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THE ROLE OF THE NATIONAL LABORATORIES IN LOCAL ECONOMIC DEVELOPMENT

HEARING

BEFORE THE

SUBCOMMITTEE ON
ECONOMIC RESOURCES AND COMPETITIVENESS

OF THE

JOINT ECONOMIC COMMITTEE
CONGRESS OF THE UNITED STATES

ONE HUNDREDTH CONGRESS

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SATURDAY, APRIL 9, 1988

THE ROLE OF THE NATIONAL LABORATORIES IN LOCAL ECONOMIC DEVELOPMENT

SATURDAY, APRIL 9, 1988

CONGRESS OF THE UNITED STATES,
SUBCOMMITTEE ON ECONOMIC RESOURCES AND
COMPETITIVENESS OF THE JOINT ECONOMIC COMMITTEE,
Washington, DC.

The subcommittee met, pursuant to notice, at 10:30 a.m., in the board room, Albuquerque Public Schools, Albuquerque, NM, Hon. Jeff Bingaman (member of the subcommittee) presiding.

Present: Senator Bingaman.

Also present: Jack Waugh, press secretary to Senator Bingaman.

OPENING STATEMENT OF SENATOR BINGAMAN, PRESIDING

Senator BINGAMAN. Let me ask everyone to please take a seat, and we'll get started with this hearing.

Why don't we start by just asking the first panel if they would come up? I know some of our witnesses are sitting down here toward the front. Would Jeff Nathanson, James Greenwood, Jim Williams, Glenn Kuswa, and Ross Robinson come up and take chairs here.

Let me welcome all of you to this hearing of the Joint Economic Committee on technology transfer and "The Role of the National Laboratories in Local Economic Development."

The issue of the role of our national laboratories in technology transfer is, of course, of vital importance in our efforts to improve both the national economic competitiveness of the country and also to improve local economic development here in New Mexico. During hearings that were held last year before the Joint Economic Committee on investment in research and development, a number of witnesses pointed out the importance of the national laboratories in improving the country's economic competitiveness.

One way in which the national laboratories can improve our economic competitiveness is by contributing to local economic development. Here in New Mexico, we've long viewed the national labs as a potential catalyst to economic growth.

New Mexico was first in the Nation in Federal R&D spending per capita in 1985. We were fourth in the Nation in total Federal Government expenditures per capita during 1986. We lead the Nation in research and development expenditures as a percent of personal income.

New Mexico can lead the Nation in harnessing our technological resources for economic renewal. Here in the Rio Grande corridor,

we have one of the larger concentrations of science and technology activity in the Nation. Our universities and our national labs lead the Nation in technological research. We need to now concentrate on transferring that technology to the private sector.

Congress has recently enacted legislation to facilitate the transfer of technology from national labs to the private sector for eventual commercialization. I was pleased to cosponsor a bill which my colleague, Senator Domenici, introduced which will further this process even more, and I commend him for his leadership in this area.

However, these attempts to facilitate technology transfer will not be effective if the local economy lacks the ability to turn the technology created in the labs into commercially useful products. It is not enough simply to transfer technology out of the labs; we need to be concerned with where that technology goes. To gain the benefit of technology transfer for the local economy, we have to have a strong local technology and entrepreneurial infrastructure to take that technology and turn it into products and into jobs.

Creating a strong technological and entrepreneurial infrastructure requires more than just the transfer of technology developed in the labs. It requires the development of the managerial and technological skills required to seek to take a product through the process from research to mass production. Many people do not realize that the first microcomputer, the Altair, was developed here in Albuquerque; but it was Apple and IBM in the high-technology areas of the east and west coasts which created the microcomputer revolution.

Clearly, it's not enough just to invent a product. A successful development requires all the entrepreneurial skills. If New Mexico is to be a technological leader, we need to start with technology transfer and move quickly to develop the rest of the needed entrepreneurial infrastructure.

Building a strong local entrepreneurial environment is primarily the responsibility of the local community, with the help of the State. The Federal Government, however, also has a role to play, both directly and indirectly, through the national labs. The purpose of this hearing today is to focus on how to improve the contribution that the national labs can make to local economic development through the transfer of technology that can be used to develop new products and manufacturing processes. We'll look at the problems of technology transfer to local firms, practical ways that the lab can nurture the growth of local spinoff firms and ways in which we can increase cooperation between the labs and the local economy.

A great deal can be said about technology transfer, entrepreneurship and economic development in general. However, it's often difficult to find specific recommendations that we can follow for improvement of the situation. I hope the witnesses today will identify for us not only the specific problems, but also the specific steps that we can take to solve some of these problems.

The hearing today consists of two panels. The first will look at the problems involving the transfer of technology to local advanced technology-based firms. We have with us today officials from two of New Mexico's leading business incubators: Jeffrey Nathanson, the

president of the Business Innovation Center in Albuquerque; and James Greenwood, the executive director of the Los Alamos Economic Development Corp. We have businessmen personally familiar with the problem of running a high-tech business in New Mexico. Ross Robinson is here from Los Alamos Diagnostics. Eugene Watson of Laser Technics was scheduled to be here, but will not be able to be with us today. We also have representatives from New Mexico's national laboratories, Glenn Kuswa, who is the Manager of Technology Transfer at Sandia; and James Williams, Deputy Director of the Office of Industrial Applications at Los Alamos.

Our second panel is equally distinguished. We'll hear from them a little bit later, and I will introduce them at that time. They'll focus on possible institutional mechanisms to improve technology transfer.

Before we begin the testimony, let me indicate that Senator Domenici has an opening statement that he would like to insert in the record. Also, let me repeat that I think he has provided tremendous leadership in helping to focus our attention in this State on the types of problems that are being discussed here today.

[The written opening statement of Senator Domenici follows:]

WRITTEN OPENING STATEMENT OF SENATOR DOMENICI

I want to thank Senator Bingaman for holding this important hearing on how the national laboratories can benefit local economic development. I am sorry that my schedule prevents me from attending today's hearing.

I have long been searching for ways in which our national laboratories could be of greater benefit to New Mexico, as well as the rest of the nation. These laboratories have tremendous scientific and technological capabilities. I strongly believe that they have great potential for improving local economic development if we can improve cooperation between government laboratories and our private industry.

Last year I introduced legislation that would help generate such cooperation; S.1480, The Department of Energy National Laboratories Cooperative Research Initiatives Act. This legislation would improve technology management at the Department of Energy and foster cooperative research environments for federal laboratories, private industry and universities. I am glad that Senator Bingaman is cosponsoring this legislation, and I appreciate his help in getting this important legislation passed.

Let me say that I am very pleased by attempts that have been made by the Secretary of Energy to remove obstacles to laboratory-private sector cooperation. Yet, rigidities still exist within the system and we will need to work on those as well.

I am sure we can use the laboratories more effectively to enhance local economic development, but the types of changes proposed in S.1480 must be made. Technology management within the National Laboratories must be decentralized to permit greater discretion by laboratory managers. Legal protection of proprietary information must be improved. Finally, cooperative research environments must be developed to bring businesses and universities together with the laboratories.

I thank you for permitting me to submit these remarks, and I look forward to reviewing the testimony from this hearing.

Senator BINGAMAN. Let me go ahead and call on the panel to give their testimony. The way we'll operate is for the entire panel to give their statements. Following that, we'll have an opportunity for questions. And if there are comments by particular panel members on statements that anybody else has made, we'll be glad to entertain those, as well.

Why don't we start with Jeff Nathanson? You begin, and we'll just take the panelists in the order that I introduced them earlier.

STATEMENT OF JEFFREY M. NATHANSON, PRESIDENT, NEW MEXICO BUSINESS INNOVATION CENTER, ALBUQUERQUE, NM

Mr. NATHANSON. OK. Thank you, Senator. I want to thank you for the opportunity of addressing you on these issues of the role of the national laboratories in local economic development. For thousand of us in New Mexico, it's hard to realize the impact that the laboratories have had. Just prior to the existence of Sandia National Labs in Albuquerque, the population of our city was about 40,000. We're now at the 500,000-plus mark in just 40-plus years hence.

I also would like to commend the laboratories, and their current administrator, Mr. Irwin Welber, for their assistance in the local economy and Mr. Kuswa and Mr. Williams for their involvement, because I know that they have had a great deal of impact on the problems that I am involved with. They have been trying to help in the effort of capitalizing on the resources of New Mexico and in interpreting the Stevenson-Widler Act, being the law that has encouraged technology transfer. And we've made a good start, but it's only a start, and I think there are a number of things that we can do.

As you mentioned, New Mexico has a high ranking in terms of its research and development dollars. I was glad to see that we've maybe increased those dollars. I had been told that we spent about $3.5 billion a year, and I thought we were around fifth in the Nation, but I'm glad we're higher.

Some people suggest that from 3 to 10 times more money is needed to commercialize the technology. So there may be a need for some kind of additional assistance beyond just R&D spending. But it's time that New Mexico and Albuquerque began to realize fully the economic potential of what I believe is its major resource—the minds, talents, and skills of its people. Unfortunately, I don't believe we've yet spawned the transfer of industrial enterprise that takes advantage of those resources.

I'm glad to note, as you suggested, that the first personal computer was created here in Albuquerque. I would like to also suggest that the first computer software was created here in Albuquerque, as well, with Microsoft, a multi-billion-dollar industry starting its office here in Albuquerque, but leaving. And one of the reasons why they left, along with the fact that Bill Gates was from the Seattle area, and his parents were well entrenched in the community, New Mexico is a tough place to do business. The Center for Enterprise Development, the organization that publishes "Making the Grade," an analysis of State economies, has just released some statistics that I have found to be rather startling.

New Mexico ranks seventh of the 50 States in new business start-ups. We rank fifth in women and minority entrepreneurship. However, the State ranks 34th in business growth. We rank 49th in export of product outside of our borders.

So we start up businesses, only to have them grow slowly or die. We operate our businesses in very narrow local markets, trading almost entirely within the State. Our entrepreneurs are unable to identify and penetrate new national and international markets, because they don't know how, and they don't know where to go for help.

As you suggested, what's necessary and what makes economies grow is the network or resources—the infrastructure, as you suggested—and it takes lots of resources. Two years ago, many of us who are going to be testifying today were part of a group that put together a document called "Change, Challenge and Opportunity," which outlined the necessary infrastructure steps to help create the entrepreneurial economy that we're trying to build. And I will include a copy of that with my prepared statement, because I still think it's a valid document, even though it's 2 years old.

The document suggests, in the infrastructure we talked about, the need to project intellectual property; the need to help raise money; the need to help find professional help; locate physical facilities; find suppliers; help deal with State and local governments; getting and keeping entrepreneurs and other support people; and then finding suitable mentors—people to help us in the process of developing new businesses.

One of the things that I've come to realize in helping new start-ups is that nationally, among people who are interested in technology and business development, and especially among people in the venture-capital community—people who invest in new businesses—there has become a realization that there is a perception out there called "The New Mexico Syndrome," a syndrome or a perception that suggests that New Mexico is without good business opportunities: no money—no local money—no management and long-term development costs on technology.

The labs have proliferated technology; but unfortunately, those are not easily commercializable. The technologies which have been developed are, as they call them, technology pushed, as opposed to market pulled. These are technologies which were developed for the national defense of the United States, mostly through military applications, and are not necessarily for commercial applications. They do not answer particular needs of the commercial marketplace.

Technology transfer is not necessarily just passing the baton of a technology to a company, whether it be a startup or an existing company. It is more of a process of development of a product and development of a business.

As my colleagues will probably tell you later, technology transfer is not just a shopping mart with shelves filled with technology for easily identifiable marketplaces. You can't just go in there with a shopping cart and pick those technologies off the shelf.

You asked in your letter of request to come up with some scenarios or examples of how the technology process has been successful or unsuccessful, and I would like to share with you some situations

that I'm familiar with, where companies have had technology transferred to them, only to have millions of additional dollars past the transfer spent on further development of the products that are still not in the marketplace, but need additional assistance.

In one particular case that I'm thinking of, the resulting products—what could come out in the end—could have major positive impact on the laboratories' mission, as well as in the commercial marketplace; but a great deal of basic research must be done in order to assist in the commercialization of this technology. In this particular case, the technology was something that was developed for the laboratories, and some entrepreneurs recognized the opportunity in some other areas. And after spending millions of dollars, they've come to realize that they still don't have a product. They spent millions of dollars of venture-capital financing, but they don't have a product on the market yet. They need assistance from the laboratories in order to take advantage of what is becoming a new opportunity in their particular marketplace. This assistance from the laboratories could come in the form of facilities, and I believe that some of those facilities were offered in the SEMATECH proposal that the State of New Mexico developed, and I'm hopeful that those similar kinds of facilities and support could be provided to local startups that are transferring technology.

Additionally, staff time could be provided; or more importantly, the labs could contract with the companies to help in the development of the technology for its commercial application.

Just yesterday, I sat in a meeting with a minority-owned, AA-certified business owner and an engineer from Sandia National Labs, discussing the transfer of technology. The engineer suggested that the Labs developed a technology in his division, but didn't have the time or the resources to continue to make these gadgets. The business owner was very interested in making the part; but as a startup, she doesn't have the resources. She just has the technology transfer. She just can't go out and develop this product. She needs an initial contract with Sandia to make the parts which the Labs can eventually use—her initial market.

Later in the conversation, we realized that there might be a strong commercial application for the technology. The company is interested in pursuing the opportunity, but it doesn't have the seed capital to explore it. We realized, as well, that the laboratories could benefit a great deal if the product were commercialized, because they would be able to get the product at a much lower cost if it was developed in quantity.

One of the questions I would have for you, Senator, is, how could we create a commercialization fund or investment incentives to provide funds so that companies like the ones I've just suggested can help in the further development of technology and in the market analysis of a product?

Now one of the things I want to suggest is that immediately, people might recommend, "Well, that's what private investment capital is for—venture capitalists." One of the things that we're starting to recognize, based on the experience that we've developed here in the short 3 years that I've been invovled with Business Innovations, is that venture capitalists don't invest in technologies. They involve in business and business opportunities, and most of

our technologies are not yet businesses. They need a great deal of additional dollars.

Another transfer of technology that I'm familiar with was not a product at all, but rather a service. This particular company is a high security implementation business which was formed by Sandia Lab personnel when it was decided by the Labs that they were getting out of the business of high security implementation. The founders were encouraged that they could offer services as security-system consultants in the private sector, since they were involved in the development of this practice while at the Labs.

The founders left the employment of the Sandia National Labs, and they are now an active participant in the local economy. But the company is a small company. They're a new startup. They have a gross annual income of $150,000 or less, and they're bidding for new contracts under the small business set-asides with competing bids by companies that are still considered small, yet have annual incomes of $16 million.

Perhaps a lower limit for set-asides might be developed for local startup companies. The company might also like an opportunity to have a preview of their technology by people at the laboratories prior to the release of RFP's to get the laboratory personnel familiar with what's happening with local companies before those contracts or RFP's are issued to potential, bidding out-of-State companies. Set-asides need to be developed that really allow a new company to compete.

This particular company has also found that they are in the business of engineering services and are viewed by the Laboratory personnel as competition. And there is a need to develop, I believe, a corporate culture within the Laboratory that allows for entrepreneurs to break away and start their own companies—and come back, if necessary, but not be ridiculed for the attempt.

There is a another example I'm familiar with of a technology that has both military and commercial application. This particular company's experience suggests that technology transfer is not just a one-way street—technology out of the Labs. This particular company has a technology that they believe has commercial applications, as I suggest, but also has ramifications for what the Laboratories are currently doing. There needs to be a process developed that allows for a transfer of technology in reverse—that provides some funding, again, for the company's efforts and, in this particular case, a protection. This particular entrepreneur is concerned that if he starts to do work with the Laboratories, that his current patents might be secured by the laboratories and keep him from commercializing the technology out of the Lab.

I believe that there is a continued need to help in this area of commercialization, and I think the technology-transfer process needs to include some kind of market-analysis process. There needs to be a process to identify market needs or problems and see if the labs have a solution or can come up with a solution readily.

I believe later this morning, you're going to hear about commercialization consortiums and other avenues that I think need to be supported in terms of helping in the process of technology transfer.

Another thing that I would like to see support of from the technology-transfer issue is Federal support for small business incuba-

tors or innovation centers. These facilities, which specialize in facility management and facilitation of management systems for new startups, have had an incredible impact on local economies. And I think that our program is an example of that—Jim's here, as well. But there needs to be more Federal support for this kind of effort of technology transfer. There is Federal money that has been utilized for business incubation facilities; but mostly, it is community development block grant programs that require immediate and direct employment of low- and moderate-income people. For the technology-transfer process, that employment area is somewhat long and drawn out, and it is not immediate, the way the guidelines currently are written.

There needs to be additional development of programs that, again, round up the resources of the community. You have been a long-time supporter of Healthnet, an area which has certainly gotten a lot of interest and excitement on the health of our community. I guess I'd like to suggest that you help develop a Businessnet, a coordinated resource base for businesses which has the direct support of the Senators and the congressional delegation. And we need your help in mobilizing the community.

Last, New Mexico has oftentimes tried to develop itself through attracting businesses from outside. Most recently, we have tried to get the U.S. West Research and Development Facility, the Federal Government Supercollider Project and the SEMATECH Project. And one of the things that I would like to suggest to you, Senator, and those in the audience, is that I have a theory of economic development which I call the hundredth monkey theory of economic development. It's based on an anthropological theory that suggests that when the hundredth monkey figured out that they could use a tool to get at the bananas, all of monkeydom knew that you could use a tool to get at the bananas. And what I'm hoping is that when we get to the hundredth economic-development official or the hundredth Senator or the hundredth congressional delegate or the hundredth person in the community to realize that whether you're talking about relocating a business to a community like New Mexico or expansion of an existing business to New Mexico or creation of a new business in New Mexico, we need the same infrastructure—the infrastructure of resources, management, marketing assistance, and money. So I'm hopeful that we need only 99 more Senators to realize that we have to help develop this network. But I highly recommend that you try to get the 99 more Senators to realize that we all need a tool.

And we also need to help what's here before we go outside. I would like to suggest to our Governor, Governor Carruthers, that I would like to see the utilization of the $11 million that was supposed to be set aside by our legislature to attract the supercollider and those resources that were set aside to support the development of the SEMATECH program here be utilized to help local companies transfer technology and develop an infrastructure here. I thank you very much for your time.

[The prepared statement of Mr. Nathanson, together with the document refered to, follows:]

PREPARED STATEMENT OF JEFFREY M. NATHANSON

Mr. Chairman, Senators, Thank You for the opportunity to address you on the issue of the role of the national laboratories in local economic development. For those of us in New Mexico it's quite clear that the national labs have had a significant impact. Prior to the Labs existence here in Albuquerque, the population was just over 40,000 people. Now we are over the 500,000 mark, just 40 plus years hence.

As far as economic development is concerned the Labs have had a positive impact given the current constraints they are under, I'll explain more about that shortly. The current administrator of Sandia National Laboratories, Dr. Irwin Welber, and the most recent administrators of Dr. George Dacey and Dr. Morgan Sparks have assisted the labs in creating very positive impacts on our local economy. The technology transfer offices of both Sandia National Labs and Los Alamos National Labs have been extremely helpful in their efforts to help New Mexico to capitalize on its resources. They have been given the task of interpreting the Stevenson -Widler act. The law which encourages technology transfer. They have made and excellent start. But, it is only a start.

Albuquerque and New Mexico are among the most rapidly developing areas in the sunbelt. With the national labs we have been a long time leader in the development of new technology. I believe we rank fifth of the 50 states in Research and Development spending, some $3.5 billion each year. We have only recently started to consider taking our place in the commercialization of technology. Some experts suggest that from 3 to 10 times that amount is required to commercialize technology.

Albuquerque and New Mexico's economic future depend on capitalizing on its current high technology environment and upon broadening its technology base to realize more fully the economic potential of its major resources--the minds, talents and skills of its people. The existing assets of a high technology environment have not yet spawned commensurate industrial enterprises. In fact due to some of the problems of our local economy we have seen major industries develop from technology developed here in New Mexico. The first personal computer was not an Apple but in fact an Altair made by an Albuquerque firm. The personal computer software industry was created by a Billion dollar plus company, Microsoft, that got its start in Albuquerque.

New Mexico is a tough place to do business. The Center for Enterprise Development. The organization that publishes "Making the Grade", the analysis of state economies, has just released some statistics that I found startling. New Mexico ranks 7th of the 50 states in new business start-ups. The state ranks 5th in women and minority entrepreneurship. However the state ranks 34th in business growth.

We rank 49th in export of product outside our borders. We start-up businesses only to have them grow slowly or die. We operate our businesses in very narrow local markets, trading almost entirely with in the state. Our entrepreneurs are unable to identify and penetrate new national and international markets because they don't know how and don't know where to go for help.

Starting a business and transferring a technology is a difficult process which takes more than lip service, it takes hard work, patience, perserverence and luck. More importantly it takes resources. A Network of resources, money, management, marketing. We need to create an economic infrastructure. Two years ago many of us who are testifying today came up with a document called "Change, Challenge and Opportunity" which outlined what is necessary for the creation of an economic infrastructure. I will include a copy with my testimony for the record. I think it is an excellent paper even though it is 2 years old. It discusses the need to assist new companies and existing companies with:

Protecting intellectual property

Raising Money

Finding professional help

Locating physical facilities

Finding suppliers

Dealing with State and Local Governments

Getting (and keeping) people--especially entrepreneurs

Finding suitable mentors

There is nationally, among some people interested in technology and business development and people in the investment, venture capital community a perception that needs to be overcome. The perception has been called the "New Mexico Syndrome," the perception that Albuquerque and New Mexico is without good business opportunities - No money, no management and long term development costs on technology.

The labs despite their proliferation of technologies, are not developing products that are easily commercializable. They are developing technologies that are driven by the technology requirements of the labs with a mission of the national defense of the United States, mostly through military applications. The technologies which may be transferred are technology pushed as they say, not market pulled.

They are not developed to answer particular needs of the commercial marketplace. Commercial products are not necessarily just cut out of these technologies.

Technology transfer is not just passing the baton to a company, whether it be a new start-up, or an existing company. And, as my colleagues who follow will tell you technology transfer is not just a shopping mart with shelves stacked with technologies that you can push a shopping cart through.

There have been several situations that I am familiar with where a company has had technology transferred to it only to have millions of dollars spent on further development and still products are not forthcoming. In this particular case the resulting products could have a major positive impact on the Lab's mission as well as the commercial marketplace. But, a great deal of additional basic research must be done. The labs could be extremely helpful if they were given the opportunity to assist this and other companies with the further development of technology. This assistance could come in the form of facilities, which I believe were offered to the Sematech proposal. And, I hope could be provided to new local start-ups. Additionally staff time could be provided or more importantly the labs could contract with the companies to provide the necessary staffing.

Just yesterday I sat in on a meeting with a minority-women owned, 8a certified business owner and an engineer from Sandia discussing the transfer of technology. The engineer said that the labs had developed the technology in his division, but he didn't have time to continue to make these gadgets. The business owner is very interested in making the part, but as a start-up she doesn't have the resources to just have the technology transferred. She needs an initial contract with Sandia to make these parts which the labs can use. Later in the conversation it was realized that there might be a strong commercial application for this technology. The company is interested in pursuing the opportunity but doesn't have the seed capital to explore it. We realized that the Labs could benefit a great deal if this product were developed for the commercial market because if produced in quantity they would be able to buy the part at a much lower cost.

How then could we create a commercialization fund, or investment incentives to provide funds so that companies like the ones I've suggested can be helped in the further development of technology and in the market analysis of the product. Venture capital might be suggested. Yet, as I mentioned earlier, we have to fight the New Mexico syndrome. Venture capitalists don't invest in technologies they invest in businesses and products. Most of our technologies are not yet businesses.

Another Transfer of technology I am familiar with was not a product, but a service. This is a high security implementation business which was formed by Sandia Lab personnel when it was decided by the labs that they were "getting out of the business". The founders were encouraged that they could offer services as security system consultants in the private sector since they were involved in the development of the practice while at the labs.

The company with a gross annual income of $150,000, has been bidding for new contracts under small business set asides with competing bids by companies that are also considered small, yet have gross annual income of $16 million. Perhaps a lower limit for set asides might be developed for local start-up companies. The company would also like an opportunity to have a preview of their technology or knowledge of contract opportunities as a local company, prior to release of RFP's to out of state companies. Set asides are needed that really allow a new company to compete.

The company has also found that since they are in the business of engineering services they are viewed as competition. There is a need to develop a corporate culture within the labs that allows entrepreneurs to break away and come back if necessary and not be admonished for the attempt.

There is an example I'm familiar with of a technology that has both military and commercial application. A process should be developed that allows for a transfer of technology in reverse that provides some funding for the company's effort and protection that the technology will be owned by the company.

I believe that we need to do more in the area of commercialization. I think that the technology transfer process needs to include the market analysis process. I think some type of program needs to be developed to identify market needs or problems and see if the labs have a solution or can come up with a solution readily. I believe later this morning you will be hearing about a commercialization consortium that I believe needs to be supported.

I think there needs to be an effort to support business incubators or innovation centers on a national level. These facilities which specialize in facilities management and facilitation of management assistance for new start-ups are important components. Our program has been very successful to date in assisting new start-up companies. We have received a great deal of local support but we have not received any federal support to date. I believe that the commercialization of technology is a worthy national agenda item and needs to be supported beyond the current federal funding priorities through the Community Development Block Grant program which requires immediate and direct employment of low and moderate income people. That will be an outcome, but its a long process.

I believe that there needs to be more efforts ion the development of enterprise zones that concentrate the resources of the community on commercialization.

Like the development of Healthnet there needs to be the development of Businessnet a coordinated resource base for business. Which has the direct support of the Senators and the congressional delegation. We need your help in mobilizing the community.

The recent failure of the State of New Mexico to attract the U.S. West Research and Development facility and the federal government's Super Collider should tell us we've got to be doing more to get our house in order. We need to build up what we already have existing here in New Mexico rather than trying to attract companies from outside. What would happen if the Governor utilized the $11 million set aside by the legislature to attract the Super Collider, to help develop local companies? We need to help what's here before we go outside.

5/5/86

Change, Challenge and Opportunity

The State of New Mexico is characterized by change, challenge and opportunity.

A recent change of major importance to us is the downturn in the extractive industries in the State.

Clearly we are being challenged to construct a new, more comprehensive State economy. We obviously do not want to abandon our extractive industries--far from it. However, we do need to build a more comprehensive economy, one less susceptible to damage by single industry problems.

The opportunity to do this exists in our State--we have only to build on what we have:

- We have an absolutely remarkable amount of brainpower available in our Universities and in our Federal labs and facilities.

- We have a quality of life second to none.

Everything else we need to revitalize and to expand our State's economy is within our grasp, and by the way, is affordable.

The principal issues are these:

- What are the things we need in order to capitalize on our brainpower and on our quality of life?

and

- How do we put them in place and get things working for us?

Frequently, the "things we need" are referred to as an economic infrastructure, or simply an infrastructure. By definition, an economic infrastructure is comprised of those elements of an economy which permit or enable it to grow and to prosper "almost without thinking about it." If an infrastructure exists, then a person wanting to start a business finds all sorts of helping hands, assuming of course his project has real business merit. If an infrastructure does not exist, then starting a

new business looks like a series of almost insurmountable problems--that is, everything is hard to get done because everything is a first.

Our State's economy obviously has an infrastructure in place already; but the infrastructure we already have is not well suited to the type of businesses that our University and Laboratory brainpower will likely produce--namely, businesses based on technical innovation. To capitalize on our brainpower, we must start now to build an appropriate economic infrastructure.

First, let's deal with the idea that "the economic sky is falling." It isn't! Pieces may be a bit loose, but the whole thing looks steady enough to let us work. In fact, the sky should be regarded as the limit, not the problem.

What we are saying is this--we don't just sit still while we build a so-called infrastructure. No, we start new businesses based on technical innovation and move ahead to a broader economy just as if we knew exactly what we were doing. It's the only way we can learn what the necessary elements are for an infrastructure that will really support our brainpower.

- Do we waste money in this process? Some--but no more than we can help--but inevitably, we will make mistakes because we will be learning and trying new things.

- Can we afford to do these things? Yes--in fact, we can't afford not to do them. But realistically, we have enough money too; we just have to use what we have wisely.

- Does this mean that we New Mexicans are all going to be entrepreneurs? Yes, it does! An entrepreneur is a person to whom the only risk in life is "to not take a risk." These people were called adventurers and pioneers in our history books. So all this stuff boils down to being modern adventurers--in a State settled by such people who put everything on the line to build a new life.

Now let's get down to work. We need to define an infrastructure, see what is missing and decide how to start filling in the gaps.

What Makes a Good Infrastructure?

Let's define our infrastructure this way--new business people need help in:

- Dealing with intellectual property
- Raising money
- Finding professional help
- Locating physical facilities
- Finding suppliers
- Dealing with State and Local Governments
- Getting (and keeping) people--especially entrepreneurs
- Finding a suitable mentor.

By definition, a good infrastructure will provide all of this help.

Before discussing each of these issues, let's get something very clear. A good infrastructure does not make it easy to start a new business nor does it in any way guarantee success. A business must have real merit or it's going to be rejected. In fact, a good infrastructure will reject a poor business idea quicker than will a bad infrastructure, i.e., a good infrastructure "knows what it's doing and can make decisions." As far as success is concerned, a good infrastructure only permits and encourages business success, it doesn't make it happen--only the entrepreneur can do that.

Now let's discuss each of the areas in which new business people need help. These discussions will really be introductions to each of the issues, not comprehensive reviews. The intent here is to provide a basis for us to initiate action--obviously this must be followed by considerable business community involvement and effort to really build an infrastructure.

