this opportunity will require hard work and planning, shaped by a broad vision of the future. Science and technology have become central concerns in the federal–state relationship. The two parties have much to discuss, as they reorder their roles to face the nation's domestic challenges. These discussions must be based on good

information and expert analysis, and both sides must prepare their positions well. Channels of communication must be improved within states and among states, between states and the federal government, and between both levels of government and industry. This new partnership based on national needs is well worth seeking. The recommendations offered in this report outline a path toward that partnership.

Such an opportunity for national renewal is rare. If we fail to grasp it now, it will not come again.

APPENDIX A
HOW MUCH DO STATES SPEND ON SCIENCE AND TECHNOLOGY?

The most comprehensive study thus far of state science and technology spending was carried out for the National Science Foundation and published in 1990.[49] The study surveyed state agencies' spending for research and development and R&D plant, and found expenditures of $1.2 billion in fiscal year 1988.[50] This sum represented an increase of 62 percent, in real terms, over the 1977 total. Although the available data are not exact, it is reasonable to assume that industrial cost-sharing for the programs and additional state science and technology funding would bring the total to about $2 billion.

CHANGING CHARACTER OF STATE FUNDING

Between 1977 and 1988, the character of state-funded work changed substantially, reflecting the industrial emphasis of the new state programs. Basic

Table A-1. Surveys of State S&T-Related Expenditures

Unit of Analysis	Estimates of State Expenditures ($1,000)	Fiscal Year	Survey
State expenditures for R&D	764,677	1988	Lambright *et al.*, 1989; National Science Foundation, 1990
Academic R&D funded by state and local governments	1,003,000	1987	Lambright *et al.*, 1989; National Science Foundation, 1990
State S&T initiatives; "total state technology budget"	550,000	1988	Minnesota Office of Science and Technology, 1989
State technology development programs; "annual state government expenditures"	400,000	1987	Atkinson, 1988
State S&T agency program expenditures	203,000	1987	National Governors' Association, 1988
State research grant and contract programs	143,000	1988	Forrer, 1989

Source: Adapted from Lawrence Burton.[20]

research, 23 percent of the total in 1977, shrank to 9 percent by 1988, and applied research and development together grew from 77 to 91 percent.

These figures tell far less than the full story, however:

- They exclude expenditures that did not come directly through the state agencies' budgets, such as industry matching funds (a substantial part of many state programs).
- They exclude state support of higher education. Higher education, of course, is the foundation of the research base for the United States. More to the point, some states (such as California) use their universities as their major research arms, and most use higher education funds as matching funds in federal competitions for research centers and the like.
- States submitted data only on their main science and technology agencies, and the study thus ignored some R&D spending in health, the environment, and other important areas.
- The study treats only research and development *per se*. Most of the state technology programs are intended to operate as integrated pack-

APPENDIX A

Table A-2. Budget Trends of State Technology Programs: Appropriations for Fiscal Years 1990–1993[a]

State	FY90	FY91	FY92	FY93	Total
Alabama	$ 2,245,200	$ 3,721,257	$ 3,418,472	$ 1,619,552	$ 11,004,481
Alaska	3,500,000	3,500,000	3,500,000	1,000,000	11,500,000
California[b]	6,600,000	3,000,000	3,000,000	–	12,600,000
Colorado	2,515,772	2,828,606	2,366,756	3,116,089	10,827,223
Connecticut	10,100,000	10,300,000	19,200,000	19,900,000	59,500,000
Georgia	10,896,000	10,949,000	9,053,000	22,768,000	53,666,000
Illinois	24,231,000	18,625,000	8,202,000	2,100,000	53,158,000
Indiana	7,500,000	7,500,000	5,900,000	5,900,000	26,800,000
Iowa	10,000,000	4,600,000	3,965,000	7,400,000	25,965,000
Kansas	5,570,486	8,084,976	7,829,896	8,449,079	29,934,437
Louisiana	1,213,870	1,403,089	843,834	1,221,646	4,682,439
Maine	629,000	1,029,680	737,000	636,000	3,031,680
Maryland	1,700,000	1,900,000	2,300,000	2,500,000	8,400,000
Massachusetts	9,195,029	6,222,484	13,828,879	16,954,205	46,200,597
Michigan	20,000,000	20,000,000	20,000,000	20,000,000	80,000,000
Minnesota	23,106,350	25,592,350	23,343,000	23,334,640	95,376,340
Missouri	3,150,000	3,087,500	2,308,000	2,337,000	10,882,500
Montana[c]	7,950,000	450,000	5,550,000	450,000	14,400,000
New Jersey	21,212,000	17,216,000	16,804,000	15,528,000	70,760,000
New York	21,451,300	21,850,195	18,845,300	18,733,500	80,880,295
North Carolina[b]	25,000,000	25,000,000	25,000,000	–	75,000,000
North Dakota[d]	0	1,500,000	1,500,000	0	3,000,000
Ohio	18,159,967	18,727,917	21,289,718	12,890,745	71,068,347
Oklahoma	3,100,000	3,100,000	3,100,000	3,100,000	12,400,000
Pennsylvania	31,777,948	32,100,000	27,800,000	28,562,000	120,239,948
Rhode Island[e]	0	0	0	0	0
Tennessee	200,000	180,000	180,000	134,000	694,000
Texas	30,063,000	30,239,000	30,657,000	30,192,000	121,151,000
Vermont	100,000	200,000	348,115	25,000	673,115
Virginia	13,013,910	10,998,113	9,979,031	8,666,936	42,657,990
Washington[f]	5,750,000	5,750,000	4,500,000	4,500,000	20,500,000
Wyoming	500,000	2,450,000	500,000	500,000	3,950,000
TOTAL	$320,430,832	$302,105,167	$295,849,001	$262,518,392	$1,180,903,392

[a] States unable to report a specific amount spent on applied science and technology programs: Hawaii, Idaho, Nebraska, Nevada, South Dakota, and West Virginia. States that failed to respond to the survey: Arizona, Arkansas, Delaware, Florida, Kentucky, Mississippi, New Hampshire, New Mexico, Oregon, South Carolina, Utah, and Wisconsin.

[b] FY93 appropriation had not been made at time of survey.

[c] FY90 and FY92 appropriations reflect the year in which authority to use funds from the Coal Trust Fund was given.

[d] $3M was appropriated for the FY91–92 biennium.

[e] A one-time $3.4M grant to the Rhode Island Partnership for Science and Technology was made in 1988.

[f] Figures reflect biennial appropriations divided in half.

Source: Survey conducted for the Task Force on Science and Technology and the States, Carnegie Commission on Science, Technology, and Government, August 1992.

ages, which may include—in addition to R&D—seed or venture capital funds, technical assistance programs, and other assistance.

On the other hand, the NSF data include much spending outside the technology development agencies themselves. Those agencies were reported by a Minnesota state study to have spent $550 million in fiscal 1988.[51]

QUANTIFYING STATE PROGRAMS

Although they have attracted much attention among students of science and technology policy in the past decade, the state programs remain poorly quantified. The fundamental reasons for this lack of precise data are the relative newness of the state programs and their emphasis on flexibility and responsiveness to local needs. They have grown up quickly, and the language of policy analysis has yet to classify their spending in useful program categories. In addition, there is little agreement on basic terminology; terms such as "technology transfer," "manufacturing extension," or "seed capital" may be used rather freely, leading to some confusion.[52]

Table A-1, with estimates of state S&T expenditure from a variety of recent studies, shows how conclusions about total spending can vary. The variety of approaches used, and consequently of spending estimates, is kaleidoscopic. Simple funding data will never capture the significance of these programs; what is needed is social science studies that outline the relationships of participants and the flows of resources, including funds, among those participants.

RECENT TRENDS

State science and technology programs seem generally to have weathered the recession-driven budget cuts rather well. A survey conducted for this report (see Table A-2) indicates that state programs have experienced funding reductions, hardly surprising given the fiscal difficulties that states have experienced in recent years. Illinois has suffered the most significant reductions. Virginia and New Jersey have seen a steady reduction in spending, and Ohio has recently undergone severe cuts. Pennsylvania and New York programs have been trimmed, while Texas, Michigan, and Minnesota have remained relatively stable. On the other hand, Connecticut and Georgia have experienced significant growth.

APPENDIX B
TASK FORCE MEMBERS AND PARTICIPANTS IN TASK FORCE MEETINGS

TASK FORCE MEMBERS

William O. Baker retired in 1980 as Chairman of AT&T Bell Laboratories, Inc. He joined Bell Labs in 1939, becoming Head of Polymer Research and Development in 1948, and from 1951 to 1954 he was Assistant Director of Chemical and Metallurgical Research. After a year as Director of Physical Sciences Research, he became Vice President of Research in 1955; for the next twenty-five years, he had overall responsibility for Bell Laboratories research programs, and in 1973 he became president. Dr. Baker received a PhD from Princeton University, where he held Harvard and Proctor Fellowships, following a BS in physical chemistry from Washington College. He has served on the President's Science Advisory Committee, the National Science Board, the Regents of the National Library of Medicine, the National Cancer Advisory Board, the President's Foreign Intelligence Advisory Board, the National Commission on Libraries and Information Science, and the President's Intelligence Advisory Board.

Arden L. Bement, Jr., is the Vice President for Science & Technology at TRW, Inc. He joined TRW in 1980 as vice president, technical resources. Dr. Bement began his professional career in 1954 as a research metallurgist and reactor project engineer with the General Electric Company. In 1965 he joined Battelle Memorial Institute as manager of the metallurgy research department; three years later, he became manager of the fuels and materials department. In 1970, Dr. Bement joined the faculty of the Massachusetts Institute of Technology as Pro-

fessor of Nuclear Materials, and in 1976 he became Director of the Materials Science Office of the Defense Advanced Research Projects Agency. In 1979, he was appointed Deputy Under Secretary of Defense for Research and Engineering. In 1990 the U.S. Senate confirmed Dr. Bement's appointment to the National Science Board for a term expiring in 1994.

Erich Bloch is the Distinguished Fellow at the Council on Competitiveness. An electrical engineer, Mr. Bloch joined IBM in 1952; he served in a variety of capacities, including vice president of the company's Data Systems Division and general manager of the East Fishkill facility. He became IBM Vice President in 1981. From 1981 to 1984, Mr. Bloch served as chairman of the Semiconductor Research Cooperative and was the IBM representative on the board of the Semiconductor Industry Association. In 1984, Mr. Bloch was confirmed by the Senate as Director of the National Science Foundation. Mr. Bloch was the recipient of the 1985 National Medal of Technology for his part in pioneering developments related to the IBM/360 computer that revolutionized the computer industry.

Richard F. Celeste was a two-term Governor of Ohio, from 1983 to 1991. During his tenure he led an aggressive program to promote international trade and investment with trade offices worldwide. At present, Celeste operates Celeste & Sabety Ltd., a company that specializes in providing linkages to world markets. Celeste attended Yale University, graduating *magna cum laude* in 1959, and taught at Yale for one year as a Carnegie Teaching Fellow. Selected as a Rhodes Scholar, he also studied at Oxford University. Celeste has been actively involved in the fields of international technology and the role of government in science, research, and development. As Governor, he chaired the National Governors' Association Committee on Science and Technology. He is a member of the Advisory Board at Oak Ridge National Laboratories. From 1979 to 1981, Celeste directed the U.S. Peace Corps, which had programs in 53 countries. He served in the Foreign Service under Ambassador Chester Bowles in India from 1963 to 1967.

Lawton Chiles was elected Governor of Florida in his fourth successful statewide political race in November 1990. Chiles began his professional career practicing law in Lakeland from 1955 to 1971 and served as an instructor at Florida Southern College from 1955 to 1958. He was elected to the Florida House of Representatives in 1959. He served his Lakeland district in that capacity until his 1967 election to the Florida Senate, where he served three years until his election to the U.S. Senate. Chiles became the first U.S. Senator from Florida ever to chair a major committee, the Senate Budget Committee, and he helped to found the National Commission to Prevent Infant Mortality, which he still chairs today.

Daniel J. Evans has been Chairman of Daniel J. Evans Associates since 1989. Trained in civil engineering at the University of Washington, Evans practiced structural engineering from 1949 to 1965. In 1956 he was elected to the Washington State House of Representatives, where he was Republican Floor Leader from 1961 to 1965. Evans was elected Governor of Washington in 1965; a University of Michigan study later named him "One of Ten Outstanding Governors in the 20th Century." After retiring as Governor in 1977, Evans became the President of Evergreen State College, a position he held until 1983, when he became a one-term United States Senator for the State of Washington. Currently, Evans is Chairman of the National Academy of Sciences Commission on Policy Options for Global Warming; he is also a political commentator for a Seattle television station.

APPENDIX B

Admiral Bobby R. Inman, USN (Retired), entered the Naval Reserve in 1951 and was commissioned as an ensign in March 1952. Over the next nineteen years he served on an aircraft carrier, two cruisers, and a destroyer as well as in numerous assignments ashore in Naval Intelligence. He graduated from the National War College in 1972 and was selected for promotion to Vice Admiral in July 1976. In February 1981, he was promoted to the rank of Admiral, the first Naval Intelligence Specialist to attain four-star rank. He retired with the permanent rank of Admiral in 1982. Between 1974 and 1982 Admiral Inman served as Director of Naval Intelligence, Vice Director of the Defense Intelligence Agency, Director of the National Security Agency, and Deputy Director of the Central Intelligence Agency. From 1983 to 1986 he was Chairman and Chief Executive Officer of the Microelectronics and Computer Technology Corporation (MCC). Following this, he was Chairman, President, and Chief Executive Officer of Westmark Systems, Inc., a privately owned electronics industry holding company. Admiral Inman served as Chairman of the Federal Reserve Bank of Dallas from 1987 to 1990.

H. Graham Jones is Executive Director of the New York State Science and Technology Foundation, a government agency that sponsors the development and application of new technology and encourages entrepreneurship in New York State. Mr. Jones earned his bachelor's and master's degrees in the natural sciences from Cambridge University and pursued further graduate work in physics at Cornell. Coming to government from a career of over thirty years in the computer industry, Mr. Jones played a lead role in the development and marketing of IBM's early scientific computers, the System/360, and special-purpose computers for military and space applications. In his present position, he administers programs that sponsor research and development in government and industry and that provide financing and consultation to small technology-based companies in New York.