Dealing with Intellectual Property

Let's start with intellectual property. This is a name for what many of us have thought of as "inventions." People started using the broader term "intellectual property" because the word "inventions" implied patents and much intellectual property is not protected by patents. A "trade secret" is intellectual property, but it is protected by secrecy, not by a patent. (Two of the most famous trade secrets are the formulas for Coca Cola--New and Classic.) The ideas behind legally protecting intellectual property so that the creator has the opportunity to directly

benefit from his or her creativity have been woven into the economic fabric of every modern civilization. This is especially true of our free enterprise system.

This all may be very interesting, but what's the issue? The issue is this--if you want to raise money to start a new business based on a technical innovation, the investors immediately want to know about the intellectual property which is the basis for the business. If you don't have or can't reasonably expect to get "clear title" to the underlying intellectual property, then the formation of the business is unlikely or doomed--one or the other. (The same thing is true in real estate. If you can't get clear title to a piece of land, you can't raise money to build on it.)

So we need an intellectual property environment in our State that encourages free enterprise by making it as easy as possible for our creative people to get and hold clear title to their intellectual property (in the US and internationally).

If a person is independently employed, the solution is straightforward--we only need to make sure that adequate and competent legal talent is readily available to help people properly protect their creations--by patent or other means.

It is more likely in our State, though, that the creative person is an employee of one of our State Universities or a Federal laboratory. In these cases the problem is one of patent policy. We need patent policies that permit an inventor to readily get clear title to his or her patent. The patent policies of our various institutions may require further evolution to provide this ideal environment. In the meantime we need to work within current policies to achieve the object which is to make it possible for an inventor to capitalize on his or her creativity. (This is the way technology transfer to the private sector will really happen from our Universities and Federal labs.)

One other thing about intellectual property--its protection is a negative act, not a positive one. A patent prevents others from capitalizing on the creativity of an inventor without his permission. In no way does a patent guarantee that an inventor will make money. Intellectual property protection such as a patent is a necessity; however, it isn't a sufficient condition for a technically based business to succeed. The rest of the elements of the infrastructure that are discussed below are all related to the other things that a new business needs for success after the intellectual property problems are solved.

Raising Money

Raising money is obviously essential to starting any new business. The following scenario is "typical" for a new business based on a technical innovation. First, an entrepreneur starts with money from "family and friends," so-called "F and F" money. This may carry the project to an investment level of a hundred thousand dollars or so. The output at this point may only be a good business case.

Unfortunately, most businesses based on technical innovation require several hundred thousand dollars or more to get them to a point that venture capitalists, for example, can "see enough" to make them interested in investing. Potential investors ordinarily want to see prototype product or something else that is really good evidence of a potential product or business before they are willing to put up large amounts of money.

The several hundred thousands of dollars necessary to carry a start-up business to the convincing state is frequently called "seed capital." This is the financing that may be the most difficult to raise. There are at least two reasons for this. First, several hundred thousand dollars, perhaps half a million, is a large amount of money to put at risk. Second, the risk is frequently significant. You can have qualified experts thoroughly investigate and review an untried technical innovation and still be uncertain whether it will work, can be manufactured at low cost or can be sold profitably. The only known way to resolve these issues is to invest time and money, develop the product, manufacture it and try to sell it. This means that an infrastructure to support technically innovative businesses must provide access to seed capital from sources that understand and accept the high risk/high reward nature of the investment.

Assuming seed capital has carried a new business to a state that is convincing to potential large investors, the investment level may then increase in steps to any number of millions of dollars. At each step, the business will be expected to meet well defined business and technical milestones. If it doesn't, the investors may intervene with a new management team. This intervention has been found to be necessary in so many cases that the post-seed capital investors frequently insist on effective control of the company in return for their money.

When millions of dollars are involved, the new company is dealing with large investors. These investors may be venture capital funds, individuals, large businesses, pension funds or some other source. One thing these investors all have in common--they don't like all their eggs in one basket. Therefore, at an early stage of a new company, a participating venture capitalist,

for example, may insist that the next step of financing include several additional investors to spread the risk (and to confirm the venture capitalist's judgment). This means that the financing of the business can, and usually does, get a lot more complicated as the investment level grows.

Now let's look at the implications of this scenario. First, seed capital must be available to entrepreneurs from a source, or sources, that understand and accept the risks. Second, entrepreneurs must have access to a number of large investors--whether venture capitalists, large companies, individuals or whatever--in order to finance not only the start but the growth of their companies. Finally, the financing infrastructure must somehow provide a suitable coupling mechanism between the aspiring entrepreneur and the financial system. This last point is very important; the entrepreneur needs "help finding help." After he gets it, he's on his own.

(One last note on finances--banks have been obvious by their absence in this discussion. The reason is simple--banks loan money against real, tangible collateral, not against ideas, patents, hopes and ambitions of entrepreneurs. Some banks have set up venture capital subsidiaries, but even this seems to be the exception rather than the rule.)

Finding Professional Help

Now how about professional help--what does an entrepreneur with a good technical idea need? We've already dealt with the intellectual property aspects--but what else?, This is at least a partial list:

- R and D
- Manufacturing
- Marketing
- Sales
- Management
- Professional recruiters
- Legal
- Accounting
- Insurance

- Benefit plans
- Fund raising
- Board members

R and D. This State is awash in science. Unfortunately, it takes engineering development work to move a piece of science into production as a commercial product. Start-up technical businesses must have access to a reasonable supply of experienced design and development engineers right at the outset (and later to a reasonable supply of newly-minted engineers from which they can grow-their-own). One observation--the engineering translation from a piece of science to a commercial product can take from 18 months to 10 years depending on the complexity of the product.

Manufacturing. Experienced manufacturing engineers are just as necessary as good R and D engineers in order to get commercial products out-the-door. They are also just as hard to find and to train. (Our own Universities surely should be the source to meet many of our needs for both R and D and manufacturing engineering people in the long term.)

Marketing. Marketing is the art of getting your company to make those products which it can sell profitably. People skilled in marketing are relatively rare since it involves working with engineers and manufacturing people on one hand and on the other with markets, advertising, salespeople and customers--and notice that profitability is also involved which means that marketing people have to deal with the financial folks, too. Rare or not, marketing skills are clearly necessary to start-up companies--particularly those with products that are brand new to the customers. So the infrastructure must include access to marketing skills by some means. In time, a local pool of skilled marketing talent must be developed.

Sales. A good, professional, technically trained salesperson is "worth a ton." These people are truly essential to a start-up enterprise. The infrastructure must include access to an initial supply and sooner or later, to a local pool of competent talent. There's not much else to say--you gotta have 'em.

Management. Managers familiar with the problems of technically based enterprises and capable of handling the problems of start-up companies are essential to the infrastructure too. Many times the people that produce the inven-

tion on which a start-up company is based, and that radiate the enthusiasm on which it initially survives, are not the right people to manage it into long term growth. There are numerous examples in which professional managers have been brought in to replace the original entrepreneurs in order to produce long term growth in shareholder equity. A satisfactory infrastructure must provide for the availability of such managers at the appropriate time.

Professional Recruiters. Obviously a technically based company will need to hire a number of professional employees as it grows. As noted above some of the earliest needs will be in R and D, manufacturing, marketing, sales and management. Frequently the best hiring is done by "recruiting through employees;" but supplementing this is usually necessary, especially with an immature infrastructure that doesn't contain a lot of available professional talent locally. In this situation professional talent must be recruited from various parts of the US and relocated; good professional recruiters with widespread contacts can be very helpful.

Legal. The legal help a technical entrepreneur needs is somewhat special--it involves partnerships, Subchapter S corporations, public stock offerings, employee incentive compensation agreements, employee profit sharing plans, employee stock options, special employment agreements and most especially, tax law.

Accounting. Beyond "setting up a set of books," an entrepreneur needs a lot of advice and help on all the tax, property and general business practices that are intended to encourage start-up businesses, especially those based on research and development. An accounting firm by virtue of its many business contacts, can be extremely helpful to an entrepreneur in establishing a business network that will prove useful. (An accounting firm obviously contributes to several of the same business areas to which a legal firm contributes.)

Insurance. These days getting insurance can be a real problem. Product liability insurance is an infamous example. Other forms of liability insurance can be a problem too. Potential Directors may not be willing to serve on the Board of a new company without "Director and Officer" liability insurance, for example. The infrastructure must provide ready help to the entrepreneur to avoid a situation like this. A new company needs the best Board it can get.

Benefit Plans. Although many of the employees of new companies are relatively young, they still insist on reasonable benefit plans, including if appropriate, relocation benefits. In some areas of the US there are consulting organizations that specialize in helping new companies set up affordable benefit packages.

Fund Raising. A lot of an entrepreneur's attention has to be paid to raising money. There are people (who are legally required to be registered brokers in this State) that specialize in helping businesses raise money from the public. A great deal of care has to be exercised in this arena relative to applicable law. Entrepreneurs probably need competent advice in fund raising more than any other area, simply because they know the least about it personally and because it can involve so much law. A good infrastructure must provide this help right at the outset.

Board Members. The infrastructure needs to provide a variety of business people as Board members for new technical companies. Frequently these people are not all local people; instead they come from all over in order to get people with a wide variety of experience. Good Board members are especially important in an immature infrastructure in a city in the middle of the US. This is true because the great majority of the venture capitalists are on the two coasts. Many venture capitalists are reluctant to invest in companies that require long trips to oversee the investment; it takes too much of the venture capitalist's time to be worth it. However, venture capitalists are sometimes willing to invest on the basis of a good Board of Directors--particularly if there are at leást a few capable, local Directors that are willing to spend significant time working with the enterprise and keeping the outside investors informed.

All of this discussion of "finding professional help" points out that there are indeed a large number of elements necessary to an economic infrastructure to support technically innovative start-up businesses. Each element must be present and competent, in order for our infrastructure to be competitive in attracting and holding entrepreneurs.

One final note--start-up businesses frequently can't afford to pay full price for first class professional services (sometimes they can't afford to pay at all); yet they need the very best. One way the professional service offerors can help is by accepting equity in the company as full or partial payment. This obviously means sharing the risk; if a professional service offeror is not willing to share the risk, this may be a first indication that the risk is too high. This is part of what was meant by the observation that a good infrastructure will reject bad business ventures quickly; but hopefully, professional service offerors will indeed see opportunities in which they are willing to share the risk and bet on the future.

Locating Physical Facilities

In addition to all the white collar help, a new company needs a place to live. The physical facilities that are needed to start new businesses based on technical innovation tend to follow the funding in terms of size. However, they rapidly develop a special character about them reflecting the specific nature of the business. For example, the labs associated with a chemical business will be very different from those of an electronics business. But the facilities all should have some traits in common--they should be:

- As inexpensive as possible
- Only as big as necessary
- Equipped with low cost communications
- Rented or leased, not purchased
- Characterized by inexpensive leasehold improvements

The infrastructure needs to recognize that new businesses do not initially want or need expensive, permanent facilities. A new business's best shot at ever needing a permanent building may be to start in a cheap temporary one. In addition, the infrastructure needs to think about shouldering a part of the risk here too. Again, the business community has an opportunity to accept equity as full or partial payment for facilities, just like the professional service offerors.

A last word on facilities--frequently an offer of inexpensive facilities can be used to attract or to retain a new business. So-called incubator facilities and research parks are sometimes used this way. This is good, but it must not be confused with providing a complete infrastructure for new businesses. If this paper has a purpose, it is to dispel the notion that any single aspect of the infrastructure is so important that, assuming it's provided, we've got it made. Not so--we need it all.

Finding Suppliers.

Speaking of things a new business needs--it surely needs a supporting group of suppliers. Most new businesses based on technical innovation get started in manufacturing by using commercially available manufacturing fixtures along with purchased parts and raw materials to the greatest extent possible--it's

the best way to get started quickly. This means that a base of cost effective, commercial suppliers is extremely important to start-up companies. (It also means that transportation costs are important. Even new companies with brand new products must be sensitive to manufacturing costs--right from the outset. Placing a high price on a new product invites competition. Having to maintain a high price because of high manufacturing costs invites bankruptcy.)

Identifying a list of suppliers of basic parts and raw materials somewhere in the US is a way for a company to get started, but ultimately the infrastructure should encourage the growth of a group of competitive and responsive suppliers located throughout the State. This is a way for the whole state to benefit from the growth of technically based businesses. The home office and central factory of the business may need to be located near a Federal lab or one of the Universities, but the suppliers can be in other parts of the State, thereby spreading the economic benefits of the enterprise.

One additional word on suppliers--the Japanese use a concept called "just in time" manufacturing. The basic idea is that suppliers deliver parts to the central factory "just in time" for them to be assembled into the final product. There are a number of benefits implicit in this system. Obviously it minimizes the inventory of parts in the central factory; but maybe more importantly, it forces high quality. If the suppliers ship low quality parts to the central factory, the "just in time" manufacturing approach "just won't work." The moral of this story is this--high quality must be expected and if necessary, demanded, of suppliers if we are to be competitive. So let's build a base of local suppliers that produce cost effective, high quality goods. It's the best way to be truly competitive.

Dealing with State and Local Governments

Now to the government--to nurture business in general, but certainly new small businesses, we need political stability and certainty. Further we need a legislative environment that does what it can to encourage businesses to be formed here and to stay here. This environment could include, for example, State and Local tax incentives for new businesses and reform, as necessary, of workmen's compensation and insurance laws. Locally, there could be special provisions for working with technically based start-ups to ease their entrance into the community--a small business Welcome Wagon approach, for example, in which among other things, local government explains the community to the business newcomer and offers its help and encouragement.

Clearly the State should also be active in higher education reform aimed at making the higher education system a more effective and responsive part of our economic infrastructure. The object would be for the Universities and the other higher education schools to support technically innovative small businesses with their people and resources--and to generate entrepreneurs as discussed in the next section.

Getting (and Keeping) People--Especially Entrepreneurs

It was not by chance that Boston and San Francisco were the first and second hot-beds of technically innovative entrepreneurial businesses in the US. Boston had Harvard, MIT, Boston University, Boston College and Tufts, while San Francisco had Stanford and the University of California at Berkeley. These educational institutions attracted some of the best and brightest students and faculty, as well as some of the best young professional people from all over the US. It is no wonder that some of these people decided they wanted to be rich--and turned into very bright, focused workaholics to meet their goal. Both towns furnished them the resources (and lifestyle) they needed--that's what this paper is all about for us.

Now what do we have? Interestingly enough--a lot. We have our home grown talent plus two Federal labs that have imported an awful lot of special technical talent. We can build on this--we need to encourage an entrepreneurial spirit in the talent we already have, and we need to move as quickly as possible to add to this talent by enhancing our higher education system until it's a really good generator of entrepreneurs. Our State's sustained growth in terms of entrepreneurial businesses must come from growing our own entrepreneurs among the faculty and students in our own Universities. It's a fact that the Federal labs do not have an entrepreneurial mission. We can capitalize on the labs' talent to help us get started, but we can't be dependent on the labs' talent for the long term. We have to generate our own supply of entrepreneurs through our own educational efforts--this is truly a must.

Finding a Suitable Mentor

Along with a source of entrepreneurs, we need a source of entrepreneurial mentors. One of our current problems is that home grown, technically innovative small businesses, that have been demonstrably successful, are in somewhat short supply. This means role models and mentors for our newer entrepreneurs are in short supply. There's no way to substantially increase the supply instantly; but there are a number of wise businesspeople in this State who undoubtedly could be helpful to our newer entre-

preneurs if the coupling were made between them. Making the connection can be difficult, but it is incumbent upon us to do it. We need to help the new entrepreneurs, but we need just as badly for some of the experienced businesspeople of the State to grapple with the issues facing these new businesses. How else can we learn what we need for an infrastructure than by working on real problems in the trenches. Now look back at the preamble to this paper--it says the same thing--we've come full circle.

Recapitulation and Action Items

Let's recapitulate the only way that will produce something useful--let's define action items for the community that will take us closer to the economic infrastructure we need. What are your suggestions?

Action Item - Immediate

Determine a mechanism--group, task force, person or institution--to focus and to integrate all of the efforts on economic development in the State. Pay attention to the problems of:

- Replacing the jobs being lost from all causes
- Bringing new plants to the State whether primary or satellite
- Encouraging the formation and growth of new businesses based on broad innovation
- Encouraging the formation and growth of suppliers to all the buying institutions in the State
- Encouraging the formation and growth of new businesses based on technical innovation and of an appropriate base of suppliers
- Asking for the support and encouragement of the people of the State for these programs

Action Item - Short Term

In concert with the Science and Technology Commission, form a "Quick Help Task Force" of seven (at most twelve) people to work on the immediate needs of the new businesses based on technical innovation, wherever they are in the State. The Chairperson will be from the private sector.

The charge to the task force is to, State-wide:

(1) Inventory the needs of the new businesses beyond those that are being met by the current infrastructure;

(2) Determine ways of meeting the needs;

(3) See to it that appropriate action is taken by the proper people to meet the needs.

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Action Item - Long Term

Form a State-wide "Economic Infrastructure Task Force of Twelve" consisting of twelve Subcommittees of three (at most five) people each. Each Subcommittee will be responsible for putting one element of the infrastructure in place on a permanent basis. Each Subcommittee will consist of two private sector people and one public sector person and will be chaired by one of the private sector people. The Task Force as a whole will meet monthly and formally report to the appropriate legislative group and to the Governor semiannually. The Subcommittee topics are:

(1) Intellectual Property

(2) Fund Raising

(3) Professional People and Recruiting

(4) Legal

(5) Accounting

(6) Insurance and Benefit Plans

(7) Boards of Directors

(8) Physical Facilities

(9) Suppliers

(10) State and Local Government

(11) Higher Education

(12) New Business Mentors

The object is to put a permanent infrastructure in place.

5/5/86

Senator BINGAMAN. Thank you very much, Jeff. That's excellent testimony. I'll have some questions after we get through with the other panelists.

Our next witness is James Greenwood, executive director of the Los Alamos Economic Development Corp.

STATEMENT OF JAMES M. GREENWOOD, EXECUTIVE DIRECTOR, LOS ALAMOS ECONOMIC DEVELOPMENT CORP., LOS ALAMOS, NM

Mr. GREENWOOD. Thank you, Senator. Jeff and I spoke a couple of days ago about what we were going to say, and we had a lot of overlap, and I think we still do. It can be negative, but it can also be very positive, because it shows some consensus among those of us involved in operating incubators in this State in the technology-transfer area.

I commend you for taking the lead in this area on this hearing. I believe the issue of the role of the national laboratories in local economic development is extremely important in this State, particularly so in the northern part, where I'm from, where it is the dominant employer, both directly and indirectly.

I would like to divide my comments into three general sections. First, I would like to make a few comments about things that I believe the national laboratories—and Los Alamos National Lab, in particular—are doing that are benefiting the local economy. Second, I would like to point out a few areas where they are not helping—and in some cases are even hindering—the economy. And finally, I'd like to close with a few specific recommendations.

First, as you said in your opening remarks, the laboratories are an incredible source of jobs and are creating literally thousands of jobs, directly and indirectly, in northern New Mexico. The laboratory's literal benefits and high wages create a very high standard of living in our part of the State that otherwise would not be there. The laboratories also create numerous jobs indirectly through the support organizations, through courier services, concerning contractors and so forth.

A relatively new addition to the local economy are the jobs that are being created by spinoff companies from these national laboratories. Typically, a spinoff company gets started by an employee of the national laboratories who sees an unfulfilled need that can be met by some technology developed at the lab. Sometimes the technology will be sold to other national laboratories; sometimes to private industry; and often, after significant changes and improvements are made, will be sold back to the national laboratories from which they originate.

Our experience in Los Alamos suggests that these spinoff companies create jobs for relatively unskilled labor in the region, as well as skilled labor that may have been released from the national laboratory due to an adjustment in employment at the lab or simply laboratory employees who are seeking new challenges and looking for new direction.

There are a number of specific examples of such spinoff companies in both Albuquerque and the Los Alamos-Santa Fe area. The only one that I would like to note specifically today is one known

as the Los Alamos Technical Associates, which is not often referred to as a technology-transfer-based company. LATA is essentially a consulting firm; but many of its employees are former employees of the National Lab, and through its consulting services, it transfers knowledge from Los Alamos National Lab to other national laboratories, to the Defense Department and to private industry.

From the standpoint of the local community, I believe that the spinoff firms are the single most important source of new economic activity. They create new jobs for this Nation, whereas a firm that relocates from, for example, Cleveland that might move to New Mexico, there is no net increase in jobs. You're simply moving jobs from one area of the country to the another. The spinoff companies are actually creating new jobs for the Nation.

The spinoff companies also tend to start small and grow somewhat gradually, which allows the local community to more easily absorb the new jobs. Training is provided and can be provided when needed, and there is the avoidance of bidding up of the salary of existing employees of other firms trying to steal them away, a problem that has been seen in the Silicon Valley. Similarly, the community's infrastructure is not burdened suddenly, as it is when a U.S. West or similar facility might be moved into a community.

Finally, the spinoff firms tend to stay within the community or the general region in which they started. They tend to have roots there, and they tend to be more committed to that area than a company that may have been located or may have been moved into that community from outside.

Specifically, in the case of Los Alamos Economic Development Corp., I would like to commend the Department of Energy, through its Albuquerque Operations' Office and the Los Alamos Area Office, for its support of our incubator facility and our corporation. DOE has been extremely supportive in the past. I also would compliment the Los Alamos National Laboratories, specifically the Industrial Applications' Office, which entered into a contract with our company last year in which our economic development corporation and the National Laboratory jointly worked on a program involving technology transfer. I think that is a fairly unique public-private partnership.

In the area of some negative impacts from the national labs on local economies, first—and I believe Jeff touched on this a little bit—there is a difference in culture in a national laboratory than there is in a enterpreneurial firm. The national laboratories tend to be oriented at basic or pure science and its applications to energy and defense needs of this Nation. The entrepreneur tends to be looking at a technology in terms of the market and whether or not it would be profitable to bring it to the market. I don't believe either of these views is wrong; they're simply different. And at least in a community like Los Alamos, given the dominance of the National Laboratory, it tends to overshadow the entrepreneur. It tends to provide a community in which the entrepreneur does not feel comfortable. And this is one reason why the incubator, we believe, has been very important in Los Alamos. We have a facility there in which there is a comfortable environment for what I call "the crazies of Los Alamos." We are the ones who are out and interested in making a profit and——

Senator BINGAMAN. "The crazies of Los Alamos" would be "the establishment" everywhere else.

Mr. GREENWOOD. Right, exactly reversed.

The second criticism I would have is the amount of time required for all of the necessary approvals for transferring technology out of the laboratory. Many technology-based products have short life cycles, or they must be introduced within a very brief period of time so that they can complement similar or related products. Also, because you cannot get very strong intellectual property rights along with many of the technologies coming out of the lab, time is of an essence. Time becomes your competitive advantage over other firms.

Unfortunately, the approval process for releasing technology at the national labs appears to be quite slow—if not by usual standards of the Government, certainly by the standard of timeliness required if the technology is to have commercial value in the current marketplace.

Again, I echo Jeff's remarks about the difference between technology push and market pull when it comes to technology transfer. The current programs at the national labs, by and large, try to push a technology out into the marketplace, hoping that there will be some application for it out there somewhere. My analogy would be Congress passing legislation pertaining to the future of the space program and then seeing if it could be applied to another area, such as a national policy on housing. The chances of that happening are very slim, and I'm afraid that's where we are right now in technology transfer at the labs. We're hoping that something that was developed for energy or defense needs will somehow also have an application in the marketplace.

Fourth, I believe that economic competitiveness is the battlefield of the future. The OPEC oil embargo back in the early 1970's is a good example of how nations can be severely wounded by an opponent without a single shot being fired. The Reagan administration's recent efforts to force a political change in Panama by crippling the country's economy is another. I believe America continues to pump billions of dollars into conventional and nuclear weapons' research, development and construction; yet, we virtually ignore our inability to effectively compete in our own Nation's economy, much less the international economy. The economic vulnerability of this country is a problem that remains largely ignored or unrecognized by the President, by Congress, by the national laboratories and by the American public in general. I believe until this problem of economic competitiveness is recognized and receives the attention that it deserves, technology transfer will not become a priority in the national laboratories.

Finally, under recommendations: First, I would like to see the national laboratories be more accepting of the entrepreneur and the entrepreneur's profit motive. That doesn't mean that every employee of the national laboratory has to become a profit-hungry monger like some of us, but simply that they might be more willing to accept it as a reasonable and legitimate driving force in technology transfer. I believe leadership in this needs to come from the directors of the national labs, from our Governor, from our Congressmen and from the President.

I also would suggest that it's needed at such a basic level as our education system. It is extremely easy in our public schools to get career-counseling assistance in learning how to write your résumé and how to interview at a company; but I would submit that there are very few schools in this Nation that teach you how to develop a business plan, how to think about a marketplace, and encourage kids to go out and pursue the American dream based on owning their own company.

The second recommendation is that the process by which technologies are transferred out of the national laboratories must be streamlined. Legislation will not be the only thing that will cause this to happen. There needs to be a commitment by the Department of Energy, the national laboratories and the operators of the national laboratories.

The third recommendation, to improve the success of technology transfer out of the national labs, I believe the needs of consumers must be recognized as the ultimate driving force behind technology transfer. To do this, the national laboratories need to be more open to companies that are looking for technology; and more so, I believe, the national labs need to educate their own employees and management about the basics of marketing and product development. Such an education will enable national laboratory employees to better understand and appreciate the needs and priorities of private industry and will also prepare those employees who might have an interest in starting companies of their own and transferring technology on their own.

Fourth, I believe that those laboratory employees that are participating in technology transfer need to be given greater incentives. I would recommend annual awards banquets, at which those who have made accomplishments in this area are acknowledged for their efforts. Also, I would suggest that there be financial incentives for the national laboratory employees—for example, a royalty system in which both the employee and the employee's group at the national lab receive financial gain, could be very beneficial. And, I believe employees should be given leaves of absence to pursue an entrepreneurial venture. I might add that Los Alamos National Laboratory has such a program, although I believe it is somewhat unofficial, and I do not believe there is a guarantee of a job for that employee, should they decide to return to the Lab.

The fifth recommendation would be that a forum be created similar to the New Mexico first Town Hall Meeting that was held last fall in Ruidoso, at which the marketing of New Mexico was discussed. We need a similar forum in which companies, the national laboratories and people like Jeff Nathanson and myself can sit down and discuss the concept of technology transfer, its impact on the local economies and its importance to economic competitiveness, and to work toward a consensus and come up with a plan for this State in terms of really exploiting the technology at the national laboratories. I would suggest that perhaps that would be a good area of leadership for you, Senator, to pull such an effort together.

Finally, I would like to, again, ask that this Nation's leaders begin building a commitment to economic superiority in the global economy. We have already lost many economic battles with other

nations, and many of our basic industries have been gutted as a result. Futurists tell us that a period of great technological advancement is starting, which would suggest that America will fall even further behind the Japanese and the Koreans in the development and sale of technology-based products. Our conventional nuclear weapons' stockpile will be worthless if we become a nation whose economy is so weak and inferior that we are heavily dependent on foreign sources of energy, materials, and technology-based products. Thank you.

[The prepared statement of Mr. Greenwood follows:]

PREPARED STATEMENT OF JAMES M. GREENWOOD

I would like to thank Senator Bingaman for his invitation to speak before this hearing of the Joint Economic Committee regarding the role of national laboratories in local economic development. This is an issue of particular importance to New Mexico because of the presence of two major national laboratories in the state which have substantial impact on New Mexico's economy. This impact is particulary significant in north central New Mexico because of the dominance of Los Alamos National Laboratory as a direct and indirect employer and source of income for both families and businesses in the region.

I would like to divide my comments into three sections. First, I would like to comment on some activities of national laboratories, and Los Alamos National Laboratory in particular, that are of benefit to the economies of the communities and regions in which they are located. Second, I would like to point out some of the areas where national laboratories are not assisting local economies and, in some instances, even having negative impacts on those economies. Finally, I would like to make some specific recommendations regarding how to increase the benefits and decrease the neutral and negative impacts of national laboratories on local economies. I will try to focus my remarks on interactions between national laboratories and local economies that are the result of technology transfer; however, there are some additional important interactions on which I would like to comment.

NATIONAL LABORATORY BENEFITS TO LOCAL ECONOMIES

As I mentioned in my introduction, national laboratories can have significant positive impacts on the economies of the communities in which they are located, as well as surrounding communities in the region. In the case of Los Alamos National Laboratory, literally thousands of jobs are created in north central New Mexico, a region that traditionally has suffered from high unemployment and jobs with little potential for advancement. The Laboratory's liberal benefits programs allow for high standards of living for many families throughout the region, and indirectly create many jobs for retailers and service providers who serve the needs of these employees.

National laboratories also are the source of additional jobs through the support-providing companies such as Pan Am World Services, which provides maintenance and construction support for Los Alamos National Laboratory, and computer and office equipment

suppliers and repairmen, courier services, and construction contractors. Los Alamos National Laboratory has made significant efforts to procure goods and services from New Mexico companies, particularly small and minority-owned businesses.

A relatively new source of jobs being created in communities near national laboratories is the "spin off" company. Typically, this firm is started by an employee of the national laboratory who sees an unfulfilled need that can be met by some technology or specialty that they developed at the laboratory. Sometimes this technology or expertise is sold to other national laboratories, othertimes it is sold to industry, and sometimes it is sold (assuming that significant changes and improvements have been made) back to the national laboratory from which it originated. Usually, the market is some combination of all of these.