Frank E. Mosier is vice chairman of BP America's advisory board. He was formerly president of the Standard Oil Company, which he joined as an engineer in the refining department in 1953. In July 1987, after the merger between Standard Oil and the British Petroleum Company, he became president of BP America. He relinquished that position upon being appointed vice chairman of the advisory board in April 1988. Frank Mosier is a graduate of the University of Pittsburgh with a degree in chemical engineering. In 1987 he received the honorary degree of Doctor of Science from Marietta College. The University of Pittsburgh Engineering Alumni Association honored him with the Distinguished Alumnus Award in March 1988.

Walter H. Plosila is President of the Montgomery County (Maryland) High Technology Council, Inc., and the Suburban Maryland Technology Council, both educational nonprofit membership organizations of high tech firms, support industry, federal laboratories, and higher education institutions. Dr. Plosila has a PhD from the University of Pittsburgh and an MA from Pennsylvania State University. Before holding his current position, Dr. Plosila was Deputy Secretary for Technology and Policy Development of the Pennsylvania Department of Commerce, where he was responsible for formulating overall economic development strategies and policies, and developing and implementing such technology programs as the Ben Franklin Partnership Programs. Dr. Plosila has served as President of the National Council on State Planning Agencies and was the Director of the Pennsylvania Governor's Office of Policy and Planning.

Donna E. Shalala is professor of Political Science and Chancellor of the University of Wisconsin–Madison. Dr. Shalala was recently named one of the top five managers in higher education by *Business Week* magazine. Dr. Shalala spent her academic career on the faculty of Columbia University. During the Carter Administration she served as Assistant Secretary for Policy Development and Research at the U.S. Department of Housing and Urban Development. Before coming to the University of Wisconsin–Madison, Dr. Shalala was President of Hunter College of the City University of New York for seven years. Dr. Shalala has been the recipient of a Guggenheim Fellowship and a Japan Society Leadership Fellowship. She has published extensively in the areas of politics and finance.

Luther S. Williams was appointed Assistant Director of Education and Human Resources for the National Science Foundation on June 1, 1990. Dr. Williams earned a BA degree in biology with distinction from Miles College, an MS from Atlanta University, and a PhD in microbial physiology from Purdue University. Dr. Williams's academic career in biology included appointments at Purdue University, the Massachusetts Institute of Technology, and Washington University. Williams joined the National Institutes of Health in 1987 as Special Assistant to the Director, National Institute of General Medical Sciences. He chaired the White House Biotechnology Science Coordinating Committee and is Vice Chair of the Committee on Education and Human Resources of the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET). Before his appointment as Assistant Director at the NSF, Dr. Williams served as Senior Science Advisor to the Director of the Foundation.

Linda S. Wilson became the seventh president of Radcliffe College on July 1, 1989. A graduate of Sophie Newcomb College, Tulane University, Dr. Wilson earned a PhD in inorganic chemistry at the University of Wisconsin. She went on to teach and conduct research, and then pursued a second career devoted to the fostering and oversight of research. Dr. Wilson served on the National Commission on Research and was chair of its subcommittee on accountability. She was a member of the Director's Advisory Council of the National Science Foundation for nine years. Dr. Wilson currently serves as chair of the National Research Council's Office of Science and Engineering Personnel and is a member of the National Science Foundation's Advisory Committee of the Directorate for Education and Human Resources. She is also a member of the National Research Council's Coordinating Council for Education.

Charles E. Young is Chancellor of the University of California, Los Angeles. Chancellor Young received a BA with honors in political science from the University of California, Riverside, and an MA and a PhD in political science from UCLA. He serves as a member of the Administrative Board of the International Association of Universities, is Chairman of the Foundation for the International Exchange of Scientific and Cultural Information by Telecommunications, is a former Chairman of the Association of American Universities, and was a member of the Los Angeles Olympic Organizing Committee. He also is a member of the Government–University–Industry Research Roundtable of the National Academy of Sciences and the Business-Higher Education Forum. Chancellor Young serves as a trustee of the UCLA Foundation. He is Chairman of the Theater Group, Inc., and a director of Intel Corporation.

APPENDIX B

STAFF AND MEETING PARTICIPANTS

Duncan M. Brown is a McLean, Virginia, science writer and editor who specializes in science and technology policy, energy technology, and the environment. Since 1983, he has been president of Duncan Brown Associates, an editorial services firm whose clients include national and international research organizations. Mr. Brown holds a BA degree in philosophy and mathematics from St. Johns College in Annapolis. Mr. Brown spent six years, beginning in 1977, at the National Research Council. While there, he served as Senior Editor and principal staff writer for the Committee on Nuclear and Alternative Energy Systems, which carried out a major study of the nation's long-term energy options, published in 1980. Following completion of that study, he worked as a staff officer of the Council's Energy Engineering Board. Before joining the National Research Council, Mr. Brown was a freelance writer. From 1972 to 1975 he supervised a team of editors at Macmillan Educational Corporation in Washington, DC.

Christopher M. Coburn is Director of Public Technology Programs at Battelle Memorial Institute. At Battelle he directs a unit working with federal, state, university, and private sector organizations in cooperative technology development, commercialization, and transfer initiatives. Mr. Coburn received his Master's degree in Public Administration from George Washington University, with a concentration in science policy. He holds a BA from John Carroll University in Cleveland, Ohio. Before joining Battelle, Mr. Coburn served as Executive Director of Ohio's Thomas Edison Program and was Science and Technology Advisor to former Ohio Governor Richard F. Celeste from 1984 through 1990. He also served as Assistant Director of the Ohio Department of Development.

Marvin E. Ebel is the Acting Director, Office of Research Services at the University of Wisconsin–Madison. He earned his PhD in physics from Iowa State College and continued his academic career at Yale University and later at the University of Wisconsin. Before assuming his current responsibilities at the University of Wisconsin–Madison, Dr. Ebel was Chairman of the Physics Department, Associate Dean of the Graduate School, and Acting Director of the Office of Research Services. Dr. Ebel is a member of Phi Kappa Phi, Sigma Xi, the American Physical Society, and the American Association of University Professors.

Richard Florida is Associate Professor of Management and Public Policy in the School of Urban and Public Affairs and the Department of Engineering and Public Policy at Carnegie Mellon University. Professor Florida received his BA in political science from Rutgers College in 1979, studied political science and urban planning at the Massachusetts Institute of Technology during the early 1980s, and received his PhD in urban planning from Columbia University in 1986. Before coming to Carnegie Mellon University, he was on the faculty of Ohio State University. Professor Florida has served as principal investigator on grants from the National Science Foundation, Ford Foundation, Joyce Foundation, U.S. Economic Development Administration, and U.S. Department of Agriculture. He has been a consultant to state economic development and technology agencies, and is currently North American editor of the journal, *Regional Studies*, published by Cambridge University Press.

Stephen J. Gage has been president of the Cleveland Advanced Manufacturing Program (CAMP) since November 1990. Trained as a mechanical and nuclear engineer, Gage began his professional career in teaching and research with the University of Texas at Austin in

the mid-1960s. During the 1970s, Dr. Gage was with several federal agencies in Washington, DC, including serving as EPA's Assistant Administrator for Research & Development under President Carter. He was also a White House Fellow in the President's Office of Science and Technology in 1971–1972 and spent the next two years with the President's Council on Environmental Quality. During the late 1980s, Dr. Gage headed Indiana's Corporation for Science and Technology and the Midwest Technology Development Institute. Dr. Gage is currently Vice President of Operations of the Technology Transfer Society; he has served on the Society's Board of Directors since 1987. Dr. Gage also serves on committees of the Government–University–Industry Research Roundtable.

Thomas H. Moss is Dean of Graduate Studies and Research at Case Western Reserve University, a position he has held since 1984. Dr. Moss obtained his BA from Harvard College and his PhD in physics from Cornell University. From 1968 to 1976 he was a Research Staff Member at IBM Research and adjunct assistant professor of Physics at Columbia University. In 1976 he became Staff Director and Science Advisor to Congressman George E. Brown, Jr. He became Staff Director of the Subcommittee on Science, Research, and Technology, House Committee on Science and Technology, in 1979. In 1982 Dr. Moss left Congress to join Case Western University. Dr. Moss serves as Chair of the Regents Advisory Council on Graduate Studies and is Chairman of the AAAS Committee on Science, Engineering, and Public Policy.

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* Through April 1990
** Through January 1989

TASK FORCE ON SCIENCE AND TECHNOLOGY AND THE STATES

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PREPARED STATEMENT OF WALTER PLOSILA

Introduction.

My name is Walter H. Plosila. I currently head an educational, non-profit membership organization of technology firms, federal laboratories, and higher education institutions. Previously I was Director of Policy and Planning and Deputy Secretary of Commerce in Pennsylvania, where I helped develop and implement one of the larger State technology development programs -- the Ben Franklin Partnership Programs. I have also advised 33 states in various facets of their technology development efforts and served on a number of committees and groups looking at the issues of federal-state cooperation in technology development. I served as a member of the Task Force.

I would strongly urge your consideration of the Carnegie Commission's Report. As a member of the Task Force chaired by Governor Celeste, I had the privilege of participating in its deliberations. The Task Force's findings and recommendations should be of considerable interest to elected officials at state and federal levels of government, whether they be in the legislative or executive branches.

An Interstate Compact for State-Federal Partnerships in Science and Technology.

The Task Force calls for greater communication and cooperation among states, federal government and industry. It also calls for an interstate compact of the states to undertake a number of efforts including helping ensure greater state government participation in national science and technology policy development and implementation. It also calls on the national government to recognize that if federal agencies are going to diffuse technology to the private sector, increased attention should focus on what foundations states have already established in their industrial technology programs.

I would like to discuss State efforts in technology development as a way to demonstrate why increased state-federal communication and coordination is necessary.

Witnesses before this Committee and other Committees of Congress have pointed out the problems American industry are facing in better utilizing Federal laboratory and Federally-funded university R & D for commercial applications. If our industry is to be competitive internationally we must do a better Job to utilize R & D for technology applications in both process and product arenas.

The American States in the 1980's, as documented in David Osborne's book, *Laboratories of Democracy*, abided by Justice Brandeis's dictum and engaged in "novel social and economic experiments," in the field of technology development. Programs such as Ohio's Thomas Edison Program initiated by Governor Celeste; the Ben Franklin Partnership Programs in Pennsylvania initiated by former Governor Thornburgh; and other efforts in 42 additional states are testimonials to efforts to experiment; to develop new relationships among States, industry, higher education, and, in a few cases, the federal government.

Today there are over 400 small business incubators in the U.S. There are more than 130 research parks. Seventeen states have industrial or technology extension programs. Approximately half the states have matching grant programs. Almost every State has at least one or more centers of excellence. As we enter the 1990's, States are continuing to experiment. My own state of Maryland has pioneered in investing in enabling infrastructure centers with test beds for information technologies and biotechnology firms. The States have been much more willing to intervene at more "downstream" aspects of the innovation process and there is a wealth of knowledge gained as to appropriate interventions and how to build sustained partnerships and relationships.

One problem has been that the national government suffers somewhat from the same problem some of our large corporations have suffered in commercializing their in- house R & D. Both have a mind set that if it was "not invented here," it is neither appropriate nor useful. Both suffer from a unique problem -- a security bureaucracy that is adverse to collaboration and sharing. Consequently, with some exceptions, the

Federal government has felt there is little to learn from these State efforts in technology diffusion as they define, modify, and develop national efforts to improve competitiveness.

The State programs in the 1980's provide an Information and knowledge base in technology diffusion that should serve as the basis for a two-way communication path for both the nation and the states. The State experience should be driving the design of national efforts and vice-versa. A recent report of the Government-University-Industry Roundtable on "Federal-State Cooperation in Science and Technology Programs" provides guidelines and criteria for this state-federal interaction. But in the absence of a sustained mechanism between the national government and the States it is even difficult to maintain the momentum in moving the implementation of this report forward.

Task Force recommendation for states to consider forming of an interstate compact may provide the kind of vehicle that will build a more sustained Federal-State partnership. The states have already demonstrated the effectiveness of such an approach when they created the Education Commission of the States. A compact would help to build a strong state partner and player to ensure sustained national government commitment in state/federal science and technology policy development, implementation and coordination. The record of national consideration of the State efforts in the 1980's in technology development alone shows how far these communications channels must be further developed. To fully address our national problem" in technology diffusion requires that the federal and state governments complement their programs anti Investments in partnership with education, industry, and each other.

Defense Conversion and Federal Laboratories.

Another area mentioned in the Task Force report is the need for close consultation and coordination between our "macro" and "micro" economic policies as the national government considers the future of its national laboratories. Governor Celeste has already acknowledged the changing circumstances in which we as a nation find ourselves with the end of the Cold War. This Congress, the executive branch, and others, are attempting to determine how we can best handle the defense conversion process as well as the future of many the defense mission-oriented national laboratories.

Re-use of land and facilities; education and training of displaced workers; new uses of workers and facilities -- all of these issues are as likely to find themselves expressed in a community and State context for local solution -- not just as a Federal "solution." Most of the attention and focus on policy development at tile national level is appropriately at the "macro" level. But we need to consider complementary State and local actions from a "micro" level as well.

States have today an "economic development tool kit" much different than the "smokestack chasing" tools of the 1960's and 1970's. They have customized training programs -- a source of human capital technology investment. They have served as catalysts in partnership with higher education and industry to build, equip, and diffuse the results of their science and technology infrastructure.

I would like to cite two examples in which I was involved that show the need for private sector, higher education, State and Federal collaboration. They illustrate why the future of federal labs and how we undertake defense conversion necessitate interaction with State technology efforts if design and implementation is to be successful. These examples come from the time when I was Deputy Secretary of Commerce in Pennsylvania:

- Gulf Oil merged into Chevron and their 55 acre Harmarville R & D park outside of Pittsburgh, Pennsylvania became obsolete. In partnership with Chevron, the University of Pittsburgh, and others, the Commonwealth of Pennsylvania matched Chevron's funding to provide operational support over several years for the facility to be transferred to university operation as an incubator for new

companies; a research park for the region; and a research center In hazardous waste supported by EPA.

- Bethlehem Steel made plans to dispose of its Home Research Lab and park adjacent to the Lehigh University campus in Bethlehem, Pennsylvania. Rather than the land being broken up into small parcels, the Commonwealth partnered with Lehigh University to provide a matching $10 million grant for Lehigh to acquire several buildings and acreage--an entire established research park. This facility is now home to one of NSF's Engineering Research Centers; an incubator; and firms participating in the matching grant program of the Ben Franklin Partnership.