Our experience in Los Alamos suggests that these spin off companies create jobs for relatively unskilled labor in the region (for clerical and assembly operations), as well as for skilled labor that has been released from the national laboratory or that is seeking new challenges. Specific examples of successful spin off companies from Los Alamos National Laboratory would include AMTECH Corporation (now located in Santa Fe), Optomec Design Company (now in Los Alamos and soon to relocate to Santa Fe), Jomar Systems, Inc. (located in Los Alamos), Los Alamos Diagnostics, Inc. (located in Los Alamos), and Los Alamos Technical Associates, Inc. (located in Los Alamos). I will not provide detail regarding each of these companies, since I expect that other speakers at today's hearing will have more to say about them.

I would like to note, however, that some of these firms represent the successful transfer of knowledge from Los Alamos National Laboratory, as opposed to the transfer of some specific device or product. I believe that we often think too narrowly of technology transfer as only including the transfer of some physical object from an energy or defense application to a commercial or industrial application; much successful technology transfer occurs when a former employee of a national laboratory transfers knowledge to other national laboratories, to other government agencies, and to the private sector. Within this broader definition of technology transfer, companies like Los Alamos Technical Associates, which provides technical and engineering assistance to government and industry, and which employs many former employees of Los Alamos National Laboratory, is a very important participant in technology transfer.

From the standpoint of the local community, I believe that these spin off firms are the most important and valuable source of new economic activity. They not only provide new jobs but, unlike existing firms that might relocate into a community, these jobs typically are created gradually and therefore make it easier for the local community to "absorb" the jobs (in terms of providing training and avoiding the necessity of stealing employees from existing firms). Similarly, the community's infrastructure is not

burdened suddenly, as it is when a firm relocates, and therefore allows for an orderly development of additional infrastructure to accommodate the growing firms. Also, spin off firms tend to stay in the community (or at least the general region) where they start, and are less prone to relocating when economic developers from other states try to entice them to their communities.

NEGATIVE IMPACTS OF NATIONAL LABORATORIES ON LOCAL ECONOMIES

While the transfer of technology from national laboratories has undoubtedly benefitted local communities, there also have been some negative impacts.

First, the "culture" of a national laboratory tends to provide an inhospitable environment for spin off companies. National laboratory employees tend to be dedicated to science for its own sake (interest in "pure" or "basic" science), and/or its application to the nation's energy and defense needs. While these are noble causes, they tend to be different than those of the entrepreneur, who typically is looking for an application of science that will yield profitable goods and services. Ordinarily there is no problem with these two different views of the world, but the dominance of the former over the latter in a community like Los Alamos can cause discomfort for the entrepreneur. The discomfort yields to business problems because the entrepreneur often must rely on the national laboratory scientist to provide information on a technology and to push the transfer of that technology through the approval process of the national lab, the operating contractor, and the Department of Energy.

Second, the time required to acquire all of the necessary approvals for transferring a technology may make the attempt valueless. Many technology-based products have very short life cycles, and must be introduced at just the right time to complement related products that are coming to market. Also, because of the inability to get strong intellectual property rights to technologies developed at a national laboratory, transferred technologies must be introduced quickly before competitors can react (rapid introduction sometimes gives the firm a large initial market share, which can be maintained despite the lack of patents). Unfortunately, the approval process for release of a technology is very slow, if not by "usual" standards then certainly by the timeliness required for a technology to have market value to an outside firm.

Third, technology transfer, as it is currently practiced at some of the national laboratories, is doomed to a slow, painful, and inefficient future. This is because of the difference between technology push and market pull as driving forces for technology transfer. . Current programs at national laboratories try to "push" a technology out into industry, in the sense that the laboratory tries to find some company which has the vision to see how a technology developed for a defense or energy application can

be used in a commercial product. An analogy would be Congress passing legislation pertaining to the future of the space program, and then seeing if the same legislation could be applied to another area, such as a national policy on housing: the chances of something that was designed to meet one specific need being a good answer for another need are very slim, at best.

Fourth, economic competitiveness is still not grasped by Americans (including the management and employees of national laboratories) as the battlefield of the future. The OPEC oil embargo in 1973 and 1974 was a good example of how nations can be severely wounded by an opponent without a single shot being fired. The Administration's recent efforts at forcing political change in Panama by crippling that country's economy is another. America continues to pump billions of dollars into conventional and nuclear weapons research, development, and construction, yet we are virtually ignoring our inability to effectively compete in our own nation's economy, much less the international marketplace. The economic vulnerability of this country is a problem that remains largely ignored (or unrecognized) by the President, Congress, and the national laboratories. Until this problem is given the attention that it deserves, I do not believe that technology transfer will become a priority of the national laboratories.

Finally, the strengths that a national laboratory brings to the local economy also hinder the potential benefits from technology transfer. National laboratories provide well paying jobs, job security, and good employee benefits. This secure, well paying environment is difficult to leave to start a risky spin off business. National laboratories also do not provide significant incentives for employees to participate in technology transfer; employees who make significant contributions to technology transfer do not receive much recognition monetarily or otherwise.

RECOMMENDATIONS

If we expect to see significant increases in the transfer of technology from our national laboratories, and in the positive impacts of these laboratories on local economies, a number of changes need to be made.

First, national laboratories need to become more accepting of entrepreneurs and their profit motives. This doesn't mean that every employee of a national laboratory needs to embrace the profit motive, it simply means that it must be accepted as a reasonable and legitimate driving force in technology transfer. Leadership in this area must come from the directors of national labs, our governors and congressmen, and the President.

Second, the process by which technologies are transferred must be streamlined. Legislation alone will not cause this to happen; there also must be a commitment by the Department of Energy and the national laboratories and their operators.

Third, to improve the success of technology transfer from the national laboratories, the needs of consumers must be recognized as the driving force behind the desirability of a particular technology. To achieve this, the national laboratories need to be more open to companies that are looking for technologies, and they need to educate their own employees and management about the basics of marketing and product development. This education will enable national lab employees to better understand the needs and priorities of industry, and will better prepare those who may have an interest in starting companies based on lab technologies.

Fourth, national laboratory employees need to be given incentives for participating in technology transfer. Annual awards banquets at which their accomplishments can be acknowledged would be an inexpensive, uncontroversial way of starting this. I also would encourage national laboratories to develop financial incentives in which lab employees can participate in the success of transferring technology to industry. A royalty system, in which both the individual employee and their organization within the national laboratory receive payment, could be very beneficial. Employees also should be given leaves of absence to pursue an entrepreneurial venture (Los Alamos National Laboratory has such a program, although it apparently is an unofficial one and it does not guarantee the employee a job if they decide to return to the Lab).

Finally, I would ask that this nation's leaders begin building a commitment to "economic superiority" in the global economy. We have already lost many economic battles with other nations, and many of our most basic industries have been gutted as a result. Futurists tell us that a period of great technological advancement is starting, which suggests that America will fall even further behind the Japanese and Koreans in the development and sale of technology-based products. Our conventional and nuclear weapons stockpile will be worthless if we become a nation whose economy is so weak and inferior that we are heavily dependent on foreign sources of energy, materials, and technology-based products.

CONCLUSION

Again, I appreciate the opportunity to make a statement at this hearing, and I would be happy to address any questions from members of the Committee.

Senator BINGAMAN. Thank you very much.

Our next witness is Ross Robinson, executive vice president, Los Alamos Diagnostics in Los Alamos. We're glad to have you here.

STATEMENT OF ROSS U. ROBINSON, EXECUTIVE VICE PRESIDENT, LOS ALAMOS DIAGNOSTICS, INC., LOS ALAMOS, NM

Mr. ROBINSON. Senator Bingaman, I'm pleased to be here today to share some ideas on economic development deriving from the national labs. My name is Ross Robinson. I'm executive vice president of Los Alamos Diagnostics. The president is John Lonergan, who was invited to make this presentation. He is not able to be here today for reasons that I'll explain later.

Los Alamos Diagnostics is a biotechnology company manufacturing instruments and reagents for the performance of rapid microbiological tests. These systems are sold in the United States and internationally to hospital laboratories, large private testing centers, as well as industrial accounts that require rapid identification of microbial contamination. Our focus is on marketing these products.

The company is now 2 years old. It had sales of approximately half a million dollars in 1987, five times that number is projected for 1988—we are on schedule for doing that—and anticipating further doubling in 1989 to about $6 million.

We presently employ 27 people, including a field sales force in the United States, distributors in Europe, as well as our own sales' staff headquartered in Holland. We have a distributor for industrial products in Japan. We have just gone public and will soon be listed on the over-the-counter market.

Technology transfer from the national laboratories was not the circumstance of this company; but a core team of LAD people came together in Los Alamos as a result of a large technology transfer agreement, which evolved into Mesa Diagnostics. That technology became known as Multiparameter Light Scattering and resulted from research within the Health Sciences Division of the Laboratory.

My industrial experience started with Abbott Laboratories and progressed from being a bench scientist to the management of three major outside technical products into an emerging diagnostics' division. Along with similar responsibilities in several divisions of Boehringer Mannheim, a German diagnostics' firm, my time with transferring products from innovators, either inside or outside the company, totals more than 20 years.

From these experiences, I learned the important lesson that regardless of the situation, technology transfer, in all of its many facets, is a tough job involving human beings who, in the end, determine the success or failure of the process.

The definition of "success" has to be the introduction and continued sale of goods or services. Unfortunately, the process cannot be reduced to procedures, policies, or computer programs. People are always involved.

Today, our focus on economic development is on the issues of transfer to local companies and specifically on what we'll refer to as small high-tech firms. All economic enterprise, obviously, assists

economic development. Small, fast-growing, high-tech local companies provide the greatest amount of economic development, for several reasons. We say the multiplier is higher.

Companies such as ours rely more than the average business on outside suppliers. We have 27 employees, but we influence perhaps over 100 different jobs, many of these in New Mexico.

Our company is essentially locally owned. The shareholders earn their wealth and spend it, to a large degree, in New Mexico. Profits and stock appreciation are largely held within the State.

We consider that we are more efficient with capital than other businesses. Small entrepreneurial companies create an opportunity to make a big business, but with rather a small amount of up-front capital.

Now there are technologies and product concepts that can be dealt with only by large companies with large R&D staffs and large budgets. The Industrial Applications' Offices of Federal laboratories promoting the sale of these have to market them nationally and perhaps internationally.

There are other ideas that perhaps can be commercialized by small focused companies targeting specific markets. Occasionally, the concept and the local company will match; but this happens seldom.

There are other ideas that, for a variety of reasons, need the creation of a company, or at least a new team, to move from conceptualization to a new commercial success. This proves to be usually a local matter. This category is frequently where the inventor decides, "If it's going to get done, I'm going to have to do it myself."

The encouragement of this process becomes most frequently a local issue, because it's logical to do it at home—an issue that has important economic consequences to the community and to the State. This is where we all want to help; but it is in an area where we know little and feel very uncertain about the best ways to proceed.

The other testimony that's being given today focuses on the laboratories' efforts to get the technology out and on the community efforts, using devices such as incubators, to ease and implement this local transition. I would like to focus on the evolving company, which is frequently a high-tech firm starting from zero, but with a product line concept suggesting much bigger things to come.

Now this evolving and growing company is critical to the process. All the magnificent benefits of economic development arising from the transfer of technology prove to be zilch unless this corporation continues to exist. It has to complete the development of the products and sell the finished goods or services. It has to proceed to develop more products. It has to continue this growth, employ more people, bring new talents to the community and consistently generate profits for its employees and shareholders.

Unfortunately, it has to be pointed out again that the availability of financing is the critical element in this process. Almost by definition, a small high-tech business must be fast moving, because in a market area that is worthwhile there will be competition, and the company needs to penetrate the market before the competition develops a better product. This means that there are frequent

changes in plans. These have to be anticipated, and decisions have to be made quickly and precisely.

It is for this reason that venture capitalists insist that the lead investor be nearby and be one who can participate in that process and optimize their interests. This is why it is said, "There is no shortage of venture capital, but only of venture capitalists."

I do not believe that there is a strong prejudice against New Mexico opportunities. It's just that the investors want someone here that they can trust to be sure everything is proceeding on course.

Further, this fast-moving, high-tech firm is going to invest in people. It's going to invest in special manufacturing equipment, in marketing and inventory, rather than bricks and mortar. This is where corporate value is established, and it is the best way for investors to be compensated for their risk investment.

Operating a business of this type requires lots of working capital; but financial statements and asset lists for such a company leave many bankers extremely uneasy. It is not the collateral they would normally loan against. Working capital is simply needed to grow the business. That's the core of the opportunity; but for the company, it's most difficult to find.

Mr. Lonergan is not here today for the very reason that our working-capital requirements cannot be met, and we need to seek help outside of New Mexico. Maybe the money is here, but not available for this critical component. In other places, other bankers know how to handle this need.

Even more specifically, we continue to talk with the Small Business Administration about filling this critical gap. While we have been rejected repeatedly, we continue to urge them to move beyond their bricks-and-mortar mentality to a position where the small high-tech business can benefit from their programs. Since this is a Federal Government program, we urge you to scrutinize this agency, which frankly has demonstrated a hostility to the very kinds of businesses you profess to encourage. They blame the problem on you. They say they are only operating under the rules that Congress created.

Now beyond that critical issue of survival, there are a number of valuable interactions that the small high-tech company can have with a national laboratory. I certainly endorse many of the ones that have been mentioned. I would like to add a few of my own.

I believe the laboratories should be encouraged in every way possible to have their staff welcome industrial people. This is true for us in Los Alamos, and it needs to be extended.

It would be good if there were times when the technical equipment could be loaned or access made to it. This would be most productive. Further, there are times when the use of laboratory facilities, which are extremely expensive for small companies, should be encouraged.

It would be good to see the laboratories develop the equivalent of a graduate-student turnover. In the university, ideas are carried out into the environment by graduate students. The laboratory student can carry the technology and enthusiasm to a multitude of other environments. Frequently, they are the ones that see the new and unexpected applications.

It's been referred to several times that what is in the national laboratories for the outside world really represents proof of principle. It shows that it can be done, but it hasn't been reduced to a point where the device can be made to be understood by other people. The laboratories may be able to help in the process of making useful prototypes which are then needed to entice venture capital.

There remain many other comments regarding the interaction with the national laboratories, the incubator process and the entrepreneur, but I'll save these for another occasion.

Your attention is appreciated, and I'll be pleased to answer questions.

Senator BINGAMAN. Thank you very much. I appreciate that testimony.

[The prepared statement of Mr. Robinson follows:]

PREPARED STATEMENT OF ROSS U. ROBINSON

Senator Bingaman - I am pleased to be here today and to share ideas on economic development deriving from national laboratories. My name is Ross Robinson and I am Executive Vice President of Los Alamos Diagnostics. The President is John Lonergan, who was invited to make this presentation, but he is not able to be here today for reasons I will explain later.

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The company is now two years old, with sales of approximately $0.5 MM in 1987, five times that number projected for 1988 ($2.5 MM) and anticipating further doubling in 1989 to about $6 MM. We presently employ 27 people including a field sales force in the United States, distributors in Europe as well as our own sales staff in Holland, and a distributor for the industrial products in Japan. We have just gone public and will be listed on the over-the-counter market.

Technology transfer from a national laboratory is not the case of LAD, but the core team of LAD came together in Los Alamos as a result of the large technology transfer agreement which evolved into Mesa Diagnostics. That technology became known as Multiparameter Light Scattering and resulted from research within the Health Sciences Division of Los Alamos National Laboratory.

My experience was first with Abbott Laboratories as a bench scientist, then a research manager moving to managing drug candidates to market, a transition to corporate planning and later the management of three major outside technical products into the emerging diagnostics division. Along with similar responsibilities at several divisions of Boehringer Mannheim, a German diagnostics firm, my time with transferring products from inside or outside innovators totals more than twenty years.

From these experiences, I learned the important lesson that, regardless the situation, technology transfer, in all of its many facets, is a tough job involving human beings who, in the end, determine the success or failure of the process. The definition of success must be the introduction and continued sale of goods or services. The process cannot be reduced to procedures, policies, or computer programs.

Our focus on economic development today is on the issues of transfer to local companies and specifically to small high-tech firms. All economic enterprise assists economic development. Small, fast-growing, high-tech, local companies provide the greatest amount of economic development for several reasons:

a. the "multiplier" is higher: in our diagnostics manufacturing business, we rely more than the average business on outside suppliers. We have 27 employees, but we generate over 100 jobs, many of these in New Mexico.
b. the company is locally owned: the shareholders earn their wealth, and spend it to a large degree, in New Mexico. Profits and stock appreciation are largely held within the state. Even a large branch plan, when the stockholders are outside of the state, cannot generate the wealth for New Mexicans.
c. we are more efficient with capital than other businesses: small, entrepreneurial companies have the opportunity to make a big business with little up front capital. Our demand on the resources of the State are less than for many more established companies.
d. the kind of jobs generated by our type of business are suited to the New Mexico work force. We use people with high school and technical school qualifications. We train people on the job.

It is important to remember there are several levels of technologies appropriate for transfer. These include technologies, or product concepts, that can be dealt with only by large companies with large R&D staffs and large budgets. Industrial Application Offices promoting the sale of these need to market these nationally and perhaps, internationally. Others can best be commercialized by small focussed companies targeting specific markets. Occasionally the concept and a local company will match but this happens seldom.

Other ideas for a variety of reasons, need the creation of a company, or at least a new team, to move from conceptialization to a new commercial success. This is usually a local matter. This category is frequently where the inventor, or someone who perceives commercial utility where others fail to see, decides "if it is going to get done, he/she is going to have to do it themselves".

The encouragement of this process becomes most frequently a local issue because it is logical to do it "at home" - an issue that has important economic consequences to the community and the state. This is where we all "want to help" but in an area where we know little and feel very uncertain about the best way to proceed.

Other testimony today focusses on the laboratories' efforts to get the technology out and on community efforts using devices such as incubators, to ease and implement the local transition. I would like to focus on the evolving company - which is frequently a high tech firm starting from zero but with a product line concept suggesting much bigger things to come.

While indirectly related to the national laboratories, this evolving and growing company is critical. The magnificent

benefit of economic development arising from the transfer of technology is zilch unless this corporation continues to exist, completes the development of the products and sells the finished goods or services: proceeds to develop more products, continues the growth, employs more people, brings new talents to the community and consistently generates profit for its employees and shareholders.

It must be pointed out again that availability of financing is a critical element in the process. Almost by definition, a small-high tech business must be fast moving because if a market area is worthwhile, there will be competition and the company needs to penetrate the market before the competition develops a better product. Changes in plan have to be anticipated and need to made quickly and precisely.

For this reason venture capitalists insist that the lead investor be nearby and be one who can participate in the process and optimize their interests. This is why it is said - "there is no shortage of venture capital but only of venture capitalists". There is no prejudice against New Mexico opportunities just that they want someone here they trust to be sure everything is moving ahead.

Further this fast moving high-tech firm is going to invest in people, in special equipment, in marketing and inventory rather than bricks and mortar. This is where corporate value is established and is the best way for investors to be compensated for their risk investment. Operating a business of this type, requiring lots of working capital but financial statements and asset lists for a company of this type leave many bankers extremely uneasy. It is not the collateral they normally loan against. Working capital is needed to grow the business-the core of the opportunity for the company but most difficult to find. Mr. Lonergan is not here today for the very reason that our working capital requirement cannot be met and we need to seek help outside New Mexico. Money is here but not available for this critical component. In other places, other bankers know how to handle this need.

Even more specifically, we continue to talk with the SBA about filling this critical gap. While we have been rejected repeatedly, we continue to urge them to move beyond their "bricks and mortar" mentality to a position where the small-high tech business can benefit from their programs. Since this is a federal program, we urge you to scrutinize this agency which has demonstrated a hostility to the very kind of businesses you profess to encourage. They blame the problem on you. They profess "they are only operating under the rules the Congress has created."

If the small high-tech company is to service the purpose of economic development, survival is absolutely critical and financial issues are critical to nearly all companies. To this end every effort must be made to accomplish the following:

1. Working capital for this kind of company is vital and all mechanisms need to be found to assure availability.
2. The Small Business Administration procedures must be modified to permit loans and loan guarentees to this type of company.

Beyond survival, there are a number of valuables interaction of the small, high-tech company with a national lab. Here are a few selected suggestions:

1. Should be encouraged in every way possible to have staff welcome industrial people. Loan of, or access to, technical equipment would be most productive. The use of lab facilities, very expensive for small companies, should be encouraged.
2. The laboratories develop the equivalent of "graduate student turnover". The "student" can carry the technology and enthusiasm to other environments. Frequently they see new and unexpected applications.
3. Help in the process of making useful prototypes needed to entice venture money.

There remain comments related to the interaction of the national labs, the incubator process and the entrepreneur, but these will be saved for another occasion. Your attention is most appreciated. I would be pleased to answer any questions.

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Senator BINGAMAN. Next is James Williams, Deputy Director of the Office of Industrial Applications at Los Alamos.

We're glad to have you here.

STATEMENT OF JAMES M. WILLIAMS, DEPUTY DIRECTOR, OFFICE OF INDUSTRIAL APPLICATIONS, LOS ALAMOS NATIONAL LABORATORY, LOS ALAMOS, NM

Mr. WILLIAMS. Thank you, Senator. It is a pleasure to be here and to represent the laboratory and those people that work so hard in technology transfer.

I should say that I'm one of "the crazies in Los Alamos," too. I believe that we can make technology transfer work; but we sure have a lot to do before we get there.

Los Alamos National Laboratory plays a major role in economic development. It goes way beyond technology transfer. And I will focus on that, but I would like to mention just a few aspects.

One of the most important things that our national labs do in carrying out their mission is to be the best at what they do, so that our programs can continue and maintain the level of employment that we have. For example, at Los Alamos, we've done economic-impact studies that show that about 1 in 20 jobs in this State are created by virtue of the fact that Los Alamos exists in New Mexico.

In addition, the laboratory is a potential area of economic development support—as well as existing area of support—where there is contractual work that has to be done, and that supports businesses in the region who have the capability to contract with us. But even more than that, there is the potential for internal support services to be contracted out. That we haven't explored. I want to mention this, because of the potential of starting up businesses that may not be high-tech businesses, but that could be businesses that are more economical for the lab on a contract basis than to do internally. These businesses are able, then, to contract more broadly—not only in the State, but outside the State—to develop new jobs for New Mexico.

We do two key things in technology transfer that I want to mention. One is that we work very hard to attract high-tech business to New Mexico. We've heard already about some of the problems we've had with that. I think we're getting smarter. We do have to be very careful that we're realistic about who we try to bring to New Mexico; that we, indeed, have the resources—especially the infrastructure—that will be needed to support new business in the first place. And we have heard much about that already from panel speakers. The main point I wanted to add is that we at the Lab are pursuing partnerships with the defense industry in a number of areas where the Los Alamos Lab has excellent capabilities in advanced concepts and technology. To the degree that large companies from the defense industry come to New Mexico to work with Los Alamos, this situation offers the opportunity that they might locate an office here, or they even might want to establish an R&D lab here and so on. So in that sense, I think it's appropriate for us to help attract new business to New Mexico.

Now I want to focus on the process of encouraging small businesses, new business startups and entrepreneurial startups from the Laboratory.

The Lab does a number of things to work with local businesses. First of all, we have spent a lot of time recently just trying to understand, "Where are there opportunities to work with local businesses?" And we've heard a lot about it here today, so I won't repeat it. We have learned what these small business startups need to be successful. They need knowledge of technology, markets, financing, good management, and so on. Now we at the Lab do not have these skills. In fact, this is where I think the local business infrastructure has been very helpful.

Over the years we have worked with the network of business entities within the State who provide support to small business—the Los Alamos Economic Development Corporation, the Technical Innovation Program at UNM, other incubators in the State such as Jeff's, the Riotech organization—those entities are more capable in the area of being able to help business people out at the Lab.

There's one key point that's been alluded to here that I want to emphasize specifically regarding the high-tech entrepreneur. Any business has to deal with the list of strengths and capabilities that I just mentioned. But the one thing the high-tech entrepreneur has to do is to deal with the question of, "How do I reduce the technical risks of a concept that may exist in a laboratory, but that's going to require significant effort to develop it to the point where we can conclude that that concept is technically not risky?" Then after that, he still has all the marketplace and business requirements that are necessary for commercial deployment. This tends to be the area in which the most uncertainty exists when we do technology transfer from the Lab. What we need is to be able to find ways to find the knowledgeable investors to invest in reduction of technical risk.

In general, the Federal Government is responsible for funding long-term, high-risk projects. In past years, the Department of Energy had significant programs which they tried to carry into the commercial marketplace. But now they've sort of backed off with new policies to find long-term, high-risk programs, thus leaving a development gap. This is something we must address if we're to be successful in helping our high-tech entrepreneurs.

So what is the key thing that the Laboratory offers? Well, we offer access to technologies that exist in the Lab, and we are very proud of the fact that there are a tremendous number of innovative ideas in the laboratory. On the other hand, we find that typically people in the Los Alamos Laboratory are not entrepreneurs. They're doing what they do best, they're doing research. They have a comfortable working environment, and in general they're not likely to be the people who spinoff and start other companies. Now there are exceptions, and I'll mention some of those in just a moment.

Of the key technology transfer mechanisms that exist right now and that are not causing problems, probably one of the most important is consulting. Laboratory employees have a liberal potential for privately consulting with small companies. They can negotiate any arrangement they want, as long as it is in no way in conflict

with the role that they perform in the Laboratory. This has been done widely over the years and is probably one of the best ways of getting technology out the Laboratory. It's hard to measure how much has been accomplished but we believe it has been one of the most effective mechanisms of technology transfer.

Another mechanism that is quite good is to have industrial staff members come to our Laboratory. A small company, if they'll pay for the individual, can send someone to work in collaboration with our people. They can work on a joint technical project that will allow this individual to take back to his company technical knowledge, since he's the one who really understands the product he's trying to develop, that should be of use to him.

Patents and licenses get a lot of attention, and, indeed, they're very important; but they do depend on the laboratories' ability to decide what has commercial potential. And I think that in many cases, since there is this risk-reduction problem, it's very difficult for us to make a wise decision. However, we have a very capable group who are doing this, and we do the best we can.

Another technology transfer mechanism is user facilities. We have a number of nationally designated user facilities which allow someone from industry to come in and use, on a full cost-recovery basis, these facilities. They then could take the data acquired and the ownership of that data with them when they leave.

The Lab encourages entrepreneurial spinoffs. Here are examples of things that we do, and Jim Greenwood mentioned some earlier. We are willing to give a leave of absence to entrepreneurs who want to go out and try their hand in the business world. We do the best we can to bring them back to the Lab, should they fail. Our policy is to try to do that; but as Jim says, there are no guarantees. As a matter of fact, LAEDC is helping us to structure programs that will recognize our entrepreneurs. We have an innovators' forum that we hold once every month. We bring recognized entrepreneurs from around the country to Los Alamos to talk to people—not only in the Lab, but from around the community—about entrepreneurship. And in some cases an entrepreneur will show his experience in the innovator forum.

Another thing we do—in the energy research and applications side of the Lab—we have as part of our performance appraisal the requirement to support technology transfer. Now I should say that these are evolving and emerging methods of encouraging technology transfer that we do as we learn. There is the potential for much more, and I'll hit that very briefly at the end.

I thought I'd mention a couple of examples of high-tech spinoffs. The one I love to talk about is the very first one that occurred back in the early years, when Los Alamos decided that we weren't going to do the engineering of particular weapons and founded Sandia National Laboratories to help us with it.

But seriously, one of the most recent, and the one we like to talk about a lot, is a company that has an electronic identification system that was developed under a Department of Agriculture program—you've probably heard of this one—that would help to measure remotely the temperature of live cattle. The expectation was that would help farmers. But, it didn't sell very well.

The patent holder was a laboratory inventor. He got some venture capital. But the way it turned out, the farmers weren't interested. But as happens in the business world many times, something else came along. Today, it looks very possible that this business will grow while they develop their device for use in tracking of cars, automobiles through toll booths, and that sort of thing. So here is a company that has spun off in the last 3 to 5 years from the Laboratory and has a great potential for growth.

There is another company that came out of the Laboratory that didn't have to have special intellectual property. They had developed an improved instrument for high-temperature and pressure data logging in the geological survey business. Their original intent was to take this, back in the days when the oil business was booming, and to manufacture and sell large quantities. They even had a backlog of orders to manufacture these instruments and sell them to the oil and gas industry.

After they got out into this private sector and got started, they found that the oil business crashed, and they could easily have folded. However, they are maintaining themselves now by doing contract data logging with the oil and gas industry to make the measurements where needed. So it's keeping them going.

By the way, I might mention that the company that I mentioned before—the electronic ID system—has about 12 people. They started up in Los Alamos. They're now in Santa Fe. The other one—on the high-temperature data logging—has 13 people, and they're still in Los Alamos.

Well, those are a couple of examples. You asked for some examples that aren't successful. I found some real difficulty with that. The way lack of success tends to manifest itself is that you try everything you know how, and you beat your head against the wall, and it just seems to die of its own weight. And it would take a long time to really sort through and explain to you exactly what it is that causes a particular venture to fail. Many times, it's simply lack of interest that is so difficult to maintain, but not until after the venture may have spent a significant amount of investments made and lost dollars in the process.

Well, what are some of the key problems? You've heard some of them already, and I'll just briefly hit them. I'll hit the one that I think is probably our biggest problem.

I mentioned earlier that in the Laboratory, we tend to have a lot of poeople with innovative ideas, but they really don't have fire in the belly to go out and be an entrepreneur. What I think we really lack is an efficient way for coupling the entrepreneurial individual with the innovative idea in the Laboratory program that Ross Robinson was mentioning of the Los Alamos Lab graduate students, a young person who could be an entrepreneur, but maybe coming from the university or from the engineering school could be the source of entrepreneurial people to work with our innovative people who could then work with the network that exists here in the State to really go out and make it a partnership—a regional entrepreneurial partnership of all the entities in the State—to make this entrepreneur successful.