In both these instances, you find a creative facilitator or broker role by a state government. This is a role that would be difficult if not Impossible for the federal government to directly play. Because of state efforts, our science and technology infrastructure was further preserved and enhanced. But there was no Federal role or responsibility even though the two cases owed much to Federal macro policy in regard to acquisitions/mergers and policies in regard to the steel industry.

We face serious and difficult times as we deal with defense conversion and the downsizing of American's larger industries. Solutions are likely to require partnerships between states and their Industry; with higher education; and, between state and federal governments. "Micro" answers will require a Federal role and responsibility; just as "macro" answers at the Federal level require a State role and responsibility. The issues of defense conversion and the future of national laboratories are not simply national problems with national solutions. They are Federal and State problems with, hopefully, Federal and State solutions, complementary In nature.

The Carnegie Commission's Task Force on Science, Technology and the States makes a number of recommendations that might assist in forging these kinds of sustained relationships in the future through Improved Federal and State government communication and ongoing relationships..

Building Sustained State Capacities in Science and Technology.

The Task Force report, as noted by Governor Celeste, also makes a number of suggestions about what states should be doing to improve their capacities in science and technology -- not just in economic development -- but across the board.

While State governments have modernized and come a long way during the past 20 years, there still remains room for improvement. A source of science and technology advice in handling crises and major issues; an overall advisory group that would develop a vision of the role of science and technology in a state's strategies; and access by state legislatures to objective analyses have all been suggested in the Task Force report.

With the increasing complexity of decisions; the Increased volume of information; aid the rapidity with which public sector decisions need to be considered and made In a context of major long term consequences -- suggests the need for States to further improve their science and technology capacity. The State experiences in technology development can then be replicated in other fields from environment to education.

Having been a Research Staff Director in a State Legislature and both an Assistant State Policy and Planning Director and Director in two different states, I can personally speak to the importance of access to expertise and knowledge. But I would also point out that the structure, design, and operating philosophy of the science and technology apparatus will vary state by state. There is not a national uniform model that every State must adopt nor Is their a Federal model that States should adopt. The Task Force's reports recognizes the need for this flexibility In adaptation to each State's environment.

Summary.

Science and technology is becoming a critical component of the governance of our state governments just as it Is for the Federal government. The Task Force on Science

and Technology and the States represents an important element in bringing the Federal and State governments into a closer partnership to learn from and contribute to each other's problems and Issues. It also suggests a set of both Federal and State actions that not only will improve the use of science and technology expertise in public decisionmaking but will also improve the coordination of mutually reinforcing science and technology efforts of the national government and the 50 States.

PERSPECTIVE

TECHNOLOGY DEVELOPMENT:

PERSPECTIVES ON THE THIRD WAVE

By Walter H. Plosila

TECHNOLOGY INNOVATION AND DEVELOPment emerged as a major component of state and local economic development strategies during the 1980s. By the end of the decade, forty-four states had some type of technology program.

These state programs could be classified in several ways. The predominant program component was technology and research centers—accounting for 41 percent of state technology development funds—followed by research and development grants, technology transfer mechanisms, seed/venture capital funds, and technical and managerial assistance. In addition, many states and localities initiated major capital programs for research center facilities and equipment, set up incubators, and launched research parks.

By and large, most state and local efforts were designed to intervene later in the innovation process than had traditionally characterized the federal science and technology policy: focused largely on basic research, that preceded them. A few states—Michigan and Pennsylvania for example—began to provide services throughout the innovation process.

THE 1980S BOOM: NEW EMPHASES

As would be expected in a period of ferment and experimentation, many of these relatively new state and local efforts were fragmented, haphazardly organized, and not well-linked to—or reinforcing of—each other. On the other hand, the programs offered the paradigm of state and local economic development practice several new emphases, namely:

- *Risk:* a new interest in risk-oriented programs, including equity, seed, venture and working capital investments;
- *Credibility:* a recognition that technology is an important component of assistance to traditional industries, particularly manufacturing;
- *Higher Education:* an increased awareness that higher educational institutions play a crucial role in state and local economic development;
- *Entrepreneurs:* an increased interest in working with and involving entrepreneur-driven businesses, as contrasted to public agency focus on Fortune 500 firms during the 1960s and 1970s.

As to the effectiveness of individual components of these 1980s-style technology innovation efforts, the jury is still out. It may stay out for a considerable while, due to the failure to establish accountability and assessment measures into these programs from the outset.

At the same time, evidence is emerging from programs like Pennsylvania's Ben Franklin Partnership, Ohio's Thomas Edison Technology Centers and Indiana's Corporation for Science and Technology that new relationships have been forged and new capacities established that link technology to economic development. Moreover, at least a few jurisdictions are establishing new public sector roles and functions.

MODELS FOR IMPACT

State and local technology development programs, like other components of economic development strategy, need new organizational structures, new types of delivery systems and modes of operation, and improved management and development incentives. In short, they need to adopt Third Wave principles.

Third Wave thinking has already arrived in some aspects of state and local technology development effort. But more is called for. Five aspects of the design of state and local technology development efforts should be addressed.

Leverage. Several technology development programs adhere to one Third Wave principle: they require that private sector funding be committed to the effort before public resource commitments are made. But more need to follow this leveraging principle.

One example is Pennsylvania's Ben Franklin Partnership Program, which links private sector firms with the specific research capabilities of educational institutions to help "spin-in" advanced technology applications to existing industries and "spin-off" new products and firms on the leading edge of innovation. The Partnership's Grant program requires that one dollar of private support match each dollar of

Unfortunately, nearly half the state and local technology investment in this country still goes to research centers, many of which do not require matching funds or industrial involvement in their efforts.

public support. The university and the firm involved in a project with the Center must reach agreement—and put their commitment in writing—before public funds are released. Likewise, before an Ohio Thomas Edison Technology Center can expend public funds, the private sector match must be in hand. Such leverage provisions and private sector commitments allow the market to drive the program, helping to assure that the private sector is setting the agenda.

Another example of leveraging is found in several states' efforts to increase the seed and venture capital available to start-up firms. Replacing the traditional loan finance programs directly operated by government, seed/venture efforts in Pennsylvania,

THE EDISON WELDING INSTITUTE: AN INTERMEDIARY ORGANIZATION

The Edison Welding Institute is a functioning example of a Third Wave intermediary organization for technology development. Located in Columbus, Ohio, the Edison Welding Institute (EWI) is one of Ohio's nine Edison Technology Centers. The Institute represents the type of intermediary organization that brokers and utilizes the resources of government, industry and higher education through shared ownership. To date, it has received over $30 million in state, industrial and university support.

EWI was formed out of the merger of a National Science Foundation-funded university-based center, the welding activities of a contract research center—Battelle Memorial Institute—and the U.S. members of the United Kingdom-based Welding Institute.

Today, EWI works closely with Ohio State University's Welding Engineering Department, particularly in basic research areas that take best advantage of faculty interests and expertise. Ohio State, as part owner of EWI, has provided five years of rent-free use of one of its buildings, and holds two seats on the Board of Trustees.