So it's the lack of entrepreneurs I'm speaking to. I think there is a lot more we could do to create entrepreneurs.

You've heard the statistics. We are one of the most entrepreneurial States in the country. The kind of entrepreneur I'm talking about is, No. 1, high tech, and, No. 2, he's going to be successful, and he's going to be successful because he's very good. That's the kind we need.

I will mention some other problems. We still have a cumbersome process in establishing any kind of arrangement. It has been our experience that it takes a long and constant ordeal. There is a lack of local authority delegated down to the field office and to the Lab, and there is still a constantly changing set of rules and guidelines. You've heard a lot about that. I won't say any more. But this is the framework within which we're trying to get the job done.

I would also like to reiterate the need for some sort of grants or investment in this area of the high technology risk reduction—coming from the Federal side, maybe, where risk is the highest, and then somehow partnering or joint costing with the private sector for lower risk ventures. I really believe it's important to have private-sector dollars in any venture with commercial potential. Without that, you don't have the market pull; and really, the market pull is going to be the key to what investment you should make in the first place. That would also keep us from frittering away government funding, whether it be State or Federal, on things that we have a good idea about, but which the private sector really somehow does not see as attractive. So those are the three problems I would mention.

Now progress is being——

Senator BINGAMAN. Let me just ask a question, before you go on. You're suggesting that we need to have private-sector funds involved in this and not just use public funds to bring about this commercialization. Do you have in mind some particular arrangement by which you have a sharing of private and public financial responsibility?

Mr. WILLIAMS. Well, we've thought about a whole host of possibilities and, of course, not had much detailed dialog on them. But you can imagine going all the way from an arrangement where, for example, an industry decides that they want to pool their financial resources to reduce technical risk. And they get into a vertically integrated consortium—not horizontal, where it's all the computer companies, but someone like a turbine manufacturer, a wire winder, a wire manufacturer, and a materials' producer—and get that industry to jointly share in the funding of a program that would benefit one of them in the industry. If one benefits, they all benefit. It would be sort of like a private R&D partnership; but then it could somehow be coupled with the universities and the laboratories to pursue a research agenda that would go toward their needs of products that haven't yet emerged from the lab, but there's a potential product that they see.

The other extreme is one we're going to talk about a little bit more that I think has great merit. It's the development of a separate organization, like ARCH, where this is a public-private corporation. Maybe it has to be created by law. And its whole purpose is to tap the resource that exists in the laboratories and take new technologies to commercial application. The entity could be funded possibly by joint funding—50-percent government and 50-percent

private. But that's the kind of thing that I think might make some sense—a type of operation focused on commercialization of a specific technical area.

That was a long answer.

Senator BINGAMAN. It's all right.

Mr. WILLIAMS. Now where is progress being made that I should mention? We recently at Los Alamos were asked by the Secretary of Energy to look at high-temperature superconductivity with the idea in mind of exploring partnerships with industry and establishing pilot programs that might test some of these concepts. We had a very good interaction with the Department of Energy, private sector companies, both large and small, and other national laboratories in trying to put this together. We're very hopeful that a partnership will come out of this as a pilot program with high-temperature superconductivity as the test area. The DOE is working very hard to see how the process might be streamlined to make this a functional example of effective technology transfer.

Another area is in defense programs, who is our major sponsor in Washington. We have had a problem for many years in that there is a conflict by the recent legislation in technology transfer and old legislation that makes it very difficult to interpret how defense-funded technologies could be commercialized. What they have done in DOE headquarters is put together a group that is preparing a policy and a plan to commercialize appropriate technologies from the laboratories—appropriate defense program technologies—without in any way jeopardizing or being inimical to national security.

I think these are two very positive signs of how, both locally and nationally, the partnership is coming together. But I do believe that we have a long way to go if we're really going to address the very, very difficult problem of improving the competitiveness of the country on any large scale with billion-dollar-a-year business impacts.

Senator BINGAMAN. Thank you very much.

[The prepared statement of Mr. Williams follows:]

PREPARED STATEMENT OF JAMES M. WILLIAMS

LOS ALAMOS NATIONAL LABORATORY ECONOMIC DEVELOPMENT ROLES IN NEW MEXICO

Los Alamos National Laboratory has a national responsibility to transfer technology to the private sector. Because we are a major scientific and technical asset of the nation, and because of our natural proximity to the private sector in this region of the country, we can play a strong supportive economic development role in the region and New Mexico. Of course, the main economic impacts of Los Alamos on local economic development are achieved when we maintain current jobs by being a first rate national lab. The Lab is responsible for 1 in 20 New Mexico jobs when economic multipliers are included.

Another potentially powerful mechanism for stimulating the local economic base occurs when the Lab can spin-off support services to the local private sector. These new local businesses, initially made viable by working under contract to the Laboratory, can then expand their services to other customers thus creating new jobs for New Mexico.

This testimony focusses on how technology transfer can impact local economic development. The primary purpose of technology transfer efforts is economic development. By appropriate technology transfer, Los Alamos can help future New Mexico economic development in three strategic areas:

diversifying and revitalizing the economic base by developing high technology industry/laboratory/university partnerships and by helping to attract high technology industry to New Mexico.

promoting entrepreneurship by encouraging Laboratory innovators to work with New Mexico entrepreneurs starting new high technology businesses.

investing in our work force by assisting universities and community colleges in science and technology education and in development of entrepreneurship programs.

A. ATTRACTING HIGH TECH BUSINESS TO NEW MEXICO BY DEVELOPMENT OF INDUSTRY/LABORATORY/UNIVERSITY PARTNERSHIPS

The success of our industrial competitiveness as a nation or as a state depends on our corporate ability to discern trends in science and technology, to detect emerging new technologies which could lead to unique commercial opportunities and to act to commercialize them. Our national laboratories and universities should be partners with industry in the process of identifying and exploiting these opportunities. If we can excel at this endeavor and work together to pursue these opportunities for technology commercialization we should be able to compete successfully in the international market place.

Some areas of emerging new technologies which could be of commercial interest to New Mexico are:

1. BIOTECHNOLOGY/Human Genome. This billion dollar national program to map the human genome will increase fundamental knowledge, new technologies and new opportunities in the business of medical science and health care. New instruments and diagnostic techniques are being developed which will need to be manufactured, new biological materials for use in medical research will be produced, and specialized methods of information analysis and exchange will be developed all for use by the medical researchers who will be exploring new clinical methods for diagnosis and treatment of disease.

2. MATERIALS TECHNOLOGY/High Temperature Superconductivity. The discovery of this new class of materials last year may portend the emergence of new technologies which could be very useful in applications wherever electricity is used or magnetic fields are needed. Potentially attractive applications include electric energy storage for utilities, magnetic resonance imaging and magnetoencephalography for medical applications and improved micro-ciruit and detector technologies.

Today we know some materials are superconducting at relatively high temperatures, but the job of developing enabling technologies to make material useful is awesome. It will require knowledge of powder fabrication, powder consolidation, how to fabricate wire, or make thin films. Here the labs can step in to do exploratory development to make ideas developed at universities and labs more useful to industry or looked at another way -- to drive down the precompetitive costs of technology development for US companies.

We have proposed such an effort to the Department of Energy and will pursue it with a most important new twist. We propose to do this in partnership with industry -- so that the market pull enters early in the R&D phase. We have worked with the DOE and private industry. In particular, PNM/US West have been most aggressive and enlightening in this endeavor.

3. MANUFACTURING TECHNOLOGY/Machine Tool Technology. Los Alamos has state of the art technical capability in a number of important areas of manufacturing technology. They include capabilities in high-speed computation systems for the tool industry, developing improved programs to make robots work, applying simulation techniques to manufacturing systems design, and developing sensors and process control feedback systems. This capability could be merged with capabilities in New Mexico universities and industry to promote new industry.

For example, the loss of the US machine tool industry to international competition is of great national security concern. The commercial competitiveness of this industry may only be regained if we can marshal the technical and business resources to bring the latest materials, computational and manufacturing systems technology to bear on solving the problem. This could be a great opportunity for New Mexico to develop a strong new US industry. It could be a first step in developing the concept of a materials valley in New Mexico.

4. COMPUTATIONAL SCIENCE/Supercomputer Applications. Los Alamos has been a primary driving force behind the evolution of the supercomputer. We worked closely with IBM in the 1950's to advance both the computer hardware and software for scientific computing. In the 1970's, it was the interaction of Los Alamos with Cray Research that was critical to the survival of Cray Research during its formative years.

Today we are part of a major national effort to formulate an initiative for the advancement of computational science. If successful, this initiative could lead to new applications in advanced productivity systems such as robotics, large systems modeling/simulation, in medical and health research efforts such as the human genome and drug design, in the energy production industry such as oil recovery, combustion, and fusion and in the transportation industry such as space plane and space flight dynamics.

5. DEFENSE TECHNOLOGY/SDI Technology Spin-offs. A major fraction of Los Alamos effort is devoted to non-nuclear defense technology; SDI, Armor-Antiarmor, etc. We are currently developing new partnerships with defense contractors in FEL, in NPB and in Armor/Anti-Armor. These arrangements take advantage of the scientific and technological breadth and depth of the laboratory and the systems and manufacturing know-how of defense industry partners. We believe that these types of creative partnerships with defense industry will bring about their greater presence in New Mexico. Eventually, this may also bring new opportunities in high tech manufacturing.

New Mexico has an advantage in this type of competition because of the tremendous concentration of defense RD&T laboratories in our state.

Opportunities such as those described thus far offer the hope of bringing greater presence of private industry to New Mexico to collaborate with the national labs. The HTSC Exploratory R&D Center is just a prototype. It could be broadened to more general areas of advance materials; including metalloys, ceramics, plastics, and composites. For example: we are also initiating an exciting new venture jointly among Sandia/Los Alamos/UNM coupled with industry, the center for micro-engineered ceramics (including HTSC) jointly funded by NSF and DOE. Since a major thrust of our industrial applications program is to develop strong partnerships with defense industries, we believe these interactions will lead to opportunities for New Mexico when defense companies come here to work with us.

B. ENCOURAGING ENTREPRENEURSHIP AND NEW BUSINESS START-UPS

From our continuing interaction with small businesses, particularly high-tech entrepreneurs, we have learned what small businesses need to be successful. High-tech entrepreneurs need: access to laboratory technology, excellent knowledge of markets, access to appropriate financing, first rate business development and expansion plans, good management and the capacity to carry through on plans.

In addition to these important skills, the high tech entrepreneur must be capable of assessing and reducing technical risk. Many innovative ideas in our laboratories will only be reduced to practice through further R&D. The question of who assumes the cost of reducing technical risk through R&D is a major issue in technology transfer to small companies with limited resources. The Laboratory can help by providing access to technology and expertise, but we cannot supply the risk capital to complete the R&D.

In general, there are a number of things we do to transfer technology to local firms. The first and most direct is when the lab provides access to technology and expertise to private firms and individuals. Normally, the initiative must be taken by the private firm to request laboratory technologies. When this is done, we work through various mechanisms to assist the firm. The best examples of these mechanisms for local firms have been:

- Laboratory employees consult with the firm on their private time
- designated Laboratory user-facilities are available on full cost recovery basis
- non-exclusive licenses can be granted for specific areas of use.
- waiver of patent rights to the inventor

Indirectly, the Laboratory also supports and encourages private programs which assist entrepreneurs. For example, the laboratory encourages entrepreneurial spin-offs, sponsors an innovator's forum to encourage innovation and entrepreneurship in the Lab and in the community, and grants leaves of absence to potential entrepreneurs. Laboratory managers also serve as board members in state and local economic development organizations.

1. HIGH TECH SPIN-OFFS WHICH HAVE CREATED LOCAL FIRMS. There have been a number of instances where spin-offs from the Laboratory technology base have assisted or created small, local firms. It is not our role to comment on their success however, two prominent examples can be discussed.

2. ELECTRONIC IDENTIFICATION SYSTEM DEVELOPED AT LOS ALAMOS NATIONAL LABORATORY BENEFITS SHIPPING, RAIL AND VEHICLE INDUSTRIES

a. THE TECHNOLOGY. Electronic identification was developed from research which initially began at Los Alamos National Laboratory. The original research conducted at Los Alamos National Laboratory was funded by the Animal Plant Health Inspection Service of the U.S. Department of Agriculture (USDA). The funded research was to provide the USDA with three interactive technologies, one of which was the electronic identification system. The system was developed to aid in obtaining unique, unambiguous, and computer campatible identification of animals without the need to restrain animals.

b. THE TECHNOLOGY RECIPIENTS. A Company was formed to explore the potential industrial applications of the electronic identification system developed at Los Alamos National Laboratory. It had its initial beginnings in the research and development project which began in 1972 at Los Alamos. The original technology was transferred from the Laboratory to the Company, with all patent rights becoming property of the Company in 1984.

The Company has made significant technological changes to the original electronic identification system developed at Los Alamos so that it can be used by the cargo transport industries, specifically the maritime shipping industry, rail industry and vehicle industry. The system uses small electronic transponders which are attached externally to a cargo unit. The transponder is energized by a radio wave sent out by an interrogator/receiver towards the transponder attached to the cargo unit. This radio wave supplies power to the transponder which reflects back to the receiver antenna with an encoded signal that gives an identification number and other unique information related to a particular cargo unit. The receiver can be small and portable, for use in the field, or it can be fixed, coupled with a computer, to operate in an environment such as warehouse or rail/shipping yard.

c. USES AND BENEFITS. The technology was named one of the 100 most significant technical developments by Industrial/Research Magazine in its prestigious IR-100 competition in 1978. The Company is able to custom-build its system to meet the specific needs of the customer. This type of interaction between supplier and consumer ensures that the user's needs are being met. Although there are other manufacturers of electronic identification systems, none of the current suppliers, have been able to meet this Company's technology standards for commercial use of the system. Their system also has capabilities to meet long standoff requirements and rapid data acquisition, neither of which have been met by other system manufacturers. The Company's system meets or exceeds most of the requirements for electronic identification applications needed in the transportation industry, both in U.S. and foreign markets.

Because the Company is able to custom-build a system to meet the specific needs of a customer, the unit price of each system varies. The Company is currently in the development stage, and most revenues up to this point have been generated from the sale of test systems to industrial entities. The market outlook for the Company's electronic identification system is difficult to estimate, but from all indications, there is strong market demand for the Company's technology. The Company currently employs 45 employees, and with the continued trend in growth, expectations are that the Company could employ as many as 100 employees by the end of 1988.

3. FLOW CYTOMETRY INSTRUMENTATION: FUTURE MARKET CHANGES

a. THE TECHNOLOGY. Many members of the Los Alamos National Laboratory Life Sciences Division have contributed to flow cytometry research work in conjuction with other world-wide research organizations. Flow cytometry research involves the examination and sorting of cells. The cells flow single file through a narrow passageway of a flow cytometer at an average rate of 3000 cells per second, where a laser beam or other light source illuminates each cell.

This technique of cell examination and sorting allows researchers to measure cell properties such as cell size, DNA content, presence of specific antibodies, permeability of cell membranes to certain molecules, and other cell characteristics. The instrumentation of flow cytometry allows for these measurements to be made with great precision and high statistical accuracy. One of the premier uses of this technology is its application in cancer research efforts, as well as cancer diagnosis and treatment.

b. TECHNOLOGY RECIPIENTS. The original research work done on flow cytometry began at Los Alamos National Laboratory in the 1960's and was supported by the Assistant Secretary for Environment of the Department of Energy and by the National Cancer Institute. Improvements in cell staining and measurement techniques led to the commercialization of flow cytometers in the mid 1970's. Coulter Electronics, founded by former Los Alamos staff, was one of the industrial pioneers to manufacture flow cytometers. In recognition of the assistance received from Los Alamos regarding this technology transfer effort, Coulter Electronics donated its 100th commercial unit to the Laboratory in May, 1983.

Remaining staff at Los Alamos National Laboratory continue to support technology transfer efforts in this area. Formation of the National Flow Cytometry Resource at Los Alamos National Laboratory has provided productive and innovative flow cytometry research. Several flow cytometers have been upgraded to provide additional unique capabilities which aid in the operation and maintenance of flow cytometer instrumentation by industry users.

c. USES AND BENEFITS. The continued and stable trend in manufacturing of flow cytometer instrumentation is a strong indication of the state of technology related to flow cytometry. According to an industry spokesman, the current world market of flow cytometers, including reagents, is estimated to be $60 million annually. Of this figure, approximately 75% of annual market sales can be attributed to the sale of flow cytometer instrumentation. The spokesman also indicated that the market for flow cytometers is currently in transition. Once dominated by the research-user market, the new market horizon lies in addressing hospital and clinical user needs. The average market price of a flow cytometer for use by researchers is between $150,000 and $300,000. The industry spokesman estimates that the smaller, more compact flow cytometer developed for hospital and clinical use will run $75,000 to $80,000 per unit. With the increase of flow cytometer use by the hospital and clinical user, the outlook for the flow cytometer instrumentation industry looks very promising.

C. PROBLEMS/OPPORTUNITIES:

1. LACK OF ENTREPRENEURS. The most significant problem in creating small businesses through technology transfer is the lack of capable high tech entrepreneurs in New Mexico. Our Laboratories are strong in creative, innovative scientists and engineers, but, in general, they are not the entrepreneurs we need. We need to find mechanisms to attract and develop capable high tech entrepreneurs if we expect significant economic impact from technology transfers from the Laboratories. Mechanisms, such as entrepreneurial partnerships, are needed to allow the entrepreneur to work effectively with Laboratory scientists and engineers on innovations that could be of commercial value. Clearly, cooperations such as those we have with the University of New Mexico, Technical Innovation Program and other elements of the Rio Grande Research Corridor are key to such entrepreneurial partnerships.

2. NEED FOR PUBLIC/PRIVATE INVESTMENT IN BRIDGING THE GAP. Another serious lack is the availability of funds to help small, high-tech businesss accomplish the R&D needed to reduce the technical risk of their future products. Although, there are important productive state and national programs such as the Small Business Innovative Research quests and the New Mexico Research and Development Inititives programs, much more investment is needed to assist the small, high tech entrepreneur in early stages of development. The Laboratory provides as much assistance as reasonable through mechanisms described earlier, but many times the entrepreneur is not able to tap Laboratory resources because of lack of funds.

3. CUMBERSOME PROCESS OF ESTABLISHING ARRANGEMENTS WITH THE PRIVATE SECTOR. Key problems here continue to be the lengthy period required to arrive at an executable agreement, lack of local authority and the environment of constantly changing rules and guidelines under which technology transfer can occur. Never-the-less the Lab is committed to accomplishing our responsibilities within the constraints which exist. In recent months, we have:

1. Worked with industry to assess the most effective mechanisms for establishing R&D partnerships with the private sector. One result of these discussions was the preparation of a draft manual by PNM and US West to describe the procedures desired by industry for working with the national laboratories.

2. Proposed a pilot program on December 16, 1987 to the Secretary of Energy to establish R&D partnerships with industry in High Temperature Superconductivity (HTS). We await DOE approval of this proposal for Exploratory Research and Development Centers in HTS.

3 Worked with ASDP to establish a defense programs technology commercialization program which will assure a proper balance between national security and economic competitiveness in technology transfer. We are hopeful that this will lead to new pilot initiatives for commercializing appropriate defense programs developed technologies.

4. Worked with ALO to develop streamlined procedures which will delegate most of the negotiation of industry/laboratory partnerships with industry to the laboratory with one stop, rapid turnaround DOE approval in ALO.

D. There is much more to be done in forging F&D partnerships between industry, laboratories and universities to improve our economic position. We must make the needed investments, both private and public, to capitalize on the directions we all know must be taken. Our Laboratory is proud to be a partner in improving the economy of our State and our Nation.

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Senator BINGAMAN. Our final witness in this panel is Glenn Kuswa, who is in charge of technology transfer at Sandia National Laboratories.

We're very glad to have you here, Glenn.

STATEMENT OF GLENN W. KUSWA, MANAGER, TECHNOLOGY TRANSFER, SANDIA NATIONAL LABORATORIES, ALBUQUERQUE, NM

Mr. KUSWA. Thank you, Senator, for the opportunity to present these views on how to improve the role of the national labs in local economic development.

Technology transfer from our national labs has already yielded very many local and national benefits; but, of course, we can do a better job.

I think we have to look a little bit at this market push versus market pull. Altogether, about $20 billion of R&D takes place in federally funded labs. Sandia accounts for about $1 billion of that and Los Alamos for about another $1 billion. These are two of the larger of these Labs. These Labs' efforts serve major national needs, and they have to focus on those national needs, of course, to justify the significant government support we have. So in that regard, one has to look at the particular technology developed specifically for major programs.

Most of the technology would be from technology push generated by these programs. Now we can live with that. It takes a little more effort than pull. And I'll say a few more words later on in the talk about how we can emphasize the technology pull, also. But the majority of the research we transfer out will be from the technology push generated by the big programs funded by the National Government.

Our proximity to the local community offers some unusual opportunities for added local benefits. So it's not just the pull. It's the proximity to the local communities, and that gives us the opportunity for local benefits. And I'll explore some of these benefits; but first, I ought to comment that we really need more than technology transfer, and I think that's been emphasized by a lot of the other statements here. Technology transfer is only part of economic development.

Experts cite that there are three factors in economic development, and those factors are technological innovation, capital formation and opening and retaining markets. New Mexico, and the Nation as a whole, really, have not developed an economic and marketing structure that matches the sophistication of the science that we're developing. And we need excellence in all three areas. I am primarily going to talk about the technology innovation and the technology commercialization, however.

The presence of major Federal research institutions in New Mexico has resulted in a very rich infrastructure that is attractive for a technical enterprise. We in New Mexico are enjoying a lot more spinoffs from these government-supported research institutions than many of us appreciate. We can, of course, do a better job if better policies become available.

I would like to emphasize a couple of things that we have spun off, just to illustrate this point. There are two things. I could pick many, but I've picked two of the larger things.

One is a Sandia-developed drill bit for oil wells, and this was developed from market pull, not technology push, because this was part of our energy program that we designed to look at needs in the energy business. We developed a new oil bit in collaboration with industry, and that saves hundreds of million of dollars each year in time and labor drilling oil wells. That is enough to pay for all of the energy programs that Sandia conducts every year. The energy program at Sandia already pays for itself, based on this one example.

The laminar flow clean room is another example. That was developed at Sandia and is central to semiconductor manufacture and some medical processes. That started with a Sandia patent, I think, roughly 20 to 25 years ago.

So these and other successes pay back handsome returns on investment. And someone that says technology transfer isn't successful needs only look at some of these examples. That's not to say we can't redouble our efforts and do twice as well.

There are many studies that detail what's lacking in Federal lab programs for technology commercialization. The most recent study that I would like to cite is one that was just completed this last March by the General Accounting Office. It gives a very good summary of all the constraints to technology transfer. There are inputs in that study from 10 national labs and six government agencies. And the main constraints are that at Sandia and other DOE labs devoted to nuclear weapons research, licensing of innovations requires that DOE waive its title to invention rights on a case-by-case basis. That causes delays and uncertainty, and it reduces somewhat industry trust in the whole process.

Computer software, which is an increasing area of technical output from all of the labs, is not really protectable and licensable under the existing laws and agency policies. So something should be done about that.

A similar statement applies to know-how, or what we also call proprietary data, because it would be very easy to copy, and is not protectable; and to mask works, which refers to a copyright-like method of protecting microcircuits. These areas also need intellectual property protection.

Under present policy federally supported labs can't hold results as laboratory proprietary data. We can't keep data that is not classified within our laboratories, we have to publish it. That's the policy: If it's unclassified, it should be published. We would like to be able to hold that data, in some circumstances, for future licensing or distribution to American industry in preference to publishing and having it go out internationally.

Unclassified data that are not sensitive, again, are openly published under the present policy. Although we believe in openness and pushing the cause of science, in many cases it would be very useful to hold, reduce publicly available details, or delay the publication of some data that has commercial implications.

Laboratories can conduct proprietary research for private companies; but the process for accepting funds for that is presently very

time consuming, and delay discourages companies, because one has to be responsive to the marketplace and move quickly. If there is a long approval process to do research for private industry, industry will lose interest. Nonetheless, we have four or five examples per year where Sandia is conducting research for private industry, and those results have a great deal of exclusivity for that industry itself. The results don't have to be published openly.

The new legislation proposed in Senate bill 1480, introduced by Senator Pete Domenici and cosponsored by Senators Jeff Bingaman and James McClure, would remove most of the identified obstacles to efficient technology transfer. I would say that passing the technology-transfer provisions of this bill would be a very positive next step toward improving all facets of technology transfer from Federal labs. And that affects not only the local economy, but the national economy.

Now I would like to explore some examples and possibilities that tend to stress local benefits. When a technology is very well developed and commercialization carries small risks, usually we consider broad distribution to be the best policy. I'll give two examples of that.

We developed some improved glass compositions that are very useful for sealing conductors into longlife batteries; for instance, the kind of lithium batteries that would be in a camera—a very longlife battery there. This is technology that came out of our weapons' program.

We also developed a computer program for calculating chemical kinetics which could be widely used in universities and industry. These are examples that are widely used and don't take a lot of extra development.

When we released news of these developments through press releases to trade journals and at technical conferences, in the case of the glass composition we received a dozen inquiries, and in the case of the chemical technology we received close to 1,000 inquiries.

Now it's very difficult for a lab scientist to answer inquiries in depth when so many come in. It's just impractical. So here, there is a possible opportunity particularly suited for local businesses. If we could license that technology to a local business on an exclusive or semiexclusive basis on the condition that that business then act as the anchor, and as the point of contact for inquiries, that would be a very good way to have some local business that would help us do the technology transfer and that could also be profitable.

For instance, in the case of computer software, such a business could produce updated versions of the code and distribute those ad infinitum. A firm that is very close to the laboratories could get frequent updates and also, incidentally, give the laboratories some help in documentation.

Senator BINGAMAN. And your ability to do that is now inhibited by statute?

Mr. KUSWA. Yes, because the work we are discussing isn't classified, and is generally given away to all.

Senator BINGAMAN. Right.

Mr. KUSWA. We haven't patented it, and we wouldn't be able to license it to anyone exclusively. But it would seem to be reasonable if we could take that data and license it to a single enterprise, on

the condition, of course, that they were not going to make a huge windfall profit. It's not going to take a big risk on our part to install this kind of process. Industry should make a very reasonable profit from that, because it would not usually require a large investment.

When development risk is high, we have another situation. Then further development is needed, and usually it takes 10 times more money to develop something for commercialization than it does to originally produce it. Then we think that there should be exclusivity, so that investors can get a fair return on their investment. Such development, of course, becomes the core of new business enterprises quite often.

We can cite a few examples of high-risk ideas that have led to new businesses. For one example, a Sandia-developed patent that has the potential to nearly eliminate harmful nitrogen oxide from combustion gases has been turned over to its inventor, Robert Perry. Mr. Perry used to work at our Sandia branch in Livermore, CA, and he started a company near the Combustion Research Center in Livermore. He has obtained government and industrial funding that should point the way to commercial prototypes.

And here, incidentally, the existing small business innovation research grants are playing an important role. Those are very important to the State. I should mention, parenthetically, that it's been very important to lab spinoffs, especially in the small high-tech enterprises in this State.

In New Mexico, we have two recent business startup companies based on Sandia patents. One company is based on a new seismic measuring technique which features a recoverable intense vibration source that operates within well bores.

The other company is based on new technologies for making explosive ignitors more reliable, safer, and less expensive. The seismic source and the explosive-ignitor company both involve multiple inventors. Some of them are active Sandia employees, and some of them are former employees or retired employees. Both of these developments include very strong ties to the research universities in New Mexico.

Now not all transfers involve inventions. The presence of large laboratories in New Mexico extends the depth and breadth of technology for all New Mexico enterprise. When the technology existing at Sandia is unique, we are willing to aid in transfer to a qualified recipient. We can do this either through laboratory programs in which we use laboratory time to offer consulting or development—and that can be done, of course, only when it's a programmatic interest—or by granting permission for employees to consult with industry on their own time, and we will do that. If it is a unique laboratory technology that needs to be transferred, we'll allow employees to consult. This is a relatively new policy. It's a little less than a year old, and so far it seems to be working quite well.

In one case, these factors helped induce an out-of-State entrepreneurial company to move its R&D and management to Rio Rancho, along with its production line. In this particular case, Sandia staff worked with Meadows Resources to develop a local capital source

to present what Sandia's skills were available to help this company, and that was an aid in the firm's decision to come here lock, stock, and barrel and not just have its production line here.

Sandia has recently assisted a long list of local high-technology enterprises, and a few of those are Tetra, DeVore Aviation, Honeywell, Advantage Production Technology Corp., Deaf-No-More, Innovative Silcon Technologies, Krysalis, and others, some of which were mentioned here earlier.

Some examples, then, of how we help these various firms include: aiding in the design of a new accelerator; suggesting incorporation of a Sandia technology into an existing product line; plans for a nearly turnkey product—in one case, this being commercially built not in Albuquerque, but by another division of Honeywell. This project is a computer that we turned over lock, stock, and barrel as a turnkey project. Initially, Honeywell made prototypes for us on contract, and later added it as a product line which is now sold commercially.

In other cases, we made special measurements for companies using laboratory equipment that they couldn't afford.

We've also given advice in networking with the local high-tech community. Sometimes we send them to Jeff Nathanson, at the business incubator, and he does a dandy job. We end up knowing a lot of places where people can go for help.

In another case, we're negotiating for the exclusive use of a specific Sandia patent by a startup company. We are, in turn, applying for a waiver on title to that patent so that we will have it in the future. It would be nice if we had automatic title and didn't have to execute that step with DOE.

In other cases, we collaborate on research with local firms. In some of these cases, the proposed new technology-transfer laws in the Senate bill would facilitate our aid to these companies.