EWI is operated by its 228 industrial members who elect both its Board of Trustees as well an Industrial Advisory Board. The Board selects research projects and establishes service priorities.

The Institute is organized into three units—research, education and applications.

Research. Research may be cooperative, involving Ohio State University and one or more members as well as EWI staff; it may be a single firm project or a group project. Confidential proprietary research activities are permitted and members have a say over how their dues are divided between core efforts, specific services, and research projects they wish to sponsor.

Education. The education and training agenda of EWI builds on the results of its research efforts, integrating the results of research into education and training services. Educational activities include opportunities for member firms to interact with EWI's 50 person staff, and to participate in workshops, seminars and conferences. EWI provides a considerable amount of information to its members through videotapes, inspection and training aids, and training and development consulting services. The education and training role includes "hands-on" work—even designing operator and maintenance manuals and providing customized training programs for large and small firm members.

Applications. The third major focus of EWI—applications—also builds on the Institute's research expertise, actively assisting firms to use research in their operations. EWI's applications work can include providing problem-solving services to one or more members at a firm's site or at EWI's facilities. Applications engineering services assure that the Institute not only "thinks" but "acts" to improve the manufacturing competitiveness of its members.

The university and the firm involved in a project with a Ben Franklin Partnership Center must reach agreement about their resource commitments—and put their commitment in writing—before public funds are released.

Michigan and Maryland have attempted to leverage public funds and, in the process, permanently change private sector behavior. These states have required between a 2- and 3-to-1 private-to-public ratio for the dollars a client firm raises.

Moreover, some states invest public funds to create larger, privately-managed funds. The public role, besides being lead investor, is limited to selection of the general manager and certification of the match, along with after-the-fact monitoring of results. Public funds are treated in these deals much like private funds—as investments that carry both the risk of failure and the possibility for good return. The public policy objective? Stimulate greater amounts of private funds for firms at the critical start-up and expansion stages, but do so in a way that will encourage a long-term change in private sector behavior and practice—that is, more ongoing investment in seed and expansion capital.

Operating Intermediaries. Effective state technology development programs, rather than take on day-to-day program management and functional responsibilities themselves, have operated through locally-owned intermediaries, usually non-profit organizations. In contrast to most public bureaucracies, these intermediaries are able to respond quickly to industry's demands. They are flexible in attitude, responsive to the customer, and see their role as investors—all aspects of Third Wave organizations. They function as what Richard Hatch elsewhere in this *Review* calls "brokers," or facilitators, rather than as direct service providers.

Although they seem to have some characteristics of intermediaries, university technology centers, whether based on campus or in an affiliate arrangement, are by and large still making Second Wave adjustments. Many states, including New York, New Jersey, Minnesota, Kansas, Iowa, Maryland, Virginia, Washington and Utah, have used such centers. But the firms they serve have generally been Fortune 500, not the newly important small- and medium-sized firms. Their focus has been the development of basic or fundamental knowledge, with only minimal attention devoted to critical services like technology transfer, testbeds, demonstrations, market information and applied R&D.

But there are now many examples of movement toward using effective intermediaries. High Technology Councils have been established throughout the U.S.—in Pittsburgh, Kansas City, Chicago, suburban Maryland—to be network brokers. Effective technology-oriented incubators in some communities have gone beyond simply serving their tenants, playing a broader broker role in their communities. Some state technology development programs locate primary decisionmaking responsibility in regional broker organizations. Intermediaries don't always do it all themselves; they often contract out for R&D and other entrepreneurial development functions, the Ben Franklin Centers being a good example. State and local government roles in these entities range from partial owner or investor to promoter.

Other new organization models are emerging that provide an additional alternative to the traditional research centers. These mechanisms, generally called "consortia" or "networks," are more often found in Europe than the U.S., and are designed to service small and medium firms. In my parlance, both consortia and networks are groups of firms that come together to define, organize and/or provide some needed information or technical assistance service. Consortia are more formally established, with staff and facilities, whereas networks may involve less formal associations among firms, without dedicated staff. In either case, they are "market driven" in design and implementation, with a particular focus on product prototype design, technology transfer and international marketing services. (For more on formal and informal networks, see Richard Hatch's article in this *Review*.)

Three standout U.S. examples of consortia include Ohio's Edison Technology Centers, the Michigan Strategic Fund-supported Technology Centers, and Pennsylvania's Ben Franklin Partnership Programs, supplemented by its new initiative to form networks through trade associations. These new structures include some of the key components of a Third Wave organizational design for technology development:

- Centers are non-profit membership organizations, private and independent, with shared involvement by industry, university and government partners.
- Higher education is an important but not dominant partner.
- The public sector role is primarily limited to that of catalyst or facilitator.

Intermediary organizations can play a critical role linking action, policy and strategy, serving as sort of a "railroad roundhouse," directing traffic, resources, and activities.

- Public support is given for both core (research) and proprietary (product development) projects using a competitive process.
- Public funds leverage private funds with private sector commitments made up-front.
- Centers provide a comprehensive range of services, with particular emphasis on design, marketing and information services. R&D is not the exclusive focus.

Competitive and Incentive-Driven Framework. Ohio and Pennsylvania have built another Third Wave principle—competition—into their technology development efforts. In each case, state-supported centers compete for a share of state funds available. They must demonstrate, both on a quantitative and qualitative basis, that they meet overall program objectives.

Another example of incentive-driven effort is technology incubators, usually located near universities. In return for access to university resources and below-market-rate rents, incubator tenants at the University of Maryland and Lehigh University must give up a small equity in their firm. Public funds help underwrite the incubator's operations. In turn, locating in an incubator helps improve a firm's survival rate, securing the public's long-term investment in the firm.

Integrating Efforts. Technology development efforts embrace many state or local government agencies and departments. But technology programs have generally failed to establish synergy among these agencies. In part, this has been due to a lack of an overall set of policies and strategies to provide a common framework under which reinforcement and linkages might occur.

Intermediary organizations can play a critical role linking action, policy and strategy, serving as sort of a "railroad roundhouse," directing traffic, resources, and activities. Pennsylvania's Ben Franklin Partnership Centers do this, with over $25 million in annual project grants to use as an incentive, along with a mandate to do much more than R&D. New York and Maryland have set up regional councils that play a similar role, but without benefit of grant funds to administer.

Assigning delivery of programs to the regional and local levels, rewarding performance and linkages through a competitive allocation process, and sending the same message of reinforcement to each element of the delivery system will more reasonably assure that efforts will be integrated than will any coordination by government fiat.

Accountability. Because public technology development programs have generally lacked a competitive nature, they have also discouraged the development of accountability mechanisms. In the new efforts, one surrogate accountability mechanism is the leveraging of private sector funds. Private sector funds and support are not likely to continue over multiple years if progress—and profits—are not being achieved. In short, leveraging is a good design measure for accountability as well as impact.

Unfortunately, nearly half the state and local technology investment in this country still goes to research centers, many of which do not require matching funds or industrial involvement in their efforts. Consortia and networks, on the other hand, are by design required to establish accountability: Their members will not renew or pay their dues if they are not satisfied. Consortia, while having to expend considerable time in maintaining membership satisfaction, provide a market-driven alternative to research centers. Consortia services—like transferring technology and providing market and design services—generate direct member feedback, assuring more effective utilization of resources.