Now let me mention universities. Universities can aid local commercialization of lab technology. Universities are very well-suited for aiding commercialization. Universities can offer an impartial forum for inventors to explore business opportunities. It's a good place to do early market research. Frequently, university staff and facilities may be available to pursue specialized development. In addition, a very good way to bring a university into the mainstream of community development and strengthen the university itself is to involve the university itself very strongly with practical current problems.

The University of New Mexico, through its Technological Innovation Program, has been very useful in assessing a number of inventions from Sandia and other laboratories in New Mexico facilities and in facilitating business formations. And incidentally, Jeff Nathanson's organization was the incubator.

The university could help local development by becoming the hub of a consortium that would help commercialize technology originating in members' laboratories. The consortium could offer a streamlined means of pooling facilities and skills without the time-consuming case-by-case approval processes we've had to employ in previous efforts. We could hope to involve the research universities, business incubators, federally funded laboratories in the State, the Albuquerque Operations' Office of the DOE and Riotech in such an

organization. We are currently working with the University of New Mexico to form such a consortium.

Now let me look at the other side of the coin. Not all transfers succeed. We can cite some technology-transfer failures and try to attribute the reasons for those failures. I will just give a few examples.

In one example from several years ago, a firm receiving Sandia technology didn't have sufficient engineering skills to adapt the Sandia design to its product. The product failures were one contributing cause to the failure of that enterprise. I think that if our present consulting policy had been in effect at that time, the outcome might have been more positive. Of course, there are many other factors, too—market changes and so forth. So it's very difficult for us, of course, to assess the true reason for the failure.

In another example, which is more recent, we developed and improved on a laboratory scale a means to create and destory micron-wide conductors that form the pathways in microelectronics chips. It's very difficult to take those small conductors and either erase them or create new conductors in their place. You like to do that in prototype developments, in case you make a mistake on the initial chip and you would like to correct the mistake and try to see if it works before you go through a typical 6-week production process. It's very long and expensive to make a new circuit. So this technology that we demonstrated on a lab basis seemed to have wide application.

Thinking that that new technology would have wide application and would be absorbed by one or more companies, and recognizing the bottlenecks caused by the traditional constraints we have to follow in handling patents, we decided to publish that technology widely. A local firm, Lasertechnics, eventually became interested enough to send an intern to work with us. The intern worked in our lab several months, absorbing that technology; but later, a decision was made not to bring the technology to the marketplace. The main reason, we think, is that there is no patent protection. The present policies would require us to also help, at least to some extent, a second firm get the same technology. The second firm could merely copy the first's work and be the winner. So there's no margin in bringing a product like that to the marketplace.

The ability to license know-how in this case also would have been very helpful. We could have licensed the know-how from our laboratory to one firm exclusively, knowing that it takes commercial investment to perfect a development. We still don't have a commercial source for that product. We need a commercialized device in our laboratory for use in the microcircuit area.

The examples cited indicate the value of technology opportunities presented in New Mexico. We need to promote awareness of the ways in which our laboratories can help local industries. With many local industries, people still don't really know how to approach us, and we need to promote more of that awareness—we need a good advertising and marketing campaign. Highlighting the services available from our Laboratories and improving the visibility of our technology infrastructure—and there is a big infrastructure in Albuquerque—should continue to help attract new industry to this area, as well as help the existing area grow. The Rio Grande

Technology Foundation can play an important role in this process, I believe.

So in summary, I would say that the primary impediments to doing a better job are excessive time delays and controls imposed by outmoded laws and policies. Technology-transfer provisions in Senate bill 1480 would markedly improve the impact of our program. This is the most important single step that we can take in technology transfer. Meanwhile, we are working with the DOE to solve some of the problems we have with redtape and bottlenecks and so forth, and we're doing that within the context—or they are, I should say—within the context of existing laws and orders. And it's possible that some of the impediments to technology transfer might be reduced somewhat through those actions.

Thank you.

Senator BINGAMAN. Thank you very much.

[The prepared statement of Mr. Kuswa follows:]

PREPARED STATEMENT OF GLENN W. KUSWA

Thank you for the opportunity to present views on how to improve the role of national laboratories in local economic development, with emphasis on technology commercialization.

Technology Transfer Will Yield Local and National Benefits

About one-third of the nation's research and development effort takes place in the national laboratories and other federally supported laboratories. These efforts serve major national needs, as they must, to justify significant government support. However, proximity to the local economic community offers unusual opportunities for added local benefits. I will explore what some of these benefits are and how we might better exploit our opportunities. The suggested improvements can strengthen primary laboratory missions while enhancing economic benefits not only for the communities near laboratories, but for the entire nation.

We Need More Than Technology Transfer

We should remember that technology transfer is only a small part of the economic development equation. Experts on economic growth cite three factors as the interdependent forces of economic growth: technological innovation, capital formation, and opening and retaining markets.

New Mexico has not yet developed an economic and marketing structure that matches the sophistication of its science. We need to achieve excellence in all three areas, but here we primarily address ways of promoting technology usage.

We Have a Rich Technical Infrastructure and a Good Success Record

The presence of major federal research institutions in New Mexico has caused the formation of a rich infrastructure that makes an attractive environment for high-tech and low-tech economic enterprise alike. We, in New Mexico, are enjoying much more spin off from government-supported research than many of us appreciate, but we can do a much better job if improved policies become available. Before elaborating, we should emphasize a few of the many Sandia developments that continue to impact the national economic marketplace: a Sandia-developed drill bit for oil wells saves hundreds of millions of dollars in drilling costs each year; the laminar flow clean room, central to semiconductor manufacture and some medical processes, started with a Sandia patent. These and other successes pay back handsome "returns" on "investment."

Major Problems Have Been Identified, and A Major Solution Has Been Proposed

There are many studies that detail what is lacking in federal programs to enhance technology commercialization. A March 1988 report by the General Accounting Office, "Technology Transfer - Constraints Perceived by Federal Laboratory and Agency Officials," gives a good summary account of opinions from Sandia and nine other laboratories, and six federal agencies. Four major constraints cited in the GAO report apply to all of technology transfer. Solving these constraints will greatly enhance both the local and national commercial benefits of laboratory technologies.

1. At Sandia and other DOE labs devoted to nuclear weapons research, it is necessary to request that the DOE waive its title to invention rights, causing delays and uncertainties that reduce industry interest and trust.

2. Computer software, an increasing area of lab development, is not readily protectable and licensable under existing laws and agency policies. A similar statement applies to know-how and to "mask works," which is a form of protection for microcircuit intellectual property protection.

3. Under present policies, federally supported labs cannot hold their research results as company proprietary for future licensing or distribution to American industries. Unclassified data and data that are not sensitive are openly published. Laboratories may conduct proprietary research for private companies, but the process whereby laboratories may accept funds from private industry is cumbersome.

4. Federal institutions, in their efforts to be fair in providing businesses opportunities to collaborate on research, are prone to institute overly complicated procedures that inhibit industrial participation.

New legislation proposed in Senate Bill 1480, introduced by Senator Pete Domenici and co-sponsored by Senator Jeff Bingaman, and Senator James McClure would remove most of the identified obstacles to efficient technology transfer. Passing the technology transfer provisions of this bill would be a very positive next step to improve all facets of technology transfer from federal laboratories.

Some Transfers Involve Inventions or New Products

When a technology is well developed and refinement toward commercialization carries small risk, broad distribution may be the preferable course of action.

Examples of such transfer include improved glass compositions for sealing connectors into long-life batteries or other devices

containing corrosives, a versatile formulation for organic coatings, and a computer program for calculating chemical kinetics. When we released news of these developments through press releases to trade journals or at technical conferences, we obtained from several dozen to nearly one thousand inquiries, only a few of which were from local firms.

In some of these cases, there may be potential for forming businesses associated with supplying materials or providing services based upon Sandia technologies. Because Sandia may be a good potential customer for the product or because close proximity offers ready access to assimilate the technology and its improvements, we may be able to identify special local opportunities. For instance, if we could have licensed or exclusively transferred our developments for glasses, organic coatings, or chemical software to vendors, we would have established a mechanism for servicing requests for information in ways that extend beyond laboratory capabilities. In the case of coatings, a vendor could provide sample kits or testing of the coatings on potential customer's products, and in the case of software, a vendor could furnish well-documented programs bearing the latest updates to the user community.

When development risk is high and considerable further development is needed, we strive to offer exclusivity so that investors have a fair chance of gaining returns. Such developments often become the cores of new start-up enterprises.

We can cite a few representative examples of high-risk ideas that have led to new business start ups or new product lines. For instance, a Sandia-developed patent that has the potential to nearly eliminate harmful nitrogen oxides from combustion gases has been turned over to its inventor, Robert Perry. Dr. Perry has formed a company near Sandia's Combustion Research Facility in Livermore, California, and has obtained government and industrial funding that should point the way to commercial prototypes.

In New Mexico, we have two recent business start-up companies based on Sandia patents. One company is based upon a new seismic measuring technique that features a recoverable intense vibration source that operates within well bores. The other company is based upon new technologies for making explosive ignitors more reliable, safer, and less expensive. The seismic source and the explosive ignitor companies both involve multiple inventors who are active Sandia employees and former employees, and the developments include strong ties to the research universities in New Mexico.

Not all Transfers Involve Inventions

The presence of large laboratories in New Mexico extends the depth and breadth of technology for all New Mexico enterprises. When a technology existing at Sandia laboratories is unique, we are willing to aid in transfer to a qualified recipient either through laboratory programs or by granting permission for employees to

consult with industry on their own time. In one case, these factors helped induce an out-of-state entrepreneurial company to move its R&D and Management effort to Rio Rancho along with its production line. In this particular case, Sandia staff worked with Meadows Research, a local capital source, to present Sandia skills that could aid the firm.

Sandia has recently assisted a long list of local high-technology enterprises, including Tetra, DeVore Aviation, Honeywell, Advantage Production Technology Corporation, Deaf-No- More, Innovative Silicon Technologies, Krysalis, and others. In each case, help has taken different forms such as: aiding in the design of a new machine, suggesting incorporation of a Sandia technology into an existing product line, making special measurements, giving advice on networking with the local high-tech community, negotiating for the use of a specific Sandia-developed patent. In some of these cases, most notably involving patents, the proposed new technology transfer laws would facilitate our aid to these companies.

Many local opportunities for technology transfer of software would open up if the new law 1480 passes.

Universities Can Aid Local Commercialization of Lab Technology

Universities are well suited to aiding commercialization. A university can offer an impartial forum for inventors to explore business opportunities. A university is a good place to do early market research, and frequently university staff and facilities may be available to pursue specialized development.

The University of New Mexico, though its Technological Innovation Program (TIP) has been a useful ally in assessing a number of inventions from Sandia and other laboratories in New Mexico and in facilitating business formation. It would further the cause of local development if the TIP program or a similar university program could expand its sphere of activity as the hub of a consortium that would help commercialize technology originating in members' laboratories. This consortium would offer a streamlined means of pooling facilities and skills, without the time-consuming, case-by-case approval process we have had to employ in previous efforts. A consortium would feature an easily activated non-disclosure agreement that could be exercised between any members; it would offer a predictable and rapid means for settling licensing agreements; it would provide ready access to sources of venture capital. We would hope to involve the research universities, business incubators, the federally funded laboratories in the state, and the Albuquerque Operations Office of the Department of Energy. Consortium members would be able to decide which of their inventions should be candidates for commercialization through the consortium. We are currently working with the University of New Mexico to form such a consortium.

Not All Transfers Succeed

We can also cite some technology transfer failures and try to attribute reasons.

In one example from several years ago, a firm receiving Sandia technology did not have sufficient engineering skills to adapt a Sandia design to its product. Product failures were one contributing cause to the failure of this enterprise. If our present consulting policies had been in effect at that time, the outcome might have been more positive.

In another example, we developed and proved on a laboratory scale a means to create and destroy micron-wide conductors that form the pathways in microelectronics chips. This technique enables one to modify prototype circuits and could save considerable time and cost in an industrial development laboratory. Thinking that the technology would be absorbed by one or more companies and recognizing the bottlenecks caused by the traditional constraints we have to follow in handling patents, we published the techniques widely. Although one local firm, Lasertechnics, became interested enough to send an intern to work with us, a decision was made not to bring the technology to the marketplace. The main reason appears to be that there is no patent protection, and present policies would require us to help a second firm to assimilate the same information.

Improving Technology Transfer Opportunities Will Give Further Impetus to Economic Growth

The examples cited indicate the value of technology opportunities presented in New Mexico. Promoting awareness of the ways in which our federally supported laboratories can help local industry will enhance our effectiveness. Highlighting the services available from our laboratories and improving the visibility of our considerable technology infrastructure should continue to help attract new industry.

The Rio Grande Technology Foundation (Riotech) can also play an important role in promoting technology transfer through interactions with larger companies. Interest in New Mexico laboratories generated through Riotech contacts may lead to extended involvement activity within New Mexico.

The primary impediments to doing a better job are excessive time delays and controls imposed by outmoded laws and policies, and intellectual property protection that is limited primarily to patents. Another impediment is our present inability to directly accept contracts from industry to carry on research in areas for which we have unique skills.

The technology transfer provisions in Senate Bill 1480 would markedly improve the impact of our technology transfer program. We are working with the DOE to solve some of these problems within the context of existing laws and orders. Some of the impediments to technology transfer are likely to be reduced through these actions.

Senator BINGAMAN. Mr. Nathanson, let me ask just a few questions. We're running late on time, as always in these hearings; but I would like to ask a couple of things.

About this commercialization fund that you've talked about, Jeff, could you elaborate on that a little as to how you think such a fund would work, how it would be administered, and what would be the proper source of funding?

Mr. NATHANSON. I think Jim alluded to that. In fact, I think everyone has kind of suggested something of the kind.

First of all, I think you would need to review what laws are currently on the books, statutes to encourage investment in these kinds of opportunities. And we are talking about the greatest-risk kinds of situations, R&D partnership kind of capability. I don't have the structure off the top of my head. I think, if given an opportunity, the group of us could sit down and start coming up with structures—something that would provide a mechanism for industries, either through vertical integration, as was suggested earlier, through industries; or, some kind of matching funds could be developed to provide that commercialization fund and incentives for private-sector resources to go along with Federal moneys.

Senator BINGAMAN. Let me ask about the SBIR program that Glenn referred to. To what extent does that program meet any of this need?

Mr. KUSWA. It helps in the formative stages of new ideas. I understand that there are weaknesses, however.

There are several phases in the SBIR program. The first phase normally sets $50,000, and if successful, that gets carried over to another phase, which can be up to a half million dollars, which will lean toward actual commercialization.

Now I understand that the test for whether something is commercializable or not is a little bit stiff right now. I guess the SBIR officials are looking for venture capitalists to already be online and so forth before they'll go for that second phase of funding. Incidentally, New Mexico, I think, is probably first in per capita grants of SBIR funds.

Mr. NATHANSON. Second.

Mr. KUSWA. Second in utilization of those. It's a very significant force here. I think the SBIR grants account for 7 or 8 million dollars' worth per year in the last several years, so that's a lot of grants for the State.

Senator BINGAMAN. Ross, did you have a comment on this? Obviously, this has not been a great help in the case of your company, or you don't feel it meets the need that you have.

Mr. ROBINSON. I believe overall that it is a very important program. It has not been important in our particular development. Of greater importance to us in the research phase, has been the New Mexico Research and Development Institution's program. That's State funded, and it's up to us now to make the product commercial; but they have funded the R&D on what represents our second major product. And so that's been our priority, rather than SBIR.

Senator BINGAMAN. I guess my concern is that we have SBIR and we have the State funding, but yet I still hear that a major problem is lack of adequate funds to get these companies up and on their feet. What is the particular niche that we still are not doing,

or are there problems in the implementing or the administration of these programs?

Mr. NATHANSON. SBIR funds are usually derived from requests for proposals addressing some need for the laboratories. Oftentimes, a company may already have an indication as to their interests in a technology, but they haven't received the request from the laboratories to bid on that particular technology.

As far as RDI funds, again, they are looking for—I know of one instance, in particular, where their group of reviewers said, "Well, there's no commercial application for this technology." And I sat in on another meeting, and they were nodding a hardy "Yes," that this is something they would like to see developed.

So it's a situation where they need a proof of principal. They need some assistance from the laboratories or from some fund to get a proof of principal—you know, a prototype on the table—and therefore, they could show that there was market potential for it.

So, again, the labs fund a high-risk kind of opportunity, and you can't yet pull a product out of it. There needs to be something more before it's a commercializable product.

Senator BINGAMAN. Jim, did you have a comment?

Mr. WILLIAMS. Yes, Senator. We have had a number of workshops with small businesses on high-temperature superconductivity, and this question of the value of SBIR's did come up in those sessions. Almost all of the small companies felt that it was a very good program, but it does have the limitations that you've heard described here.

One suggestion made that we keyed in on was the thought that maybe these SBIR grants ought to be administered through the laboratory; and further, that they ought to be coupled with a laboratory commitment of some kind of resources—technical assistance, equipment, or so on—as in a joint project.

I think that's an innovative idea. We've done nothing about it at this point; but it's the kind of thing that does come out of a real dialog.

Senator BINGAMAN. Glenn.

Mr. KUSWA. One suggestion would be for the Government to offer chits to new enterprises, and they could spend those chits at whatever national laboratory would best help them develop their needs. I think that could be effective, at least on a trial basis.

Mr. WILLIAMS. Yes.

Senator BINGAMAN. Similar to the voucher program?

Mr. KUSWA. Well, similar.

Senator BINGAMAN. Like Secretary of Education Bennett's proposals for schools.

Mr. KUSWA. There's another point with SBIR grants. Now requests for SBIR proposals are issued by agencies according to the ways the agencies ascertain their needs. Now the agencies don't always come up with comprehensive lists of needs—for instance, no agency has said, "We need a long-lasting cutting blade for industrial processes for cutting up paper pulp"; and yet, a private firm that's going to be coming to Albuquerque on their own nickel is going to do it. If they could get an SBIR grant on that, it would make it much easier for them.

Senator BINGAMAN. And you think that having the lab's administer these grants as Jim suggested, makes sense?

Mr. KUSWA. Yes. Not all of the grants, but some. I think for certain exceptional projects, it should be available for the labs to issue SBIR-like grants; we ought to be able to respond very quickly, not propose to some agency to produce an SBIR request next year. Then it takes half a year to complete the bidding process, and pretty soon 2 years have passed, and the Japanese have come out with the product.

Senator BINGAMAN. How extensive is the practice of having folks from private companies working in the labs, like Lasertechnics did and like you indicated happens at Los Alamos? Is that brand new? Is it something that you have just a few examples of or is this something that's really being marketed to the private sector? In other meetings I've sat through on the subject of technology transfer, I've heard it said—and it sounds right—that the most effective way to accomplish technology transfer is moving people back and forth in and out of the laboratory setting. Does this hold real promise?

Mr. WILLIAMS. This has been an extensive program at Los Alamos for many years. It goes back, for example, to the Rover days, when we were jointly developing nuclear rockets with people like Westinghouse, and we had on-site people from the company who spent years doing development.

In recent years, it tends mostly to focus on companies that have the resources to invest in their people spending significant time at the lab. There have been a couple of small companies. Scantech is one that has sent one of their people to work with us in an area that they are working on products that looks attractive to them. We don't have the results of that yet; but I would guess in the Laboratory today that we have on the order of 20 to 30 industrial staff members coming in, either on a short-term basis or as long as a year.

Mr. KUSWA. It has been a little less extensive at Sandia. Now we have some sporadic examples from the past years; but there has been a market increase recently. A large company is sending an intern with us for a year to pick up some technology that is used, actually, in the pharmaceutical industry. There is a series of grants the DOE gives to help smaller companies with industrial interns, and we have three people coming this year on those. They'll spend a year in the laboratory, some of them on a clearance basis. In one, it's unclassified; but they need facility access. And that's, incidentally, somewhat of a stumbling block, because it takes typically a year to get clearance. You have to get an expedited clearance, which is difficult. You're lucky to get it in 5 months. So that is a problem.

But we have a desire to increase this sort of activity and help strengthen the lab, too, because the people that come to us will offer another dimension.

Senator BINGAMAN. Glenn, could you describe in a little more detail this consortium that you referred to with the University of New Mexico and the laboratories?

Mr. KUSWA. Yes. Currently, for instance, when we develop a new patent, we would like to know, "Should we patent this or not?"

We'd like to work with somebody to do market surveys on a nondisclosure basis. We wouldn't like to have to sign a separate contract for each new development. We would like to, say, work with the university, because they could in many cases assign students being guided by a professional staff. And those ideas that would be well suited for local development could perhaps be developed in a process similar to that used in the Technological Innovation Program. Develop a business plan. Maybe the inventor wants to stay at the lab, in which case he'll have to find an external CEO to take the reins and develop the enterprise.

We think that in some cases, laboratory facilities should be easily used. Say you need a day's worth of production on some special tool that sits in the laboratory. Now in order to do that legally, you have to go through a very involved process unless it's directly connected with the lab program.

So if we have a consortium in place and had the paperwork in place, so that as a routine matter we could say, "Yes, you can use the lab facilities," we'd either have a budget account or a way to forgive this sort of use without violating any principle of use of Federal property for private benefit. A consortium could form a center for doing that sort of thing on a routine basis for approved projects.

And we think, also, that it would be good to have others involved, such as Lovelace or the university medical school. We develop tools at our lab that are useful in the medical industry. We aren't concerned with medical knowledge as a direct part of the research that takes place in our lab. Nonetheless, we would like to see these developments pursued rapidly.

So why not have a consortium set up, so that we can easily trade manpower and lab facilities, at least on a limited basis? I'm talking about a day here, a day there, maybe a week or two. And I think a consortium would be an excellent way of doing that.

Senator BINGAMAN. Thank you. I know we have a lot of other things we can go into, but, as I said, we're running late.

Let me thank this panel very much for their testimony.

We will take about a 10-minute break, and then we'll start with the second panel.

[A 10-minute recess was taken.]

Senator BINGAMAN. If everyone would take a seat, we'll start the second panel.

The second panel will focus on the possible institutional mechanism to improve technology transfer.

On the panel, we have Steve Lazarus, president of ARCH Development Corp.; Gary Smith of UNM's Technological Innovation Program; Tommy Thompson, who is the president of Riotech; Arlyn Blackwell of Sandia; and Paul Risser, who is vice president of research at the University of New Mexico.

We're going to have to try to summarize things a little more in this panel than we did in the last one, not because of less interest in what this group has to say, but because of the lateness of the hour. So why don't we go ahead in the order that I just introduced folks?

Steve, why don't you go ahead?

STATEMENT OF STEVE LAZARUS, PRESIDENT AND CEO, ARCH DEVELOPMENT CORP., CHICAGO, IL

Mr. LAZARUS. I will try to summarize my prepared statement in a fairly brief period of time.

I am your emissary from Chicago. I think probably the most interesting thing you're going to learn from me is how similar conditions are in the middle of the country to those described in New Mexico and, I guess, also the fact that some of the things we've done are the beginnings of demonstration proofs that some of the requirements enunciated in the earlier panel can be met.

Let me describe first what ARCH is. "ARCH" stands for the Argonne National Laboratory, University of Chicago Development Corp. Consequently, it is an entity that combines the research and development that goes on at a national laboratory and a large research university. It is not for profit. It holds a 501c3 finding from the IRS. Its revenues are distributed, first to the inventors—they get 15 percent of all gross revenues received by the corporation—and the remainder are distributed back to the university and the laboratory, with ARCH taking a certain amount for expenses. It is independent. The University of Chicago is the sole member of the corporation, but it is an independent corporation. It has a blueribbon board of directors. I won't name them. It includes five of the university trustees, one member of the board of governors of Argonne, soon to be three. Most of them are the CEO's of large corporations, including Dick Morrow, the CEO of Amoco. It gets its basic operating funds from an investment of endowment by the university and a contribution of government funds.

Senator BINGAMAN. State government funds?

Mr. LAZARUS. No, sir. The DOE permits the investment of $200,000 a year of laboratory money into the support of patent and licensing activity, although we have access to State funds in other directions.

Perhaps one of the more interesting and unique aspects of ARCH is, it is placed physically in—one of its two locations is the Graduate School of Business of the University of Chicago, and I also serve as associate dean of that graduate school. Consequently, we have had an influx of student volunteers, and we call them "The 58th Street Irregulars." They work without compensation. They contribute between 15 and 20 hours a week apiece to doing the kind of evaluations that Jim Williams and Glenn Kuswa described a moment ago. It's proven to be an enormously successful start.

A quick report card: July 1, 1987, to date, we've done six licenses. Three are complete. Three more are almost complete. We have completed negotiations on two joint ventures. One, I should say, is an example of the kind of vertical collaboration that Jim Williams was describing. It deals with an invention—a monolithic solid oxide fuel cell. The original funding comes from the Defense Department and the primary work is done at Argonne—the basic research and development. The Air Research Division of Allied Signal does the basic scaleup, and combustion engineering will do the basic distribution into the energy-consumption marketplace. So it can work with outsiders. It took us 14 months to negotiate that.

We have health qual systems, and I just brought its first product to show you. I won't take time to tell you what this does. I just wanted to show you what kind of fine end design a pickup team of startup people can produce with technology that, in this case, originates from the university.

We are managing right now over 40 patents, some of which we applied for ourselves, some of which have been waived to us from the DOE. We have two offices, the one I mentioned in the Graduate School of Business and one at the Argonne National Laboratories. We have a major effort in high-temperature superconductivity. We've started an affiliate program with industries signing up. We have 10 signups already and more coming every day.

Argonne has anchored a joint statewide submission to the National Science Foundation petitioning for a science and technology center in superconductivity. The submission includes the University of Chicago, Champaign-Urbana, Northwestern, as well as Argonne, and it's the first time to our knowledge that those institutions have been yoked together toward a specific purpose in our State.

Let me kind of end the report card at that point, because I'm watching the time, and quickly breeze by what I consider to be the concerns and impediments and obstacles that we still continue to face.

The issue of exclusivity is extremely important in my mind. The anecdote that I think Glenn Kuswa described is something that we encounter every day; and as long as there is a network of laws and regulations, including Freedom of Information and enforced publication, it will severely handicap our ability to start the technology-transfer cycle moving. I am a strong advocate of strengthening the exclusivity provisions.

But having said that, we negotiated for the first 6 months of ARCH's existence with the Department of Energy and produced a useful patent amendment to the contract between the Department and the University of Chicago, and I am now able to obtain intellectual property very rapidly in about two-thirds of the cases. So I think the effort put into the negotiation of that patent amendment was useful. It is what delayed our start until July 1, 1987.

We have the same development gap that has been described here; that is, the difficulty of finding funds to move from the point of laboratory demonstration that an idea works to a market-ready end item with substantial risk having been extracted from the idea. There are no readily available development moneys accessible to us; and consequently, we've been expending the bulk of our time raising an early-stage venture-capital fund, which is aimed at $10 million. We have $6.5 million promised from the private sector; and when we complete that, the ARCH Development Corp. will be the general partner with several limited venture-capital partners.

We also have identified what we call the management gap as a real problem. Each one of us—and there are three of us like myself who operate for ARCH—has a band width or a capability of managing about two new starts a year. And if you're going to do it well, if you ask the people in the venture-capital community, that is about the limit. So to have trained people like ourselves out of industry at some greater profusion would help immensely in speed-

ing up and moving on a broader front to commercialize more ideas. We have, in Chicago, perhaps not as serious a problem of infrastructure as you have here, but certainly nothing that compares to the infrastructure that exists in San Mateo and Santa Clara Counties, where there are numerous people to help with business start-ups.

And I subscribe to the hundredth-monkey idea of economic development. We are working daily to try to improve that infrastructure and hopefully to reengage the venture capitalists in the middle of the Nation area to return to early-stage work, so many of them have gone off into messenine funding and leverage buyouts.

And finally, we have the fundamental problem of measurement of results. We think we're doing well. It's a hard thing to prove. You get, ultimately, at the end of 5 or 10 years, a good set of tertiary effects; but by that time, few people are interested. So we constantly have to find out, such as by demonstration, that we have an independent item out of our company, that we are doing well and that we're worthwhile to continue to invest in.

We're close to the 7 minutes.

Senator BINGAMAN. You did great. Very good. I appreciate that.

[The prepared statement of Mr. Lazarus, together with attachments, follows:]

PREPARED STATEMENT OF STEVE LAZARUS

I. Introduction

To many observers the large and persistent trade deficit is a symptom of the nation's declining ability to compete in the international economy. The origins of this decline have been widely studied and its causes are said to include an artificially strong currency, an excessively short investment philosophy, a failure to modernize, an inefficient management structure, an uneven global playing field, and an inability to take maximum commercial advantage of our unsurpassed scientific creativity.

Each of these causes has been addressed by a variety of private initiatives and public policy changes. There is evidence that the international economic position of the United States is strengthening. Questions remain, however, as to whether the United States can return to and maintain competitive parity. Plant closings and corporate restructurings are one time events. Of greater concern is the excessive time (twice that of Japan) it takes the United States to bring an idea from conception to ultimate economic fruition. There is also a growing apprehension that the U.S. work force and its management echelon will not have the skills to compete.

Scientific discovery and technological development are major constituents of economic growth and competitiveness. Even though the United States invests annually approximately $110 billion in R & D, there is serious

question as to whether it gets an optimal return for this investment -- and an equal concern that it may actually subsidize foreign competition. Half the investment -- $55 billion -- is federally funded and is expended through universities and federal laboratories. Yet of the 120,000 patents processed by the U.S. Patent Office annually, less than 3000 cover federally sponsored research. Recognition of this fact has produced a strong national resolve to increase U.S. commercialization of federally generated products and processes.