EIGHT DESIGN RULES FOR IMPACT

State and local technology development efforts represent "novel experiments" and are important components in building state and local entrepreneurial economies. Small firms account for much of the innovation in this country and a disproportionate share of the job growth. Large firms rely on technological innovations from small firms to maintain their competitive edge. If state and local technology development efforts are to contribute to these efforts at a sufficient scale and with significant impact, they must give more attention to Third Wave organization and design characteristics. Utilizing Third Wave principles, I can suggest eight rules for improving the design and operation of state and local technology innovation programs in the 1990s.

Private sector funds and support are not likely to continue over multiple years if progress—and profits—are not being achieved.

■ *Build Networks and Consortia.* Give as much, if not more, support to building network and consortia arrangements as is now given to university-based research and industrial affiliate centers.

■ *Establish Local Intermediaries.* Develop local intermediary organizations with sufficient flexibility and resources to offer incentives for linked programs and efforts.

■ *Wholesale Services and Programs.* Provide funds and services on a "wholesale" basis to such intermediaries, allowing them to leverage those resources and become the service delivery agent for their natural constituencies, instead of having state government itself directly provide—or "retail" its programs. This helps build local ownership and private sector leadership.

■ *Require Leverage and Commitment.* Assure a more market-driven approach by building such principles as leverage and private sector commitment into public policies and decisions.

■ *Make Policies and Programs Comprehensive.* Address technological innovation through comprehensive rather than narrowly-defined programs. For example, don't separate the needs of manufacturers from the rest of industry, or limit a program to simply funding R&D while not including an entrepreneurial support role.

■ *Generate Competition.* Provide ongoing funding through a competitive process. It designs accountability *in* and furnishes a basis for future investment.

■ *Fill Gaps and Change Behavior.* Design and provide public programs that fill actual gaps in needed activity and encourage changes in private sector behavior—so that the gaps don't reappear in the future.

■ *Invest, Don't Grant.* Use public funds as investments rather than as grants or loans to firms. This compels both the public and private sectors to share risk and reward.

State and local technology development efforts should remain pluralistic. There are roles for higher education institutions and research centers, matching grants, incubators, and seed and venture capital. Third Wave principles can help guide and improve these programs, further demonstrating the effectiveness of these experiments in our states, regions and communities.

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PREPARED STATEMENT OF EDWARD HUDGINS

I want to thank the Committee for the opportunity to comment today on the Carnegie Commission's Report on *Science, Technology, and the States In America's Third Century*.

I will begin by complimenting the Carnegie Commission and this Committee for focusing on two topics that will be of increasing importance to America through the end of this century. First, advances in science and technology in the past have kept America a leading world economic power. These advances have improved immeasurably the quality of life for Americans and made possible a prosperity for all. Rapid advances in the future, and the need for rapid applications of discoveries and innovations by industry, will make science and technology even more crucial. Second, as society grows more complex, the limitations of centralized federal government policy become clear to all. The need to decentralize science and technology policy means giving more attention to policy at the state level and returning to the states greater power to control, to make and implement their own policies.

Since the end of World War Two, science and technology policy has been dominated by the federal government As the Carnegie Report notes, this was due in large part to defense and Cold War needs. In addition, national laboratories have had a significant influence on scientific research and agendas. Further, the National Aeronautics and Space Administration (NASA) also has controlled agendas and resources. The end of the Cold War now requires policy makers to question the purpose of science and technology policy, and the proper role of federal and state governments respectively in its development and implementation.

The Carnegie Report offers a number of recommendations for establishing new government structures to coordinate and facilitate government science and technology policy. One set of recommendations would create advisors and institutions within the states to provide the governors and legislators with information necessary for sound policy decisions. I am generally in agreement with these recommendations.

The second set of recommendations focus on coordination of efforts between the states. With these recommendations I have some concerns. The call for information sharing between the states is appropriate. I am concerned, however, with attempts to harmonize policies among the states. There certainly is a common interest in seeking to regain control over policy and resources from the federal government. But innovations in state policies often come through competition. Education reform, especially school choice, and welfare reform come through pioneering efforts of policy entrepreneurs, not from the National Governors Conference. Thus, the benefits of cooperation between the states in science and technology policy should not be oversold.

The final set of recommendations suggest cooperation between the federal and state governments and partnerships with the private sector. With these I have concerns as well. They raise the specter of national planning that could discourage technological entrepreneurs, as politically powerful elites, whether from business, private foundations or universities, gain undue influence in science and technology decision making. I also fear the creation of yet another layer of stifling bureaucracy, this one overlapping the layers of the states and the federal government.

What I will do in my analysis of the Carnegie Commission Report is offer observations concerning the role of government in science and technology policy. I will then raise issues and topics of concern and opportunity that I hope the Committee will take into account in its deliberations.

THE GOALS OF SCIENCE AND TECHNOLOGY POLICY

Science and technology serve a number of valuable functions in a modern society. The philosopher Aristotle said that "All men by nature desire to know." The pursuit of scientific knowledge for intellectual enlightenment and fulfillment is a defining characteristic of the human race. Universities and private foundations should be the principal facilitators and funding sources for this purpose.

Of course, governments, especially state governments, now provide major funding to universities. But I call attention to the lead played by non-government entities even in huge, costly science projects. The largest working telescopes in this century, for example, were privately funded. These are on Mount Wilson, California, funded early in this century by the Carnegie Foundation, on Mount Palomar, California, built and opened in the 1940s with a Rockefeller grant, and the recently opened one on Mauna Kea, Hawaii, paid for principally by the W.S. Keck Foundation.

Government non-defense concerns with science and technology are more appropriately focused on two principle issues. First is America's economic competitiveness. Science and technology has made possible the development of new products, more cost-effective production techniques and medical breakthroughs that have made American firms world leaders. Second is so-called public goods. For example, advances in science and technology allow for a cleaner environment and improved transportation.

FROM DISCOVERY TO END PRODUCTS

I assume that the proper place for the development of new commercial technology is in the industrial laboratories of America's businesses. To place the Carnegie Report's recommendations in perspective, it is important to note that the ability of American firms, universities or other institutions to keep at the cutting edge of basic research in science and technology is unsurpassed in the world. From a point of view of competitiveness, the problem often is their inability to translate such advances into marketable end products. The Carnegie Report correctly observes that federal laboratories have a spotty record of making their work accessible to the commercial sector. For an interesting discussion on state efforts to promote competitiveness, I call your attention to *Innovations In Industrial Competitiveness At the State Level* prepared by Edward V. Regan and Bruno J. Mauer, co-chairs of the Task Force on State and Local Government Initiatives in Industrial Competitiveness, and released in December, 1984 as a Report to the President's Commission on Industrial Competitiveness.

It should also be added that in many cases businesses themselves have made poor economic judgments and after the fact claimed to need government help to keep on the cutting edge of technology. For example, in response to declining market demand, in the late 1970s and early 1980s many American manufactures of small "dynamic random access memory" (DRAM) semiconductors decided to drop production of these then-unprofitable products. Many turned instead to manufacturing larger chips. This generally was a wise move. But demand for DRAMs again rose. When the Japanese began to dominate the market in small chips, some American firms complained that they could not compete and sought, among other things, a government-business partnership. The resulting fourteen member consortium, Sematech, was created in 1988 with half of its $200 million annual budget paid for by the federal government. As with other such partnerships, Sematech has given rise to calls for increased funding and increased scope. The federal government is placed in the position of picking winners and losers, which it can do no more adequately than private enterprise.