Public laws 96-517, 98-620 and the President's patent policy memo combine to give universities, small businesses and not-for-profit contractors the first right of ownership to patentable inventions made with federal funds. Public Law 99-502 extends the principle to government operated laboratories. In response to this legislation, the Argonne National Laboratory, and its contract/manager, the University of Chicago, chartered an independent, not-for-profit corporation -- the ARCH Development Corporation-- to improve the level and increase the impact of technology transfer from the two institutions. ARCH is the first entity in the nation to combine the resources of, and to serve simultaneously the needs of a large research university and a major multi-purpose national laboratory.

II. ARCH

1. WHAT IS ARCH?

ARCH is a not-for-profit (501c3) corporation activated by the Board of Trustees of the University of Chicago in October 1986. Its full name is the Argonne National Laboratory/The University of Chicago Development Corporation and its principal purpose is to develop and commercialize the science and technology generated at the Laboratory and the University.

The establishment of ARCH is timely because science and technology both have developed to the stage where many of the most basic discoveries can have important and immediate technological ramifications. This accelerated evolution has greatly increased the importance of, and the urgency for effective technology transfer.

ARCH is an experiment. It is designed on the theory that (1) management of commercialization should be decentralized as close to the point of technological transfer as possible; (2) decision-making should be as independent as possible; (3) inventors and managers should be motivated by the potential of rewards; (4) but the mechanism should be not-for-profit in nature to better fit with the University/Laboratory culture; and (5) emphasis

should be given to longer term, higher value added commercialization activity.

2. DESIGN OF ARCH:

A. The University of Chicago operates the Argonne National Laboratory under contract with the Department of Energy. Therefore the University has the option to claim Laboratory technology for the purposes of exclusive commercialization. The combined annual research budgets of the two institutions is $350,000,000, thus producing a large critical mass of technology for potential commercialization.

B. After examining other technology transfer models, the University of Chicago Trustees developed a mechanism that is private, independent, and motivated in the fashion of a venture capital partnership, but not-for-profit in the fashion of most public research and education institutions.

C. Initial funding for operations was generated by investing $5 million of University endowment in a 7% note yielding $350,000 annually for 5 years. The Department of Energy permits Argonne, on a discretionary

basis, to contribute to ARCH $200,000 a year for 4 years.

D. The board of directors of ARCH, which includes five University trustees, directed the Corporation to pursue all forms of commercialization including new company start-ups and joint ventures, and to avoid over reliance on traditional licensing approaches.

E. The President and CEO of ARCH was simultaneously appointed the Associate Dean of the Graduate School of Business. This gave the head of ARCH faculty standing, provided a basic support structure for the Corporation, and afforded access to the intellectual and practical resources of the GSB.

F. The board sought a business executive with general management experience to be the first President and CEO. I had been Senior Vice President for research and manufacturing of Baxter Healthcare Corporation. I became President and CEO of ARCH on October 21, 1986.

III. FIRST 18-MONTH ACHIEVEMENTS:

1. Three licenses have been concluded, two utilizing technologies originating at Argonne, one utilizing technology originating at the University of Chicago. Three additional licenses are in the advanced stages of negotiation.

2. One company has been formed - Health Qual Systems, Inc. - to market new devices to the anesthesia and critical care section of hospitals. I have brought a prototype product to show you. A second company, involving recombinent DNA production of certain receptor proteins, is under formation.

3. Negotiations have concluded on two major joint ventures - one involving a monolithic solid oxide fuel cell and the second involving extraction of nitrous oxide from coal gas. These agreements are in the process of being finalized.

4. Over forty patents have been either brought into ARCH from the Department of Energy or applied for.

5. Two offices have been established - one at the University and one at the Laboratory.

6. Close working relationships have been established with the Technology Transfer Center at Argonne and

the Office of Research Administration at the University.

7. The Argonne/ARCH Superconductivity Industrial Affiliates Program has been formed. (SEE ATTACHED)

8. The ARCH Associates Program has been formed. Presently over forty Graduate School of Business students volunteer their services to ARCH each at the rate of between ten and twenty hours a week. These Associates pair off with University scientists and investigators and perform marketing studies, competitive analyses, and patentability reviews. They also prepare business plans. They relieve the inventor of many of the tasks of commercializing an idea.

9. ARCH, through Dr. Fred Stafford, formerly Program Director for Solid State Chemistry of the National Science Foundation, is contributing to the establishment on the University campus of multi-disciplinary centers such as the Imaging Science and Polymer Science Centers. These centers have the potential for a much stronger industry contact and interaction.

IV. IMPEDIMENTS AND CONSTRAINTS

The first year of operation of ARCH demonstrated the potential for an independent not-for-profit corporation to increase substantially the volume and quality of technology transfer from national laboratories and research universities. It also demonstrated the profound limitations faced by such an enterprise. Chief among these are:

1. The Development Gap

Technology transfer is really a continuous series of processes. Basic research leads into applied research which in turn leads to "development" and finally commercialization. The task of "development" is the rate limiting step in this series because funds are not available for it.

Development includes reduction to practice, prototype building, systematic removal of commercial risks, early market assessment, and application of initial management resources. Sometimes funds for these tasks can be obtained through industrial partners or early stage investors but usually only after long and laborious negotiations. Availability of incremental funds would accelerate the closing of the development gap.

2. The Management Gap

The key success factor for a technology transfer mechanism is the ability to make the right choices -- choices of which technologies to select out and patent, choices as to the form of commercialization, choices of the right industrial or venture capital partner. The most critical problem for ARCH is the shortage of seasoned executive talent capable of making these judgments. The most relevant model for ARCH is a venture capital partnership in which there are a number of partners, often representing complementary specialties, each capable of shepherding a limited number of business developments to the point of independent operation.

3. The Cultural Differences Among Institutions

The twelve government owned contractor operated (GOCO) laboratories spend approximately $5 billion in public funds annually. While part of these funds support national mission programs, e.g. nuclear breeder reactors, strategic defense initiative -- and are consequently limited by some security restrictions -- the larger portion produces technology with the potential for commercialization. The GOCO's, however, are

interesting and unusual institutions. Their traditions, cultural characteristics and, above all, funding relationships influence their effort to transfer technology to the private sector.

GOCO's resemble research universities in that the individual investigators have a great deal of independence and frequently propose the area of work to be funded. They also resemble contract research organizations like Battelle and SRI in that they seek to participate in larger programs. Individual scientists, however, have had virtually no incentive to divert portions of their time to commercialization of technology unless such diversion results in additional funds for their particular programs. This is especially true for basic research at both institutions. The technological R & D at Argonne has traditionally involved collaboration with industry and there is more willingness to engage in technology transfer in that sector of the Laboratory.

In the 1984 legislation, the objective of technology transfer was specifically added to the mission of the laboratories. In the 1987 implementation of that legislation it became possible to reward individual investigators to assist in commercialization. This form of personal motivation appears to be having a positive effect.

In addition, the 1986 Bill (PL 99-502) requires laboratory managements to recognize technology transfer as a laboratory mission and as part of every employee's job description. Contractor performance evaluation by the Department of Energy will include responsiveness to this legislation. But until funds with which to support specific programs become available the individual investigators will remain somewhat ambivalent toward technology transfer. Consequently, it will be difficult for laboratory directors to implement the legislative and administrative changes.

ARCH is attempting to bridge the gulf between two dissimilar cultures. Not only does the majority of the University/Laboratory research population view technology transfer as a low priority effort, but some investigators see it as an inappropriate activity under any circumstance. The business culture has seen the university and the laboratory as impenetrable bureaucracies with little sense of urgency. Furthermore, the business community has been systematically dismantling its own central research laboratories which had the best chance of establishing productive contact with the university/laboratory.

The task is to build a variety of bridges so as to access the vast latent potential of publicly

funded university/laboratory research, increase the commercial yield of such research, and consequently enhance the competitive posture of the nation.

V. POTENTIALS

Despite the impediments, ARCH has several significant potentials which could be realized during the next five to ten years. With adequate financial and personnel resources to bridge the development and management gaps the cultural difficulties could be overcome. When such a point is reached ARCH can yield the following:

1. A practical demonstration of a working technology transfer mechanism for the national laboratory system.

2. A training program for the creation and management of such a mechanism.

3. A demonstration of the organized utilization of graduate business students to overcome certain of the key human resource limitations of many university based technology transfer programs. Simultaneously, an experience for those students in the art and science of entrepreneurship and decision-making in technologically-oriented businesses.

4. Creation of a business development practicum to

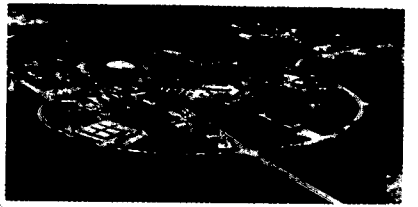
serve as a foundation for a business development curriculum and research program for the Graduate School of Business of the University of Chicago.

5. A demonstration that public and private or industrial and academic interests are not irreconcilable and can be bridged.

6. Substantial technology transfer and resultant added economic value and job creation both nationally and regionally.

arch

Your Access to a $380 Million R&D Budget



Argonne National Laboratory

Moving from Discovery to Commercialization

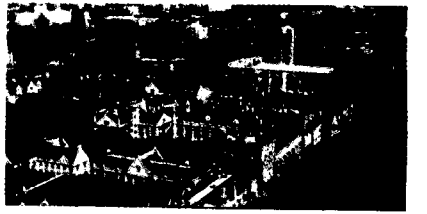
The Argonne National Laboratory-The University of Chicago Development Corporation (ARCH) was formed in 1986 to facilitate the commercial development of scientific and technical intellectual property originating at the university and national laboratory. The primary function of ARCH is to move discoveries from these world-renowned institutions to the marketplace.

ARCH is the first development corporation in the nation to capitalize on the combined resources of a major university and a major national laboratory. It provides commercial developers with access to discoveries from combined science and research budgets totaling more than $380 million annually.

Among the honors earned by former or current staff, faculty, and students of the two institutions are 36 Nobel Prizes in science and 33 IR-100 awards, given for discoveries judged to be among the 100 most significant industrial research achievements in the nation each year. More than 30 patents are granted annually to inventors at the two organizations.

ARCH can:

- License patents
- Bring together venture capitalists, entrepreneurs, and inventors
- Provide market studies and strategies
- Obtain limited financing for R&D
- Form cooperative R&D partnerships
- Create new companies
- Evaluate technical and market feasibility
- Provide information to prospective participants



The University of Chicago

Applications for Every Market

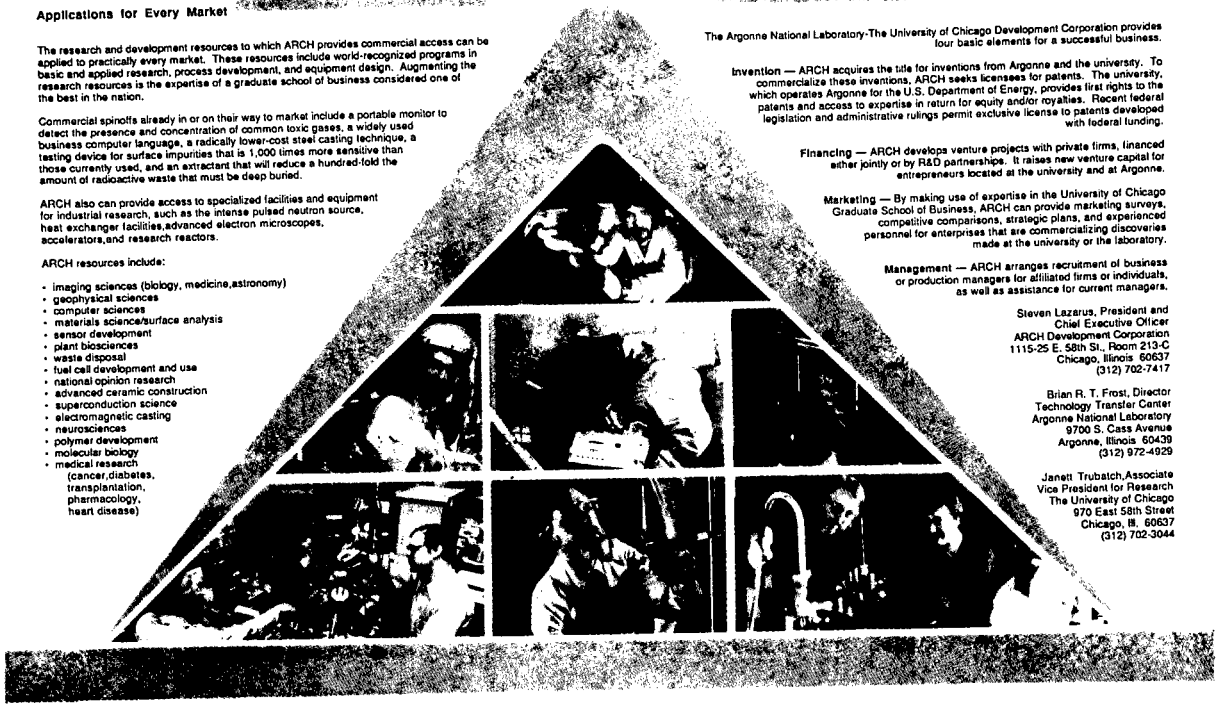
The research and development resources to which ARCH provides commercial access can be applied to practically every market. These resources include world-recognized programs in basic and applied research, process development, and equipment design. Augmenting the research resources is the expertise of a graduate school of business considered one of the best in the nation.

Commercial spinoffs already in or on their way to market include a portable monitor to detect the presence and concentration of common toxic gases, a widely used business computer language, a radically lower-cost steel casting technique, a testing device for surface impurities that is 1,000 times more sensitive than those currently used, and an extractant that will reduce a hundred-fold the amount of radioactive waste that must be deep buried.

ARCH also can provide access to specialized facilities and equipment for industrial research, such as the intense pulsed neutron source, heat exchanger facilities,advanced electron microscopes, accelerators,and research reactors.

ARCH resources include:

- imaging sciences (biology, medicine,astronomy)
- geophysical sciences
- computer sciences
- materials science/surface analysis
- sensor development
- plant biosciences
- waste disposal
- fuel cell development and use
- national opinion research
- advanced ceramic construction
- superconduction science
- electromagnetic casting
- neurosciences
- polymer development
- molecular biology
- medical research (cancer,diabetes, transplantation, pharmacology, heart disease)



How ARCH Operates...for You

The Argonne National Laboratory-The University of Chicago Development Corporation provides four basic elements for a successful business.

Invention — ARCH acquires the title for inventions from Argonne and the university. To commercialize these inventions, ARCH seeks licensees for patents. The university, which operates Argonne for the U.S. Department of Energy, provides first rights to the patents and access to expertise in return for equity and/or royalties. Recent federal legislation and administrative rulings permit exclusive license to patents developed with federal funding.

Financing — ARCH develops venture projects with private firms, financed either jointly or by R&D partnerships. It raises new venture capital for entrepreneurs located at the university and at Argonne.

Marketing — By making use of expertise in the University of Chicago Graduate School of Business, ARCH can provide marketing surveys, competitive comparisons, strategic plans, and experienced personnel for enterprises that are commercializing discoveries made at the university or the laboratory.

Management — ARCH arranges recruitment of business or production managers for affiliated firms or individuals, as well as assistance for current managers.

Steven Lazarus, President and
Chief Executive Officer
ARCH Development Corporation
1115-25 E. 58th St., Room 213-C
Chicago, Illinois 60637
(312) 702-7417

Brian R. T. Frost, Director
Technology Transfer Center
Argonne National Laboratory
9700 S. Cass Avenue
Argonne, Illinois 60439
(312) 972-4929

Janett Trubatch,Associate
Vice President for Research
The University of Chicago
970 East 58th Street
Chicago, Ill. 60637
(312) 702-3044

GSB CHICAGO

Winter 1987 Graduate School of Business The University of Chicago

GSB to Play a Major Role in Joint Venture

Lazarus Named President and CEO of ARCH

Plans to Engage Talents of GSB Faculty, Students, and Alumni

On October 14, 1986, the University of Chicago officially announced the creation of a joint venture with Argonne National Laboratory, called the Argonne National Laboratory/ University of Chicago Development

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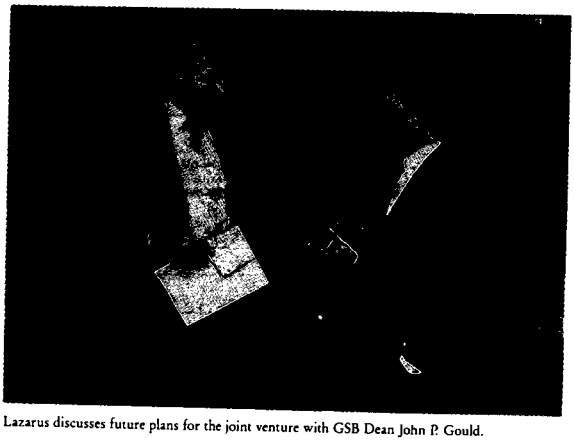

Lazarus discusses future plans for the joint venture with GSB Dean John P. Gould.

Massey Is Appointed Chairman of the Board of ARCH

Walter E. Massey, the U. of C.'s vice-president for research and for Argonne National Laboratory, chairman of the board of directors of ARCH

After a few minutes' talk with Dr. Walter Massey, it becomes evident that he is a man whose happiness increases in direct proportion to the number of his responsibilities. With the establishment of ARCH Development Corporation, he has added chairman of the board of directors to his two university positions.

Massey's enthusiasm is intensified by the fact that each of his three jobs provides strong support for the others.

"I'm a physicist—a solid state physicist," he says when asked about his background. "I taught physics at Brown and was also dean of the college during my last four years there."

In 1979 Massey came to the University of Chicago from Brown Uni-

continued on page 4

Lazarus

Corporation, or ARCH Development Corporation.

John P. Gould, dean of the business school, described ARCH's purpose as "two-fold—to serve as a bridge and to transform scientific discoveries from the two institutions into high technology products and services." Gould then announced: "This exciting new venture will be housed here at the GSB."

Steven Lazarus, formerly with Baxter Travenol Laboratories, Inc., was named president and CEO of ARCH Development Corporation and associate dean at the GSB.

GSB Chicago interviewed Lazarus shortly after the announcement of his appointment.

EDITOR: You had been at Baxter Travenol Laboratories for twelve years, during which time you were involved in a great variety of the company's functions. (See box.) When you left you were group vice-president of health care services. Why are you taking on this new job with its heavy responsibilities?

LAZARUS: I was approached by the trustees of the university. They're a tough group to turn down.

But my own reasons for taking the job were at least as persuasive.

(1) It is unique. As near as I know, there's not another job like it.

(2) It involves the commercialization of new technology, which is something I like to do.

(3) It has entrepreneurial quality. It requires association with venture capital.

(4) An equally significant reason is that the appointment at the Graduate School of Business appealed to my other interests. I have always wanted to teach, always planned to teach. Indeed, before the trustees of the University of Chicago contacted me I had already agreed to give nine lectures at the Harvard Business School in '87.

EDITOR: So they stole you from Harvard?

LAZARUS: Oh, no. I'll give the lectures.

EDITOR: In the description of the corporation, there is a section that mentions "close and substantive interactions with the Graduate School of Business at the University of Chicago." Could you explain how the school will be involved in the activities of the ARCH Development Corporation?

LAZARUS: We will call on the talents of the GSB faculty and the students.

One of the keys to success for ARCH is the shaping of what are fundamentally technological ideas—shaping them into business ideas. We are going to bring to bear a selection of the GSB's faculty on the issue of shaping these ideas.

Harry Davis is going to help put together a patent evaluation committee of the university, which will include not only business school people but people from other divisions and departments.

As for GSB students, I've already had four of them volunteer to help

SARISA, a laser-based system that measures impurities on material surfaces, is the kind of technology developed at Argonne National Laboratory that could eventually lead to a licensing agreement with a private manufacturer.

Two New Professorships Push Campaign Over the Top

Chicago, Dec. 31—In the final days of 1986 the GSB's capital campaign soared past its $21.5 million goal to $23.2 million, adding two professorships to the school's previous total of nineteen. The two new endowed chairs were established by James W. Lewis, '70, and the Chicago Board of Trade.

The next and final issue of the capital campaign newsletter will cover the establishment of nine new professorships; eight new faculty research funds; twenty new scholarship funds; and other highlights of the campaign.

with the transformation of technological ideas into business ideas.

Students will be involved in still another way. We are now investigating a tie-in between ARCH Development Corporation and certain courses at the business school.

But ARCH is new, and we have just begun our efforts to build a relationship with students and faculty.

EDITOR: How can alumni get involved?

LAZARUS: Jack Gould and I are working through lists of alumni so that when we get a technological idea in a particular industrial field we can make an initial contact with GSB alumni who are involved in that same field.

EDITOR: Will you issue stock to fund the corporation?

LAZARUS: No. The ARCH corporation is a not-for-profit Illinois corporation, and the sole member of the corporation is the University of Chicago. The university is capitalizing the company with a substantial piece of its endowment that will generate operating funds. We expect that certain industrial companies will contribute funds to its operation in return for first exposure to the technology, much in the way that MIT maintains relations with industrial affiliates, and these affiliates pay an annual fee for that relationship.

EDITOR: I've read about an arrangement whereby inventors get royalties on their discoveries.

LAZARUS: That occurs after the idea has been successfully commercialized. The traditional way is for universities to license the industrial property (the patent) to an industrial company, and the company pays the university a certain share of the profits in the form of royalties as part of the licensing arrangement. In turn, a fraction goes back to the inventor.

EDITOR: Will the relationship between Argonne and the university be affected?

LAZARUS: The University of Chicago is the contract manager of Argonne. Because of recent changes of law and administrative procedures at the federal level, the intellectual property generated at Argonne is waived by the federal government for a nominal fee and goes to Argonne itself, which means it goes to the University of Chicago, which means it goes to ARCH. The new corporation collects the intellectual property of both the University of Chicago and Argonne National Laboratory.

I said at the outset that this was a unique situation; that's what makes it unique. A large research university and a federal lab—a very large federal lab—are involved.

EDITOR: When you call the University of Chicago a large research university, which research bodies are you referring to?

LAZARUS: Primarily the Division of the Biological Sciences, which includes the medical school, and the Division of the Physical Sciences, which includes the computer science group. Coming up with ideas all the time as they do, they're basic generators.

At Argonne ideas are subjected to technology examination and evaluation. If an idea appears to be a candidate for commercialization it moves from Argonne to ARCH, where further evaluation and elaboration take place. Similarly, when ideas are developed at a division of the university, those ideas are examined by Chicago's research administration—another form of evaluation—before coming to ARCH for our testing. Theoretically, ARCH is sent an idea just before the "do we patent or do we not patent?" decision. But in practice the

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"I'm a person who has lived his life in chapters." Ask Steven Lazarus about himself and that is how he characterizes his professional career. A graduate of Dartmouth College with an M.B.A. from Harvard, he spent over twenty years in the Navy, retiring with the rank of captain. But in the second half of his Navy career, he says he was "borrowed by two government agencies." The first one was the office of the Secretary of Defense. "I was an executive assistant to the chief financial officer. Then I went to Commerce where I was assistant maritime administrator and later a deputy assistant secretary of commerce for East-West trade. In that position, I acted as a trade negotiator with the centrally planned economies, including the U.S.S.R. and China."

Lazarus left the Navy in 1974 to join Baxter Travenol Laboratories, Inc. He remained there for twelve years, until he joined ARCH and the Graduate School of Business. While at Baxter, he held a number of positions, including head of technology, research, development, engineering, and manufacturing. He adds: "I guess the other thing to mention is that I developed Baxter's computer software businesses."

Steven Lazarus president and CEO of ARCH

4

Massey

versity to be director of Argonne National Laboratory. "I was appointed professor in the physics department at the same time," he explains, "but since I spent all of my time running Argonne I never taught a class." After some four years, Massey was appointed vice-president for research for the university as well as director of Argonne. He filled those positions for about a year and then was made vice-president both for research and for Argonne National Laboratory, which means, he says, that "I am responsible for the university's management of the lab and for the research activities of the university on campus. We have a lab director now, so I only go out to Argonne a day and a half, maybe one day a week."

From its inception Argonne National Laboratory has been operated for the federal government by the University of Chicago. "Over the past four or five years," Massey says, "we've been trying to strengthen the ties between the university and the lab. We make joint appointments, arrange for joint research projects, and place more U. of C. students at Argonne."

When Massey and Alan Schriesheim—then Massey's deputy, now director of Argonne—first came up with the idea of starting a development corporation, what they had in mind was to develop technologies emanating from Argonne. The changes in federal regulation not only made this possible but required laboratories to set up a technology-transfer mechanism.

Massey recalls the next step. "I moved to campus as vice-president for research and for Argonne, and the more time I spent here the clearer it became that the idea could serve the needs of the university as well as the lab. It would be efficient; it might be easier to attract outside interests because the corporation would be unique; and it would give us a broader range of possible ideas that might find their way to the marketplace.

"I won't go into all the details; but we worked through various faculty committees at the university,

continued on page 5

Lazarus

ARCH corporation must join the game much earlier than that. It should have a head start to determine whether it needs to direct certain preliminary efforts toward patenting. That is the case with both Argonne and the university.

EDITOR: Why is there a need for ARCH to get involved early?

LAZARUS: Picture two streams of thought coalescing at ARCH. The first great natural milestone in all of this is the patent procedure. To be effective, you've got to start well before the patent procedure and make sure the inventors and investigators and discoverers in both institutions—the university and Argonne—have a sense that ARCH provides a viable mechanism through which ideas of value will be treated seriously.

That is what didn't exist before. What existed was an arrangement between the university and an organization that has similar relationships with a number of universities. It takes the intellectual property and examines it and in some cases patents it. It pays for the patent in return for 40 percent of any commercialization that results from the idea. From my conversations with the faculty here, I got the impression that the faculty felt an adequate job was not being done. Thus, the contract was not renewed.

EDITOR: Eventually, you'll be working from a base here on campus and probably will have less commuting to do between Chicago and Argonne.

LAZARUS: I see no way to avoid being a constant circuit rider. That's part of the job. I start at my house in Glencoe and drive down to Argonne where I have an office, and then I drive to my University of Chicago office. I have duties to perform in each. I have my involvement with the Division of Biological Sciences or Physical Sciences or the GSB, and then I often have to go uptown. What we will do is not build a huge organization but build a core organization.

Walter Massey, vice-president for research and for Argonne National Laboratory, has already contributed enormously to our enterprise. I keep in close touch with Brian Frost, director of the technology transfer center at Argonne, and with Janett Trubatch, associate vice-president for research and director of research administration at the university. By maintaining really strong lines of communication with them and their staffs, we already have a good nucleus. ARCH's board of directors, chaired by Massey, is a remarkably strong one. (See box.) With such a rich and varied array of talent—researchers Frost and Trubatch, students, Dean Gould, Deputy Dean Davis, Vice-President Massey, and the experienced businessmen on our board—we are indeed off and running. ■

groups at Argonne, the trustees, the Department of Energy, the Department of Commerce, local companies.... a number of people were involved. And finally we came up with a model that was *almost* ARCH. The last element was put in place when Jack Gould became interested and suggested interaction with the Graduate School of Business. That really made it all jell."

When asked about the goals of the corporation, Massey replies: "Our primary motivation for both the university and Argonne is to provide new opportunities for different kinds of research: at the lab, research that might be more focused and at the university, what might be labeled applied research. Since Chicago doesn't have an engineering school, our image is one of a university uninterested in the kind of research that might have practical applications. However, the work of a number of people here, if carried just a little bit further, could result in practical applications. But government agencies don't finance that kind of research—not on this campus, at least, because such contracts usually go to engineering schools. So we need to find some other support."

The university trustees encouraged the idea. The people now on the board of directors of ARCH had been on an ad hoc advisory group appointed by the trustees of the university at the request of President Gray. The advisory group worked with Massey and Schriesheim for almost two years.

Massey adds: "Strong support came not only from the trustees but from such people as Arthur L. Kelly, '64, a member of the Council on the Graduate School of Business as well as a director of ARCH.

"We hope that ARCH will do several things: One, show the faculty and staff at Argonne that the two institutions think this is a legitimate activity. Two, support research that could have practical applications. Three, allow us to attract outside support for more research at both institutions. Four, indicate to the broader community nationally and locally that the U. of C. and Argonne are concerned about possible spinoffs that could contribute to economic development.

"Both institutions have been accused of being so withdrawn from the community that we have not benefited this area in the same way that, say, Stanford has the West Coast or MIT, the East Coast. I hope ARCH will go a small way toward sending a signal to the outside community that we see ourselves as potential contributors to the growth of new enterprises. Finally, if we all get lucky, we will make money to be used for the benefit of both institutions."

Massey admits to being most excited about his latest job. "We all had different ideas, different models as to how the corporation might work because, since it's never been done before, we had to create something new.

"But for ARCH to have even a chance of succeeding we absolutely had to have the right person. That's not easy. First of all, you need a person who can gain the respect of the faculty at the university plus the respect of the scientists and engineers at the lab, a person who understands science and technology and at the same time understands the nature of an academic institution. Second, someone who knows the business community and the financial world and knows how to put deals together. And third, someone who can work with a variety of people—from faculty to administrators to venture capitalists. And that's just a start. We also demanded a nice person. Steve Lazarus fits those qualifications perfectly. We were lucky to find him—and I think we all feel we now have a good chance to make ARCH a success." ■

ARCH DEVELOPMENT CORPORATION

STEVEN LAZARUS

STEVEN LAZARUS is President and CEO of the Argonne National Laboratory/The University of Chicago Development Corporation (ARCH), and associate dean at the Graduate School of Business (GSB), the University of Chicago.

Established in the fall of 1986, ARCH is a joint venture of the Argonne National Laboratory, The University of Chicago, and the Graduate School of Business of the University of Chicago. ARCH is involved in the process of transforming scientific discoveries into viable technology products and services.

Prior to joining ARCH, Lazarus was Group Vice President of the Health Care Services Group of Baxter Travenol Laboratories, Inc. During his 13 years at Baxter, he held various positions including Senior Vice President for Technology, which included manufacturing, materials management, research and development and engineering, and Senior Vice President of strategic planning, materials management, information services and human resources.

From 1972 to 1974, Mr. Lazarus served in Washington as Deputy Assistant Secretary of Commerce for East-West Trade, and was the founder and first director of the Bureau of East-West Trade. He is a 21-year veteran of the U.S. Navy, retiring with the rank of captain in 1973.

He received a bachelors degree with honors from Dartmouth College, and completed his M.B.A. with high distinction at the Harvard Graduate School of Business Administration, where he was also a Baker Scholar.

THE ARGONNE NATIONAL LABORATORY/THE UNIVERSITY OF CHICAGO DEVELOPMENT CORPORATION
Argonne National Laboratory · 9700 South Cass Avenue
Argonne, Illinois 60439 · (312) 972-7483
The University of Chicago · 1115-25 East 58th Street
Chicago, Illinois 60637 · (312) 702-7417

Senator BINGAMAN. Next is Gary Smith, who is with UNM's Technological Innovation Program.

Go ahead, Gary.

STATEMENT OF GARY S. SMITH, DIRECTOR, TECHNOLOGICAL INNOVATION PROGRAM, NMRDI TECHNOLOGY COMMERCIALIZATION OFFICE, UNIVERSITY OF NEW MEXICO, ALBUQUERQUE

Mr. SMITH. Thank you very much, Senator. I appreciate the time to speak on this very important topic this morning. Unfortunately, you have heard my testimony three times now; so I would like to try to focus on the key points of my prepared statement. I will submit the whole prepared statement for reference purposes.

Here in New Mexico, we are currently in a very active planning phase, both from a broad perspective of an economic development plan and as a subgroup which consists of members from the Science and Technology Commission and the Technical Advisory Committee from the New Mexico Research and Development Institute. That group is currently addressing, "What should the State of New Mexico do in the coming 5 years regarding technology commercialization?"

The national laboratories will play a very key role in that plan, as well as the Department of Energy. We have come to the conclusion that the burden should not be placed solely on the shoulders of the national laboratories to do this technology commercialization. It is a multifaceted function that should be performed by a focal organization. It should have participation by the private sector; the national labs; the universities; and as Glenn Kuswa mentioned, maybe even a private-sector group like Lovelace Research. We are looking at forming a high-bred type of an adjunct organization like ARCH because we think that we have a unique situation to develop a national model of cooperation to address this topic.

Having two national laboratories, two DOD labs and three research universities, we think, allows us the opportunity to form a consortium that addresses the key points that Steve Lazarus was addressing in his testimony and all of the points that were brought out earlier. The main rationale for utilizing an adjunct organization is that you should not confuse missions. We cannot turn out national laboratories and our universities into pull-oriented market development-research organizations for the private sector. We're stuck with them being technology-development laboratories and we should not change that.

How best then can we interface with the private sector? I'm suggesting that there is a need for a neutral entity that can address the gaps and all the problems and impediments that we are facing in New Mexico. If we were to develop a consortium whereby all of the technology producers would join together and create a master ARCH, so to speak, we would have agreements between all of the organizations to facilitate the transfer process. We could also try to raise the necessary funds to address all the impediments. We would have the qualified staff on board to identify and to evaluate commercial opportunities, to assist in the patenting process, to address the technology-development gap and to provide a focal point so that private sector has a reason for coming here.

One of my key points I'd like to make is that if the system were working, we wouldn't be here this morning. By definition, we assume that something must be wrong with it.

We also are going forward on a level of subjective evaluation assuming that there is something of value within these laboratories that has commercial potential, but we haven't yet made a quantitative or qualitative evaluation. What has been the return on that investment? What if we were to invest another $2 million in commercial development here in New Mexico? What would be the return on that?

There's been a lot of piecemeal, subjectively driven analyses done, yet no one has taken the time to pull it all together, do a comprehensive analysis and put a plan in place with the sufficient resources, with the commitments of time and people to make it work.

To date, New Mexico has spent in excess of $40 million on the Rio Grande Research Corridor Initiative. Now the Science and Technology Commission has changed its name to add a focus on "Commercialization." So I submit to you that the State of New Mexico is in a very good position to do that kind of comprehensive analysis so that we know what to compare to. How do we know that we aren't achieving a high enough rate of return on that investment already? We don't know. We need to have some kind of analysis that gives us a roadmap to go forward, as opposed to going forward on a gut level.

Assuming that all that could come into place, I suggest that by capitalizing on the sharing of resources and the commitment of all the players in one area like New Mexico, that we can probably serve as a national model, going much beyond what ARCH has been able to accomplish already. So far, the plan, so to speak, is in a very early stage, and we are having some difficulty defining who should take that lead. When you have a lot of diverse entities, there is always a concern about the leadership and whether or not it's somebody else's initiative. The intent of this plan, this initiative, is to try to build a bipartisan effort within New Mexico that does it right. And I submit to you that you can take a strong leadership role in creating that environment that gets away from whose initiative it is, as opposed to coming together under one master plan.

Senator BINGAMAN. Thank you. I appreciate that description. As you said, having heard your testimony several times, I would say you're getting it right.

[The prepared statement of Mr. Smith follows:]

PREPARED STATEMENT OF GARY S. SMITH

Technology Transfer/Commercialization
from National Laboratories--
The Need for a Comprehensive Approach
Based on a Strategic Plan

Thank you for the opportunity to express several ideas that I believe are important for maximizing the commercial utilization of technologies developed at national laboratories. The information presented focuses on the unique situation in New Mexico, but many of the concepts apply more broadly.

I. Summary of Recommendations

A. Develop a comprehensive program with a strategic plan. (This encompasses both the national and local level.)

1. Analyze the history of commercializing privately developed technology as a point of reference. This should define proven methodology and a rate of success for comparison.

2. Analyze the history of technology transfer/commercialization from national laboratories and universities. This should define what has worked and what hasn't and quantify the general results as a basis from which to measure success. It should also identify what changes to make in policies, procedures and resource allocation to allow the system to work more effectively.

3. Based on the above, develop a comprehensive program with an appropriate strategic plan. This should include the definition of realizable goals, the allocation of the necessary resources to accomplish the goals and the implementation of the policies and procedures required to make the program work. This will require a general plan at the national or agency level and a specific plan for each lab which recognizes their special circumstances.

B. Build an organization that can carry out the above plan.

1. Determine the cost effectiveness and appropriateness of using an internal vs. adjunct (external) organization.

2. Create the organization with the proper business-oriented staff, resources, authority, mission, flexibility and accountability to implement the plan.

C. Review progress and adapt as necessary.

II. Background

The UNM Technological Innovation Program (TIP) was formed in 1981 with a National Science Foundation grant to assist in and to promote the commercialization of technologies developed in New Mexico. Since 1983, when the program transitioned to State funding, the staff has assisted more than fifty companies through the start-up phase. These companies have raised more than $25 million in capital to date and are employing more than 200 people with the expectation of employing substantially more people as they mature. Several of these cases were spinoff companies from either Sandia National Laboratories (SNL) or Los Alamos National Laboratory (LANL).

The TIP is currently working jointly with SNL on one particular case to develop a progressive model of technology commercialization. Preliminary results from a DOE Albuquerque Operations study on technology transfer are also pertinent to the subject.

The observations and recommendations in this testimony are therefore based on the above experiences and are biased towards the circumstances found primarily in New Mexico. It is anticipated, however, that most of the information should be applicable generically.

III. Some Observations about the Technology Transfer/Commercialization Process

Indirect vs. Direct Transfer and Information Dissemination/Problem Solving vs. Wealth Creation

Technology transfer as a national topic has steadily gained in importance over the last ten years, primarily for economic reasons. There are basically two modes of technology transfer from national laboratories, direct and indirect. Direct transfer has been in existence since the initiation of the national laboratory system and it has been quite successful. Research results have been directly transferred either to the private sector and local governments, as in the case of the Federal Highway Administration labs or the Department of Agriculture labs, or to the defense industry or integrated contractors, as in the case of Department of Defense labs or Department of Energy labs.

Although there is probably a long history of limited, undocumented commercial utilization of research results from national labs, it is only in the last ten years that it has become a national issue because of international competitiveness and economic survival. This type of transfer results primarily from the spinoff or indirect use of technology. National laboratories are not typically in the business of developing commercial

products for the private sector. However, it has been recognized that national laboratories develop a lot of technology that could be commercially utilized in the private sector. This type of transfer is therefore more correctly referred to as commercialization as opposed to just technology transfer.

This relatively new mission of the national laboratories is somewhat foreign to their culture, is complex, is not well understood, is a secondary mission that sometimes conflicts with the primary mission, is expected to be done in a less than optimum environment and is being judged on an unknown and changing basis of criteria. But, because of the amount of money being invested in research and the generally recognized level of excellence of the work done, it stands to reason without much substantiation that this is a resouce that could be better utilized.

There are generally two types of indirect technology transfer, information dissemination/problem solving and wealth creation. There are numerous interactions through a variety of mechanisms between laboratory personnel and the private sector that result in an information exchange. This exchange is usually driven by the quest for knowledge or by the need to solve a problem. It may result in commercial benefit, but that is hard to measure.

Wealth-creation transfer often requires a more detailed transfer of a technology. It is intended to create a new service or product or significantly improve an existing one. It requires a higher level of commitment by both the lab and the recipient. Intellectual property rights are usually an important factor. This type of transfer will hopefully result in the direct creation of new wealth in the form of jobs and profits to the risk takers. These transfers are much more difficult and the results and failures are more measurable.

Both types of transfer are important and can be enhanced. However, subjective analysis suggests that more can and should be done for the wealth-creation type of transfer which should yield a higher level of economic impact.

Technology Development Gap
Clarifying the Candy Store Myth

National laboratories and universities do not typically do research that is geared towards developing products for commercial markets. Their research is primarily driven by the quest for general knowledge or by the needs of a non-commercial customer. Often, however, the results of this research will have a direct application for commercial markets because of similiar needs or the research can be applied to a spinoff use that has a commercial market.

This research often stops short of the development required

for commercial use. In order to be produced and marketed, some organization must complete the development process. This involves a high degree of risk and requires substantial resources. Labs and universities don't have the proper resources for this mission. This suggests that each lab or university must: 1. develop the capability to address this commercial technology development gap, and/or 2. rely upon the private sector to do it on an ad hoc basis, and/or 3. develop the proper intermediary organization to facilitate this process and interface with the private sector.

Unfortunately, because of the increased awareness of the national labs as a potential resource for commercial technology, a myth has developed that the labs are a candy store with products on the shelf waiting to be exploited. That is not true, and those that do not know this become frustrated in their attempts to cash in. The knowledgeable don't waste the resources to work with the labs unless they know the system and are aware of an opportunity. As a result, the system is working, but on a limited basis. To date, many changes have been made to enhance the system and several additional changes are actively being suggested. The time, however, has come to do a proper evaluation and develop a strategic plan which matches resources to realistic expectations.

Complaints are being made about the system without the benefit of this important management process. Certain changes to the system with unreasonable expectations may not be cost effective. Indeed, there may not be as much commercially valuable technology as expected. Subjective evaluation suggests that this can be improved. Prudent management requires a more thorough, orderly approach before charging forward. There has been sufficient experimentation and data generated to now do a proper analysis and implement a reasonable strategic plan.

IV. Impediments to the Transfer/Commercialization Process

This section deals primarily with the wealth-creation type of transfer. The process is complex, subject to individual laboratory circumstances and involves many variables. Each case has unique problems but most are hampered by a common set of impediments. The following is a list of the key obstacles that are being addressed in a planning effort to implement a comprehensive strategic plan for New Mexico public-sector research institutions which includes both national laboratories and universities.

* Most technologies being developed require additional technical development before they can be marketed.

* Only a limited number of technologies are appropriate for commercialization. It requires considerable time and resources to determine which ones. Even with the proper

resources and caution, it is a risky and imperfect process.

* Commercialization usually requires the commitment of valuable resources that have an opportunity cost and return on those assets often takes three or more years.

* Most of the technology producers do not have the resources to evaluate commercial potential and it is not part of their mission to directly participate in the commercialization process. Participation, when appropriate, is still on a limited basis.

* Patenting decisions are frequently made without the benefit of evaluation for commercial potential. Budgets for this purpose are also limited. Foreign rights are often not sought which limits U.S. commercialization potential in foreign markets.

* Many potential opportunities either lie fallow or are lost because they aren't recognized or if the are recognized, they aren't commercialized because of limited resources and nonsupportive environments.

* Most research institutions currently have case-by-case procedures that cause delays which impede the process and discourage private sector interaction.

* It is difficult for the public-sector research institutions to deal directly with the private sector. The interaction must be closely monitored and controlled to avoid overloading the system and impairing primary mission responsibilities. In addition, caution must be exercised to minimize the liability of interaction with the private sector.

* Commercialization programs at an individual instituition require a certain critical mass in order to work. This may not be cost effective in many situations.

* Public-sector research organizations typically are not entrepreneurially oriented and do not have the flexibility and organizational environment necessary to efficiently handle the business tasks required for commercialization.

V. Proposed Solutions

Proposed Organizational Structure

New Mexico has a particularly intriguing situation in that it is the home to two large DOE national laboratories, the Air Force Weapons Laboratory, White Sands Missile Range, and three research universities, but it has very little industry. Assuming that it

is reasonable to utilize some type of an adjunct organization to effect technology transfer/commercialization, a joint venture organization such as a consortium is being proposed for New Mexico that could hopefully be a model program. This further assumes that it would be more productive and cost effective to develop a single, larger commercialization support organization for the participants to use than could be cost justified on an independent basis.

Many of the features of the consortium would be similar to efforts like ARCH at Argonne National Laboratory or Edge Technologies at Ames Laboratory. The main difference would be the benefits associated with sharing resources among several laboratories in order to obtain a more cost effective use of a larger set of resources.

Generally, the reason for using an adjunct organization is to address all of the impediments noted above in a form that would be more cost effective and interfere less with the primary mission than if done internally. The organization, if formed, would need to have sufficient support, resources and time to be successful. The primary role would be to identify, evaluate, and package opportunities as an intermediary between the lab and the private sector. In essence, the organization would be an independent extension of the technology transfer function at each research institution.

Each research institution would be able to use the organization on a case-by-case basis, but the relationship for each case would be exclusive. This would not interfer with or preclude any other relationships. The entity should be neutral so as to avoid conflict of interest and charges of preferential treatment or unfair competition. It would package opportunities and assist in completing the commercial technology development. The spoils of success would go towards making the organization self-sufficient and, assuming sufficient returns, would be shared with the sponsoring research institutions on an agreed upon basis. The operations should also be managed in as business-like a manner as possible without violating its neutrality.

Major Programmatic Issues to be Addressed

There are five major programmatic issues that the commercialization entity must address: 1. intellectual property rights, 2. access to people, 3. access to facilities, 4. commercial technology development, and 5. interface with the private sector and the market place.

Patents, etc.--

Intellectual property rights must be available in order to justify the investment and risk. This includes broader coverage through other forms in addition to patents and foreign rights, faster access and clearer, better defined procedures.

People--

People are the key to success. It requires the right people from the labs, the right assistance staff, and experienced management for start-up situations. To start any project properly, a better environment needs to be created for access to the technology developers. Whether it turns out to be a transfer to an existing company or a start-up, the technology developers need to be made available for a sufficient amount of time in a mode that does not jeopardize their employment status. As opposed to a leave of absence, this could be better handled as an inter-governmental personnel act transfer. Initially, the sponsoring research organization could loan them to the commercialization entity, and eventually they could be supported by the commercialization effort.

Facilities--

Getting access to facilities at a national laboratory or university for transfer projects is difficult and costly at the start-up level. Even if money and the facilities are available, the process of getting a work-for-others agreement in place is presently prohibitive, especially for small amounts and on short notice. A general work-for-others agreement with guidelines should be put in place to expedite the process. Each request could be put forth in a prearranged manner and a decision at the local level could be made within a week assuming the propriety of the request and the availability of the facilities.

Technology development gap--

The commercialization entity must address the question of how to package the opportunities in order to make them viable to attract private sector interest. This usually requires developing the technology to the point of commercial use. Although this can be done in conjunction with a private sector partner, it will likely require some development before such a partner can be acquired. This will take resources and staying power. The commercialization entity must develop these resources and contacts to accomplish this.

Private-sector interface--

Each research institution can only handle a limited amount of interaction with the private sector before it starts to interfere with the primary mission of research or education. There is also the additional concern about various liability issues. It is difficult to generate much private sector awareness and enthusiasm unless there is a sufficient base of opportunities and a conducive environment.

A consortium in New Mexico would hopefully be able to package enough opportunities and create the right environment to develop a much higher level of private sector interaction than could be done on an individual basis.

Anticipated Benefits

With a consortium in place, there should be more commercialization of technology, particularly in New Mexico. It should also result in greater interaction among the technology producers in the State. This will increase collaborative research, which will, in turn, result in more commercial technology. The sharing of a common base of expertise will not only be more cost effective, but will ensure that each member has the best commercialization assistance available. This should increase the net financial rewards to each member through its share of the returns from licensing and equity participation. A consortium will also be an effective tool to assist each member in changing it internal and external environment to accomplish its goals in technology commercialization.

VI. Summary

The topic of technology commercialization must be addressed from a strategic systems approach. Fixing only part of the system and trying to accomplish technology transfer on an ad hoc basis is not efficient and will continue to be frustrating. The State of New Mexico is currently working on a five-year plan for technology-based economic development. The consortium approach is being considered as a major aspect of the overall strategy. The exact legal structure, its relationship to existing organizations, funding and the details of implementation are actively being considered.

Senator BINGAMAN. Next, Tommy Thompson, who is the president of Riotech and is doing an excellent job in that position.

Tommy, we're glad to have you.

STATEMENT OF T.H. THOMPSON, PRESIDENT, RIO GRANDE TECHNOLOGY FOUNDATION, ALBUQUERQUE, NM

Mr. THOMPSON. My name is Tommy Thompson. I worked for AT&T for 33 years, mostly at Bell Labs, before I retired to New Mexico, and as has been observed, I'm currently president of Riotech here in Albuquerque, New Mexico.

Riotech was a Pete Domenici initiative, and both he and Senator Jeff Bingaman here are on the board of directors.

Riotech has three goals. We want to help strengthen engineering education in New Mexico, using the talents of New Mexico's Federal labs as a resource. We want also to help improve the coupling of the Federal labs into the private sector. Finally, we want to serve industry by supporting research and education programs directed at industry's problems.

The first major thrust of Riotech has been in manufacturing engineering education and research. Manufacturing engineering programs have been initiated, one at UNM and one at New Mexico State. These two masters' programs are complementary to one another and are designed to share teaching resources by use of instructional television facilities between the two universities.

The manufacturing engineering program has the support of local New Mexico industry, as evidenced by their willingness to give manufacturing engineering fellowships and summer jobs to students, as well as their willingness to encourage the participation of their current employees in the program.

Developing a thrust in manufacturing engineering has already resulted in an increasingly better relationship between local industry and our universities. The manufacturing people in New Mexico are anxious to have a local source of manufacturing engineers. This will enable them to recruit, locally and less expensively, some of the engineers they need to be competitive on a global scale. It's expected that as this porogram grows, it can help furnish manufacturing engineering talent on a wider geographical basis to assist in the continuing renaissance of manufacturing in the United States. Finally, from a local economic development viewpoint, this program should help make New Mexico a more attractive location for new manufacturing plants because of the growing manufacturing and engineering talent pool.

The second major thrust of Riotech, which is just now being initiated—as a matter of fact, it was approved at our board meeting yesterday—is in the area of technology commercialization. The basic intent is to develop a program that will facilitate and encourage the commercialization of technology generated in Federal and university laboratories within New Mexico. While recognizing that commercialization of technology is not necessarily a respecter of political boundaries, it is expected that local economic development will be enhanced by this program.

Commercialization of technology has been carried on by industry for decades, ordinarily using technology internally generated

within a company. Almost two decades of my own career at AT&T were spent developing communication products and putting them into commercial manufacture. So I contend that the commercialization process is well understood—but it's harsh. It's harsh because it's a process that winnows out much new technology that can't compete. If your technology is winnowed out, you usually aren't too happy and may ask, among other things, "Why me?"

To answer that, let's start at the beginning. Research is truly a wonderful thing. It can create whole new multibillion-dollar industries. The transistor and the laser are examples. Superconductivity may turn out to be another example. However, most research leads to improved products that have been or can be achieved in some other way. This means a new, improved technology just of research ordinarily has to compete with an older technology already in place.

An older technology that is already in manufacture, and around which a body of understanding and support has been developed, has a very big advantage. This advantage has, more often than not, resulted in the decision to stay with the old, well understood technology, rather than assume the risk of the new. This competition with old technology—which is basically economic not emotional—may well be the biggest enemy of the transfer of new technology. Many rules of thumb are used, but a new technology must frequently have a two to four times performance-cost advantage to survive. This is a tough requirement; however, research and inspired inventions in the United States have met the requirement many times.

The Riotech project is basically to develop a matchmaking capability. We want to work with existing companies—as you heard this morning, many others are working with startup companies—to produce a match between the product opportunities of the marketplace and the technology skills of our New Mexico laboratories.

Notice I didn't say that we intend to push our specific technology into the marketplace. As has already been observed many times, it's a rare case that an already existing technical answer is a readymade solution to a marketplace need. Success usually results from marketplace needs pulling appropriate technical solutions out of the laboratories.

So marketplace pull is the process we're going to try to encourage. To learn how to do this better we intend to start working with a few existing companies that are interested in capitalizing on the Federal labs' skills. One of the first steps is to identify a "champion" in an interested company who really wants to make the process work. Based on a limited number of successful experiences that we've looked into, we believe this "champion" is mandatory. With such a person, we can begin to identify the company's market needs, then match the available technical skills at the Federal labs to that need—or for that matter, to the skills at our universities. Once that match is made, a business arrangement for the company and the lab to work together must be identified and put in place. Parenthetically, may I remark that you've heard again this morning how difficult suitable business arrangements are to make. Once a business arrangement is in place, my experience says you've set the switches for good things to happen, and the race is on. The rest

of the process is well known and understood; and if things work out right, a profitable revenue stream will be created.

Now I'm excited about this. The matchmaking process is going to be frustrating and difficult—it certainly was when I worked in industry—but the personal rewards are enormous when you see new products in use that you've personally touched in some way. I know this for a fact, because I frequently see telephones that my engineers designed on TV. And when I do, I collect my residuals just like the owner of the program.

Thank you.

Senator BINGAMAN. Thank you. We appreciate your statement.

[The prepared statement of Mr. Thompson follows:]

PREPARED STATEMENT OF T.H. THOMPSON

My name is T. H. Thompson. I worked for AT&T for 33 years, mostly at Bell Labs, before I retired to New Mexico. I am currently President of the Rio Grande Technology Foundation, frequently called Riotech, in Albuquerque, New Mexico. Riotech was started by Senator Pete V. Domenici and both he and Senator Jeff Bingaman are on the Board of Directors.

Riotech has three goals. We want to help strengthen engineering education in New Mexico using the talent in New Mexico's Federal Labs as a resource. We want to help improve the coupling of the Federal Labs into the private sector. Finally, we want to serve industry by supporting research and education programs directed at industry's problems.

The first major thrust of Riotech has been in manufacturing engineering education and research. Two Masters degree programs in manufacturing engineering have been initiated -- one at the University of New Mexico and one at New Mexico State University. These two Masters programs are complementary to one another and are designed to share teaching resources by use of instructional television facilities between the two Universities. The manufacturing engineering program has the support of local New Mexico industry as evidenced by their willingness to give manufacturing engineering fellowships and summer jobs to students, as well as their willingness to encourage the participation of their current employees in the program.

Developing a thrust in manufacturing engineering has already resulted in an increasingly better relationship between local industry and our Universities. The manufacturing people in New Mexico are anxious to have a local source of manufacturing engineers; this will enable them to recruit, locally and less expensively, some of the engineers that they need to be competitive on a global scale. It is expected that as this program grows, it can help furnish manufacturing engineering talent on a wider geographical basis to assist in the continuing renaissance of manufacturing in the U.S. Finally, from a local economic development viewpoint, this program should help make New Mexico a more attractive location for new manufacturing plants because of the growing manufacturing engineering talent pool.

The second major thrust of Riotech which is just now being initiated is in the area of technology commercialization. The basic intent is to develop a program that will facilitate and encourage the commercialization of technology generated in the Federal and University laboratories within New Mexico. While recognizing that commercialization of technology is not necessarily a respecter of political boundaries, it is expected that local economic development will be enhanced by this program.

Commercialization of technology has been carried on by industry for decades, ordinarily using technology internally generated within a company. Almost two decades of my own career at AT&T were spent developing communication products and putting them into commercial manufacture. So I contend that the commercialization process is well understood -- but it's harsh. It's harsh because it's a process that winnows out

much new technology that can't compete. If your technology is winnowed out, you usually aren't too happy and may ask among other things, "Why me?" To answer that, lets start at the beginning.

Research is truly a wonderful thing. It can create whole new multi-billion dollar industries -- the transistor and the laser are examples; superconductivity may turn out to be another example. However, most research leads to improved products that have been, or can be, achieved in some other way. This means a new, improved technology just out of research ordinarily has to compete with an older technology already in place. An older technology that is already in manufacture, and around which a body of understanding and support has been developed, has a very big advantage. This advantage has more often than not resulted in a decision to stay with the old, well understood technology rather than assume the risk of the new technology. This competition with old technology -- which is basically economic, not emotional -- may well be the biggest enemy of the transfer of new technology. Many rules of thumb are used, but a new technology must frequently have a 2 to 4 times performance/cost advantage to survive. This is a tough requirement. However, research and inspired invention in the United States have met the requirement many times.

The Riotech project is basically to develop a matchmaking capability. We want to work with existing companies -- others are working with start-up companies -- to produce a match between the product opportunities of the marketplace and the technology skills of our New Mexico laboratories. Notice I did not say that we intend to <u>push</u> our specific technology into the marketplace. It is a very rare case that an already existing technical answer is a ready-made solution to a marketplace need. Success usually results from marketplace needs <u>pulling</u> appropriate technical solutions out of the laboratories.

So marketplace pull is the process we are going to try to encourage. To learn how to do this better, we intend to start working with a few existing companies that are interested in capitalizing on the Federal Labs skills. One of the first steps is to identify a "champion" in the company that really wants to make the process work. Based on a limited number of successful experiences, we believe this "champion" is mandatory. With such a person we can begin to identify the company's market needs that match the available technical skills at the Federal Labs (or for that matter, at our Universities). Once a match is made, a business arrangement for the company and the lab to work together must be identified and put in place. At that point my experience says you've set the switches for good things to happen and the race is on. The rest of the process is well known and understood -- and if things work out right, a profitable revenue stream will be created.

If I sound excited, it's because I am. The matchmaking process is going to be frustrating and difficult -- it certainly was in industry -- but the personal rewards are enormous when you see new products in use that you personally touched in some way. I know because I frequently see telephones that my engineers designed on TV; when I do, I collect my "residuals" just like the people that own the show.

Thank you.

Senator BINGAMAN. Next witness is Arlyn Blackwell, Director of Management Staff at Sandia. We're very pleased to have you here.

STATEMENT OF ARLYN BLACKWELL, DIRECTOR, MANAGEMENT STAFF, SANDIA NATIONAL LABORATORIES, ALBUQUERQUE, NM

Mr. BLACKWELL. Thank you, Senator. I'm really pleased today to be here to tell you about the relationships between Sandia and the university, as you've asked, and to identify potential barriers in those relationships and to discuss the possibility of joint research facilities with the university.

I would like to applaud our two New Mexico Senators, Pete Domenici and Jeff Bingaman, who have fostered cooperation among the New Mexico universities and the laboratories and industry. Their visionary leadership has strengthened our determination—and that could be read another way as, they've held our feet in the fire—to find ways to work together, and that's really happening.

We find substantial relationships between Sandia and the universities in the State, and I'll give you a few examples. The university supplies a great deal of our educational needs, as you might expect. Of our 7,200 people here in Albuquerque, 4,300 of them hold university-level degrees and a total of 8,500 degrees—that's almost two degrees per person—and 20 percent of all those degrees came from New Mexico schools.

Sandia also relies on these institutions for a variety of services, including research. Now last year, we expended some $4 million for research projects in universities here in New Mexico, and we have open contracts totaling almost $11 million today with those universities. In addition, Sandia grants or loans property and materials to universities in New Mexico for research and educational processes, and we employed last year some 300 temporary students and faculty from the universities across the Nation, and over half of those were from New Mexico schools.

Now I have attached to my prepared statement a recent report which enumerates all of the ways in which measurable relationships exist and identifies what—I thought maybe you might be interested in some of those things.

Senator BINGAMAN. We'll include that in the record. Thank you.

Mr. BLACKWELL. OK. Thank you.

Now most of these relationships are those that are easy for us to identify, because they involve either students going to the university, professors coming to our place or relationships where there's a transfer of funds between Sandia and universities. But I'd like to suggest a whole different category of relationships where there is no fund transfer. It would be more of a partnership relationship, where the research ideas are developed jointly and either because one party or both parties have existing funding or would apply for funding jointly to some agency and then cooperate together, either at the university or at Sandia, for the execution of the work.

Now we have a current example of that kind of relationship, and it involves a jointly submitted proposal to the SEMATECH organization for inspection, analysis and metrology of online control of semiconductor manufacturing. SEMATECH represents the semiconductor industry's association of manufacturers, as you know.