More important to translating discoveries into end products are government regulatory and tax policy. Companies often cannot afford the costs of development due to high taxes or restrictions on banking. Others find that the uncertainty created by changing federal regulations discourage investments. This happened to the American automobile manufactures in the 1970s. Because they were not certain of what sort of fuel efficiency standards of other regulations would be placed on them from one session of Congress to the next, they often hesitated to invest in the sort of new technology that would have keep them competitive with their foreign counterparts.

Antitrust laws have prevented the sort of cooperation that has allowed the Japanese to translate new discoveries quickly to marketable products. The recent increase in joint ventures among American firms and between American enterprises and foreign companies is an appropriate means by which the high costs of developing new technologies and translating them into marketable products can be covered, and the time required for this development shortened.

An instructive discussion of this topic is found in the January 1985 Report of the President's Commission on Industrial Competitiveness, *Global Competition: The New Reality*. This Report examines some of these problems of translating discoveries into marketable products.

The point I make here is that it is often unwise to spend taxpayer funds on new basic research in the name of competitiveness if the mechanism for bringing end products to the market is defective.

In the context of the central role played by the private sector in science and technology, we can now turn to a consideration of the proper role of governments, both federal and state, in this area. One way to do this is to examine some of the problems in this area that we face and ask how governments help or hinder.

POLITICIZED SCIENCE

America's economic strength is tied closely to its preeminence in science and technology. The pursuit of knowledge in these areas is characterized by the honest, rational quest for an objective truth. Ideology has no influence on the laws of nature. Wishful thinking will not discover a cure for polio or invent a computer chip.

In recent years, as science and technology has become more a matter of public policy, the integrity of the pursuit of knowledge has been threatened. For example, the federal government's ten-year, multi-agency study, the National Acid *Precipitation Assessment Program (NAPAP), was conducted by scientists seeking the truth about acid lakes and streams. Their conclusion, however, that acid rain had little to do with this problem, did not fit the ideological disposition of Congress and the Administration. The Administration, knowing the contents of the report, rushed ahead with clean air policies that the study could not support ahead of the report's release date in order to avoid facing uncomfortable facts.

In March of this year, NASA announced that a hole in the ozone layer over North America could open up in the summer, threatening increased levels of cancer and other direct threats to the public health. The concern was over the presence of a CFCs, an element in the atmosphere associated with ozone depletion. What NASA failed to mention was that this association occurs only in the presence of an arctic winter. It seems that NASA was interested in making political points over their concern for the environment and building a sound basis for further federal funding of its projects.

Other recent debates have been characterized by distortions of evidence and ignoring of the most recent research and facts. The global warming controversy especially has stretched the integrity of science.

Politicized science threatens to undermine the public trust in one of the few institutions that enjoy a reputation for integrity. The Carnegie Commission recommendation that states create their own scientific advisors thus could be a positive step, a way creating balancing sources of information and knowledge. State officials could thus question some of the assumptions, based on ideological beliefs masquerading as scientific fact, on which Washington bases many of the unwise policies that it imposes on states. I would suggest that state science advisors or boards of experts, while keeping abreast of what federal agencies and experts claim, also keep their independence.

SPECIAL INTEREST DOMINATION

The need for advanced technology is especially susceptible to manipulation by special interest groups seeking to profit from taxpayers funds in the name of the public need. Military spending, absolutely essential to the country's defense, has been one of the principle sources of pork barrel spending and special favors for the districts and states of influential politicians. Increased attention has been paid in recent years to academic pork, such as research centers, opened in the name of science but more serving political interests and not representing the rational allocation of resources.

The Space Station is perhaps the most outstanding current example of special interest pork in the name of science and technology. Many analysts point out that

neither the Station nor the Shuttle is needed as a platform for a return to the Moon or journey to Mars. Many scientific experiments that proponents say can be done on the NASA Station also could be done on smaller, cheaper mini-stations. And most scientists, if asked which projects on which to spend public funds, would put the Station at the bottom of a list of priorities. But a handful of large contractors who benefit from the station are politically more powerful than other groups and thus will be able to commandeer $40 billion from the taxpayers.

The danger of a politicized distribution of resources argues against too close a partnership between governments and industry in the pursuit of science. The Carnegie Commission recommendations along these lines, while well intentioned, pay too little attention to the unintended consequences of mixing political and economic power.

TRANSPORTATION

To understand the benefits and limits of government involvement in science and technology, it is useful to consider the example of transportation, cited by the Carnegie Report as an area that could benefit from new technological advances. First, many of the solutions to problems that state officials might seek in technology can be found in public policy. The high costs of mass transit, for example, might conjure up dreams of cheap monorails or other exotic technologies.

In fact, close inspection of the Section 13(c) of the 1965 Urban Mass Transportation Act would be a better route to inexpensive transport. This Section mandates that, when receiving federal grants, local transit officials must show that the funds will not be used to the detriment of the transit workers. In practice this has meant that transit official must hold special negotiations with transit unions and grant extra pay hikes or concessions that keep the cost of mass transit high.

In the area of transportation, often the most important question is not "What new things can we invent?" but "What is the most appropriate, cost-effective technology for dealing with a problem?" A Denver-based, private, not-for-profit group, Transportation-2000, has sponsored conferences in the past two year and plans future ones to explore the use of new technologies and a whole range of transportation issues. The most interesting thing about these conferences are concern the costs of technologies and systems. Here an analogy with foreign aid is useful. In the past it was believed by some that the best way to help less developed countries would be to help them purchase state-of-the-art technology. But now the concept of "appropriate technologies" tells us that a small plough to be pulled by abundant local animals might be better than expensive tractors.

For an American city, a high occupancy vehicle or bus lanes might be far cheaper and more effective than a costly, modern subway.

THE ENVIRONMENT

A recent environmental example illustrates the problem with a concentration of science and technological decision making at the federal level and the benefits of competition with state science policy. Donald Stedman, a chemistry professor at the University of Denver found in his research that fewer than 10 percent of the cars, primarily older cars or those not tuned up, cause over half of the total auto pollution. Not satisfied with mere information, Stedman invented a device that works similar to a radar gun. It can measure the real pollution output of moving cars, which is more accurate than measuring emissions annually at inspection stations. This invention would allow local officials to target the polluters.

The federal EPA knows of the Stedman device but is doing little to promote it's use. Why should it? After all, it takes away from the importance of the EPA? Now, however, some state government official have been made aware of the device and are considering its use. Here is a case in which a state government science advisor or board of experts could evaluate and make use of such a device. This is also a case in which information exchange between the states, as suggested by the Carnegie Report would benefit. And it is also a case in which the states might work together to oppose

federal policies that severely limit local flexibility to deal with their own environmental problems.

CONCLUSION

The states are correct to focus more attention on science and technology, on the need to acquire the information necessary to make sound policy decisions in an advanced industrial society, the need to counter federal government control and unsound policies in this area, and to cooperate on a very limited basis to maintain a certain degree of autonomy in this area. But they should avoid establishing new bureaucratic structures that, like the present ones, will only serve to hinder basic scientific research and the development of new technology.