And if funded, this proposal would bring $1 million to the university and $300,000 to Sandia for a collaborative project to be conducted in part in Sandia's facilities.

Now we have similar joint proposals with SEMATECH that involve other universities—the University of Arizona and with Rensselaer Polytechnic Institute—so that dispels the idea that we have to have close geography in order to work together, because those two universities are much more distant. And we have a history of successfully conducting cooperative research relationships with other universities, and we even encourage the universities here in New Mexico to accentuate that practice of getting your own development funding to join us in these relationships.

These relationships' arrangements have been very effective at our Livermore laboratory in our combustion research program, where we have partnerships with universities all around the world. We also have relationships with industry—principally American industry—where interns and professors come to work in our facility there. This is one of Sandia's user facilities, and it's the one that I'm most familiar with, because I played a role in getting it started. And there, independent funding is available to the researchers who come there. They work out a research plan with our researchers that matches the interests of the Department of Energy and our program and utilizes the special capability of that facility.

We also need to remember, as others have said here, that our relationships with universities are important; but we really do need to make sure that industry or the private sector are fully partnered in our activities, because the universities and Sandia and the other national laboratories can provide technology, but only industry can apply it to the marketplace for the competitive benefit of our economy. And a joint proposal I described a little earlier for the relationship with SEMATECH would be an example of what I have in mind.

One of the strengths of our combustion research program out in California that I described involves industry. Industry brings to the table the understanding of the issues that are important to them in achieving a marketplace position with the technology that we have in mind. And they serve a valuable role in focusing our research and those of research partners from the universities. So I encourage us to always involve industry early in our dialog.

There are some barriers to keep in mind. We work behind fences because of the classified nature of our work. We may need to clear more people from the universities in this relationship. The uncleared industry visitors and university visitors, though, we have been able to assimilate into the workplace, either through administrative escorts—we're always reviewing the boundaries between the fence line and our facilities to be sure that we can accommodate these visits.

I mentioned I would say something about facilities. You are very well aware of our offer of our radiation-hardened integrated-circuit laboratory to SEMATECH as a part of the New Mexico proposal, and I think we've learned a lot from that. One of the things we learned was that SEMATECH was concerned about the entanglements—entanglements with the Federal Government—that might

attend use of a Federal facility of that sort. So we have to learn to make sure that we don't scare people off like that.

We are siting a major new facility next door to the radiation-hardened integrated-circuit laboratory—it's called the Integrated Materials Research Laboratory—just because we want to provide future access to industry and university researchers.

I appreciate the offer to say these things today, and I appreciate your time.

Senator BINGAMAN. Thank you very much for that testimony.

[The prepared statement of Mr. Blackwell, together with the report referred to, follows:]

PREPARED STATEMENT OF ARLYN BLACKWELL

I am pleased to appear before you today representing Sandia National Laboratories. I have been asked to address problems and barriers to cooperative research arrangements between Sandia and New Mexico universities, and possible solutions to those problems including the possibility of joint research facilities between Sandia and the University of New Mexico.

I want to applaud our senators, Pete Domenici and Jeff Bingaman, who have fostered cooperation among New Mexico universities, laboratories, and industry. Their visionary leadership has strengthened our determination to find ways to work together. And it's happening.

We have very productive relationships with the educational institutions throughout the state of New Mexico.

First, I would like to state that we have very productive relationships with the educational institutions in New Mexico, particularly with the research universities.

Sandia has benefitted from New Mexico higher education: 4300 of our employees hold 8500 university-level degrees; 20% of those degrees are from New Mexico schools. Sandia also relies on these institutions for a variety of services, including research. In the last fiscal year, our expenditures for these services totalled $4.0 million to state educational institutions. Today, open contracts with these New Mexico institutions have a value of $10.8 million.

In addition, each year Sandia grants or loans property and material to universities in New Mexico for research and educational purposes. In 1987, Sandia employed over 300 students and faculty members on a temporary basis at a cost of $2 million. Over half were from New Mexico schools.

We're making progress toward greater cooperative efforts.

I have attached a report that describes our efforts with the state institutions, **SANDIA NATIONAL LABORATORIES AND HIGHER EDUCATION IN NEW MEXICO**, dated April, 1988. This report will explain in more detail the cooperative activities now in progress between Sandia and New Mexico universities.
As the report shows, we've been successful with joint research activities that Sandia directs and funds. Now, however, we'd like to expand into more cooperative efforts. We'd like to join hands as partners in seeking funds and executing work.

Partnerships provide greatly expanded opportunities.

I suggest that a very effective arrangement between the Universities and Sandia would be through a partnership philosophy. Through this partnership concept, the individual researchers agree that the project is mutually interesting. Each defines his own area of expertise, and brings to the effort his own resources. So, there is less need for contracts, fund transfers, and other complicating factors.

A current example is the joint proposal, submitted by UNM and Sandia, to SEMATECH for the inspection, analysis, and metrology of online control of semiconductor manufacturing. SEMATECH represents the semiconductor industry's association of manufacturers. If funded, this proposal would bring $1 million to UNM and $300,000 to Sandia for a collaborative project to be conducted in part in Sandia's facilities. We have similar joint

proposals to SEMATECH with the University of Arizona and with Rensselaer Polytechnic Institute. We have successfully conducted many cooperative research efforts this way, and would like to encourage the universities to emphasize this practice in the future.

Sandia has also used these partnership arrangements very effectively in the Combustion Research Facility in our California laboratory. We have partnerships with university faculty and students from all over the world and with industry researchers from all over America. This has been a very successful model that deserves emulation elsewhere. In all cases, the visitors to our Combustion Research Facility have independent funding sources and a research plan that meshes well with Sandia programs for the Department of Energy.

We need to develop more partnerships with industry.

We have explained our relationship with the universities and how we want to expand those efforts. However, the national labs and the universities need to expand partnerships with industry. We need to remember that our interest here today is to help industry develop our technology and make it useful in the competitive marketplace. The universities and Sandia can provide technology and assistance, but only industry can implement results of these research projects for the benefit of the economy. The joint proposal I described earlier by the universities and Sandia to SEMATECH is aimed in that direction.

One of the strengths of our Combustion Research program has been partnerships that involved industry. These partnerships have

brought forth a good understanding of the important technical challenges and provided a focus for the research conducted at the Combustion Research facility by universities and Sandia. Industry partners generally conduct their portion of the research in their own laboratories. Often, university partners do likewise: they work at their own laboratories as much as possible, and use Sandia facilities only when needed.

These joint projects do not necessarily need to be conducted in the same place. Often collaboration in these joint projects occurs in this way: the universities, industry, and Sandia partners each work in their own laboratories, then meet to share results, which are published jointly.

There are barriers that we must keep in mind.

Most Sandia facilities and people are located inside a secure area where we do classified work for the nuclear weapon program and other defense projects. These factors do complicate work with universities and industry. However, access by uncleared people from both sectors is possible and manageable. We are often limited, though, to access only by citizens of the United States.

We continually examine the boundaries of our secure areas with respect to other facilities to determine whether other facilities should be located outside the classified secure area. For example, we purposely located the Combustion Research Facility outside of our secure area, because we realized free access would better serve the facility's mission. The bottom line is that the security issue is not an insurmountable barrier to cooperation with either industry or the universities.

Further, our mission is not the same as that of an educational institution. As I mentioned, Sandia exists to provide R&D for national security; universities are here to educate. But we do have overlapping interests, which provide opportunities to work together.

With imaginative people addressing these barriers, we have been able to overcome them and identify areas where we can perform productive work together.

In summary, I'm pleased by our progress . . .

We are taking great strides toward establishing truly productive partnerships with universities and industry. Joint proposals and those cases where each participant obtains his own funding can facilitate more opportunities for creative partnerships. We stand ready to work with higher education in New Mexico to contribute to programs of national need.

I want to thank you again for the opportunity to be here today. I am confident that we can work together and provide new and innovative opportunities to contribute to programs of national need.

SANDIA NATIONAL LABORATORIES

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HIGHER EDUCATION IN NEW MEXICO

April 1988

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SANDIA NATIONAL LABORATORIES

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HIGHER EDUCATION IN NEW MEXICO

April 1988

ABSTRACT

Sandia National Laboratories interacts extensively with colleges and universities in New Mexico. This report briefly covers these relationships in employee education, research contracts, loaned equipment, temporary employment, and other areas.

SANDIA NATIONAL LABORATORIES & HIGHER EDUCATION IN NEW MEXICO

Contents & Comment

Sandia National Laboratories &
Higher Education in New Mexico

President's Perspective

A modern research and development laboratory uses and creates a vast amount of knowledge. A continuing exchange of ideas and information with the faculty and students at colleges and universities is an integral part of this process. At Sandia, we draw on the knowledge of university researchers and consultants every day. In addition, colleges and universities supply us with new employees, provide additional education for employees already on roll, and help shape the cultural climate of the community in which these employees and their families live.

We at Sandia owe much to the colleges and universities in New Mexico, particularly our nearby neighbor, the University of New Mexico. Our exchanges with these institutions date back more than 30 years. Because this relationship has progressed so long and so well, it only rarely comes to public attention. But we count it one of the true assets of the Laboratories, one that continues to appreciate with age. We work to ensure that the association remains one of mutual benefit. We believe that it is, today encompassing not only special courses of instruction for our employees, but joint faculty appointments, research and consulting contracts, equipment loans and grants, and temporary employment of both faculty and students. In the ensuing pages, we briefly describe this symbiotic relationship that has served the State and Sandia so well for more than three decades.

Irwin Welber
President

Many Sandia Employees Hold Degrees From New Mexico Educational Institutions

New Mexico educational institutions have had an extraordinary influence on the Sandia work force through the years. Today, the approximately 8,350 employees of the Laboratories hold a total of 1,864 graduate and undergraduate degrees from the four-year colleges and universities in the state. This is 21.9% of the 8,511 degrees held by Sandia employees. In addition, employees hold another 520 two-year associate degrees from New Mexico educational institutions. The total number of degrees -- 2,384 -- is nearly twice the number from the next leading state, California (table, Page 6). When only the highest degree held by an employee is considered, that degree (PhD, master's, bachelor's) came from a New Mexico college or university 28% of the time (table, Page 7). Employees whose highest degree is from the University of New Mexico (UNM) rank, in numbers, at the top of most categories of management and staff at Sandia Albuquerque, (table, Page 8).

The University of New Mexico, with its proximity to the Labs' headquarters in Albuquerque, has granted the most degrees -- 1,245 -- to Sandia employees. Employees hold 253 degrees from New Mexico State University (NMSU), 33 from New Mexico Institute of Mining and Technology (NMIMT), and 333 from the other four-year regional institutions in the state. Engineering degrees, 689, and degrees in business, 428, are the most numerous of those granted, although employees hold degrees in many other fields, reflecting the diversity of work being done at the Laboratories by graduates of colleges and universities in the state (table, Page 9).

SANDIA NATIONAL LABORATORIES NUMBER OF DEGREES BY SCHOOL/STATE

RANK	STATE	PHD	MAS	BCH	SUB TOTAL	% OF SUB TOT	ASSO	TOTAL	% OF TOTAL
1.	New Mexico	88	768	1008	1864	21.9	520	2384	22.5
2.	California	220	426	350	996	11.7	248	1244	11.7
3.	Texas	102	221	357	680	8.0	108	788	7.4
4.	Illinois	127	172	161	460	5.4	191	651	6.1
5.	New York	77	107	158	342	4.0	101	443	4.2
6.	Oklahoma	20	98	159	277	3.3	66	343	3.2
7.	Indiana	49	85	116	250	2.9	65	315	3.0
8.	Michigan	36	88	126	250	2.9	13	263	2.5
9.	Colorado	24	61	144	229	2.7	39	268	2.5
10.	Arizona	32	107	90	229	2.7	53	282	2.7
11.	Other*	474	822	1638	2934	34.5	688	3622	34.2
		1249	2955	4307	8511	100.0%	2092	10603	100.0%

*Includes all other states and countries

HIGH-DEGREE COUNTS BY STATE FOR REGULAR ON-ROLL EMPLOYEES (1/7/88)

Rank	State	PhD	MAS	BCH	Subtotal	% of Subtotal	AAS*	Non**	Total	% of Total
1.	New Mexico	90	650	446	1186	28	416	1624	3226	39
2.	California	216	252	90	558	13	162	266	986	12
3.	Illinois	128	58	58	244	6	150	54	448	6
4.	Texas	102	119	78	299	7	64	61	424	5
5.	New York	78	40	27	145	3	75	46	266	3
6.	Ohio	15	43	41	99	3	85	23	207	3
7.	Missouri	14	47	41	102	2	76	21	199	2
8.	Oklahoma	21	74	34	129	3	50	19	198	2
9.	Arizona	31	75	49	155	4	24	14	193	2
10.	Indiana	49	49	19	117	3	57	17	191	2
	Others (states and countries with less than 190)	484	413	328	1225	29	357	436	2018	24
	TOTAL	1228	1820	1211	4259	100%	1516	2581	8356	100%

*Two-year Associate Degree
**Includes High School Diplomas and College Attendance without Degree

HIGH DEGREES FOR SANDIA ALBUQUERQUE MANAGEMENT AND STAFF* (2/18/88)

Classification	MTS**		MLS***		Division		Department		Director	
Total Population	2058		464		473		122		30	
School		% by School		% by School		% by School		% by School		% by School
University of New Mexico	348	16.9	153	33.0	125	26.4	37	30.3	2	6.7
Stanford University	100	4.9	1	0.2	19	4.0	1	0.8	1	3.3
University of Illinois	97	4.7	2	0.4	17	3.6	4	3.3	2	6.7
University of Texas	71	3.4	9	1.9	14	3.0	0	0.0	0	0.0
New Mexico State University	63	3.1	20	4.3	5	1.1	0	0.0	0	0.0
Oklahoma State University	62	3.0	3	0.6	11	2.3	4	3.3	2	6.7
Purdue University	57	2.8	0	0.0	17	3.6	1	0.8	0	0.0
Texas A&M University	52	2.5	0	0.0	5	1.1	3	2.5	1	3.3
University of Arizona	49	2.4	8	1.7	14	3.0	2	1.6	0	0.0
University of Michigan	47	2.3	2	0.4	6	1.3	0	0.0	0	0.0
University of Albuquerque	3	0.1	17	3.7	10	2.1	0	0.0	0	0.0
NM Highlands University	3	0.1	40	8.6	3	0.6	0	0.0	0	0.0
NM Inst. of Mining & Tech.	8	0.4	0	0.0	1	0.2	0	0.0	0	0.0
Eastern New Mexico University	1	0.0	9	1.9	2	0.4	0	0.0	0	0.0
University of Phoenix - Albuquerque	0	0.0	1	0.2	0	0.0	0	0.0	0	0.0

*Top ten universities for MTS population, plus five other New Mexico universities.
**Member of Technical Staff
***Member of Laboratory Staff

DEGREES FROM NEW MEXICO COLLEGES AND UNIVERSITIES

DEG. FIELD	PHD				Master's				Bachelor's			
	UNM	NMSU	NMIMT	OTHER	UNM	NMSU	NMIMT	OTHER	UNM	NMSU	NMIMT	OTHER
Engineering	37	1		0	324	31	1	0	199	92	1	3
Physics	4	6		0	11	8	2	0	9	8	7	4
Math	8	1		0	13	1	1	1	24	4	4	21
Chemistry	10	2		0	9	1		0	38	11	4	16
Other Sci.	2	1	1	0	7	1	4	0	31	6	2	4
Business				0	105	13		70	89	25		126
Computing	8	2		0	103	13	2	2	41	11	4	21
Other	5			0	41			4	127	15		61
TOTAL	74	13	1	0	613	68	10	77	558	172	22	256

Education of Sandia Employees At Institutions in New Mexico

Sandia-sponsored education of employees was the first formal relationship the Laboratories had with colleges and universities in New Mexico. It remains an elemental part of that relationship today, with approximately 400 employees taking classes at (or receiving instruction from) a college or university in the state at any one time at Sandia expense. In addition, the Laboratories pays the expenses of about 50 employees attending the Technical-Vocational Institute in Albuquerque. Instructional television (ITV) courses, taught at Sandia primarily by UNM instructors, have become an increasingly important part of employee education in recent years. Payments to New Mexico educational institutions for employee education total approximately $300,000 annually.

Educational Assistance Program

The Educational Assistance Program (EAP), begun in 1956 at UNM, is the forerunner of all Sandia-sponsored employee education. Today, approximately 300 students each semester attend classes taught by personnel from UNM and College of Santa Fe (at its Kirtland Air Force Base branch). This total includes employees enrolled in ITV classes broadcast from UNM.

While about half of the employees in the EAP take classes only during the evenings, eligible employees may take up to 7-1/2 hours a week to attend classes at UNM. All College of Santa Fe classes, which lead to a bachelor's degree in business administration, are taught after hours. Courses taken at UNM are diverse, including engineering, physics, mathematics, chemistry, geology, computer sciences and several others. About 80% of all students in the EAP are seeking a degree and slightly more than 50% are graduate students.

The Educational Assistance Program is one of mutual benefit, providing the educational institutions with a steady stream of capable students while enabling Sandia to help on-roll employees advance their careers. The Laboratories' expenses for tuition and other EAP expenses totaled approximately $180,000 in FY'87 -- $120,000 at UNM, and $60,000 at the College of Santa Fe.

IN-Hours Technical Education Courses

UNM instructors also teach most of Sandia's IN-Hours Technical Education Courses (INTEC), a non-credit, on-premises educational program consisting of both ITV and live lecture classes. In the current academic year (1987-88), two of the 15 live lecture classes are being taught by UNM professors, while 44 of the 47 ITV courses originate from UNM. (The others are received via satellite from the National Technological University, a consortium of 21 universities headquartered in Fort Collins, Colorado.) ITV enrollment for the academic year totals 286 employees, of whom 153 are degree-seeking EAP students. Sandia pays a surcharge for each student in the UNM-originated classes to cover the cost of the broadcast. The estimated charge for the 1987-88 academic year for all students is $80,000.

Special Instruction Programs at UNM

While employees have attended UNM under Sandia sponsorship since 1956, the Technical Development Program (TDP), which piloted at the university in 1959, was the first of several at UNM tailored specifically to Sandia's needs. This program, which ran for 10 years, helped change the face of the Laboratories, coming as it did when Sandia was making the critical transition from a production-oriented installation with emphasis on testing and manufacturing

engineering to a modern R&D laboratory. For this program, devised in cooperation with UNM faculty and administration, a special curriculum was organized for a master's degree in engineering -- heavy in analytical engineering methods, nuclear physics, advanced mathematics, and statistical analysis. More than 400 Sandia engineers completed this rigorous program, spending half-time in classes and the other half on assignments at the Labs. These employees were extraordinarily successful at the Laboratories. At a count in mid-1985, 200 of these TDP graduates were still on roll, with that number including two directors, 13 department managers, 69 division supervisors and 12 Distinguished Members of Technical Staff.

This very fruitful Sandia/UNM exchange has been followed by two more recent specialized programs of instruction for Sandia's technical staff. The Special Microelectronics Master's Program, now terminated, permitted new BS-level employees to earn an MS degree at UNM in electrical engineering. The Specialized Engineering Development Program (SED), begun in 1985, enables an employee to earn an MS while working at Sandia half-time. Highly qualified undergraduates from colleges throughout the country are chosen for the program; they study electrical, mechanical or computer engineering or computer science.

UNM benefits from this program in two ways: it gets select students from other colleges, and Sandia gives a grant of $2,000 per student, plus paying tuition and other expenses. Students also have access to Sandia computers and research equipment. Sixteen employees are currently enrolled in the program at UNM. Sandia expenses approximate $50,000 annually for the program.

Other Graduate Education Programs

Sandia sponsors three other employee education programs that impact the graduate schools at the state's three research institutions (UNM, NMSU, NMIMT):

One-Year-On-Campus (OYOC), University Part-time (UPT), and the Doctoral Study Program (DSP). The latter permits members of Sandia's technical staff to attend engineering schools at selected universities, including UNM and NMSU, although presently there are no DSP students attending either of the schools. The UPT program permits employees to work at Sandia while pursuing a master's or PHD in engineering or computer science at UNM. There are presently four students in this program. Sandia pays tuition and other fees, plus a grant of $2,000 for each student. The Labs pays the same expenses and grants for the OYOC program participants, who are minority and female bachelor-level employees pursuing a master's degree in engineering. Candidates for this program are selectively recruited from several campuses, including the New Mexico research universities. There are typically about 15 participants in the program, with the current group including three from UNM, two from NMSU, and one from NMIMT. Two of the participants are attending New Mexico universities -- UNM and NMSU.

Interactions with T-VI

The Laboratories has a continuing relationship with the Technical-Vocational Institute (T-VI) in Albuquerque. Approximately 50 employees attend T-VI each semester, taking courses that are job related, or related to jobs that employees aspire to. Classes are taken during the evening. Sandia pays all expenses, which total about $5,000 annually. The Labs also supports T-VI with approximately $100,000 in loaned equipment. Sandia also cooperates with T-VI and the Albuquerque Public Schools Career Enrichment Center in a program that enables students to work and take classes at Sandia in their third and final trimester after completing the first two trimesters at T-VI or the Center. More than 100 students have graduated from this program since it began in 1974.

Adjunct Professors, ITV & Other Programs That Support Instruction in New Mexico

Sandia funds several activities, such as adjunct professorships at UNM, that contribute directly to the instruction of students at colleges and universities in New Mexico. In addition, the Laboratories is using its expertise in instructional television (ITV) to explore the further use of this promising teaching technique throughout the state.

Adjunct Professors

Twenty-five members of the Laboratories' staff, primarily from technical organizations, are teaching at UNM as adjunct professors. They are the reciprocals of the 25 UNM professors who teach, mostly via ITV, in the Labs' EAP and INTEC programs. Twenty-three of these Sandians teach in the College of Engineering, two in the Anderson School of Business. Teaching loads typically include about three college-credit hours a week in such courses as thermodynamics, nuclear reactor kinetics, mechanical vibration, adaptive signal processing, and electrical engineering materials and devices. Occasionally, members of the Sandia technical staff also provide instruction on-premises for UNM students, a current example being a theoretical solid state physicist at the Labs who is working with two post-doctoral students from UNM.

Science & Technology Alliance

The Laboratories has recently (late 1987) formed a Science and Technology Alliance with three educational institutions, including Highlands University, Las Vegas, New Mexico, that have predominantly minority student populations.

The Alliance, which also includes Los Alamos and Oak Ridge national laboratories and educational institutions in North Carolina and Puerto Rico, was formed to benefit Hispanic, Native American, and Black institutions. This program includes strengthening existing research programs through peer interactions and exchange of science and engineering personnel, through participation in "cutting edge" science and engineering research and development programs, and by providing access to specialized facilities and technical support services.

The program, only now getting under way, will include joint faculty and staff appointments and exchanges; collaboration to improve undergraduate and graduate curricula and research programs; summer jobs; and cooperative education programs for outstanding graduate and undergraduate students. As part of the program, Sandia is assisting with the new electronics and computer engineering curriculum at Highlands, recently having arranged for a Sandia retiree to teach three electronics classes on a temporary basis.

Instructional Television (ITV)

Sandia has developed a state-of-the-art capability in ITV for education of its own employees and is playing a lead role in determining whether this technique can be more widely used in New Mexico. The Labs initiated a joint ITV Working Group in 1985 that is coordinating the exchange of ITV information in the state and reviewing ITV problems in other states and identifying possible problems in New Mexico. Findings are being reported to the State Commission on Higher Education. A Statewide ITV plan is being developed at the request of the Legislative University Studies Group. In addition to Sandia, the Working Group includes several public and private entities: UNM, NMSU, NMIMT, Los Alamos National Laboratory, Kirtland Air Force Base, White Sands

Missile Range, Holloman Air Force Base, BDM Corporation, Honeywell-Sperry Defense Systems, Mountain Bell, Public Service of New Mexico, Riotech, and Technet.

Sandia facilitated installation of the ITV system at UNM, providing technical aid, equipment and seed money -- $100,000 in FY'86 to employ 24 instructors for the INTEC/EAP programs. The Labs is continuing to fund instructors through tuition and the ITV surcharge and, in FY'88, is providing $37,000 in equipment. The Labs is also assisting NMSU and NMIMT with their ITV systems; it participated in the NMSU market survey and is helping establish the ITV link at the university via the Technet fiberoptics net. Assistance to NMIMT includes loans of cameras and help in switching into the Technet link. Cost of this assistance is expected to be about $35,000 in FY'88.

Sandia soon expects to deliver courses from the Labs to not only UNM but to NMSU and NMIMT via the Technet network. ITV courses from these latter two universities would also be used in Sandia's on-premises classes, explosives technology courses from NMIMT being a good example of this potential exchange. It is envisioned that the three research universities might ultimately offer joint degrees in certain technical fields by providing instruction, via ITV, in those areas in which each excels. Such efforts could ultimately be facilitated by continuing Sandia investigations of more cost effective means -- data compression, for example -- of transmitting video signals.
principally by members of Sandia's technical staff. Thirty-two Sandians are scheduled to teach in the summer of 1988. In addition, the Laboratories employs math and science teachers chosen by the local schools to coordinate the program in the schools. Budget for this summer's program is $20,000.

Other Educational Programs & Interactions

Sandia supports various advisory efforts and interactions that promote education and instruction in New Mexico. Many of these activities are centered in the Labs' Education and Training Department, which provides five or six employees (full-time equivalents) whose principal responsibility is support of -- and interactions with -- higher education in New Mexico and other states. In addition to ITV and the specific college and university programs detailed previously, these activities include representation by Laboratories personnel on several advisory boards and committees, including:

UNM/Sandia Joint Education Working Group

Board of Directors of the School of Management Foundation at UNM

New Mexico Vocation Education Council

New Mexico Consortium for Research and Development in Occupational Education at UNM

Mathematics, Engineering and Science Achievement (MESA) Program Board of Directors at UNM

State Commission on Higher Education

Albuquerque Public Schools Career Enrichment Center Advisory Committee

Albuquerque Technical-Vocational Institute Advisory Committees

New Mexico Industrial Technology Advisory Council

Academy for Educational Leadership

New Mexico Apprenticeship Coordinators' Association

In addition, Sandia personnel assist with a variety of university programs and proposals at UNM and NMSU, such as:

Graduate degree program in telemetry at NMSU, where Sandia personnel have helped design and develop the curriculum and provided other support such as hiring two NMSU students for the One-Year-On-Campus program;

A ceramics research center proposal to National Science Foundation. Developed jointly by UNM, Los Alamos and Sandia, this proposal would provide for a center that includes graduate level training in ceramics sciences;

Center for High Technology Materials at UNM -- Sandia personnel have assisted with proposals to Sematech, the U.S. consortium on semiconductor manufacturing, on uses of laser diagnostics and optical techniques to monitor and control processes.

Nuclear Research and Education Committee at UNM -- Sandia has assisted with curriculum design and development and provided career counseling for both students and faculty.

Contracts for Research & Other Services Placed with Universities in New Mexico

Sandia relies on colleges and universities in New Mexico for a variety of services, including research. Expenditures for these services in the fiscal year ended September 30, 1987, totaled $4,028,000; $3,154,000 of that amount was awarded to UNM (table, page 27). Open contracts with New Mexico institutions as of September 30, 1988 had a value of $10,777,000.

Awards for independent research by faculty and graduate students constitute a substantial portion of these contracts. Such work is conducted across a range of technical and scientific disciplines; at UNM, for example, research is presently under way in biology, chemistry, geology, mathematics and statistics, meteoritics, physics and astronomy, engineering (electrical, mechanical, civil, chemical, nuclear, computer), and several other fields. The quest may be for knowledge that will be used to solve a specific technical problem in one of the Labs' defense or energy programs -- high power switching studies for Sandia's Particle Beam Fusion Accelerator, for example -- or for information that does not have a specific application, such as that obtained under a Sandia University Research Program (SURP) contract.

Such Sandia-sponsored research is often at the forefront of modern science and technology. For instance, a UNM professor working with the Labs' Intelligent Machine divisions on robotics has developed software algorithms for a computer program that controls a three-finger hand. This hand, powered by 12 separate motors, is believed to be the most advanced hand of its kind. It might ultimately be used for such tasks as picking up items from a hazardous area -- the bottom of a nuclear reactor pool, for example. Also in Sandia robotics research, UNM personnel are investigating force feedback control of

mechanical grippers and how computers communicate with each other in robot control.

Sandia also awards contracts for a variety of technical services, such as one with the New Mexico Solar Energy Institute at NMSU for operating and collecting data from photovoltaic arrays at a test facility in Las Cruces. Services of a non-technical nature are also secured; for example, the Laboratories contracts with the UNM library for inter-library loan services -- obtaining copies of technical journal articles not available at Sandia. This contract typically has a value of about $70,000 annually.

Sandia University Research Program (SURP)

The core of the Sandia research effort at New Mexico universities through the years has been the Sandia University Research Program. SURP dates back to 1957 when the Labs began supporting research projects at UNM; the program was expanded in 1985 to include the state's other two research institutions, NMSU and NMIMT. In 1987, Sandia supported 12 SURP projects at UNM at a cost of $360,000, three at NMIMT for $90,000, and two at NMSU for $60,000. In 1988, the Labs is supporting 16 projects -- nine at UNM, four at NMIMT, and three at NMSU -- at a total cost of $480,000.

SURP is basically a faculty development program in which promising new faculty members are granted a research contract. The contracts are actually "seed grants" -- usually the first grant money the investigator has received. The program is limited to faculty members who have been on the staff of one of the three universities two years or less. The research is conducted on campus and the project is limited to two years, with $30,000 in funding each year. The grant is just large enough to fund research by a graduate student, pay the

summer salary of the faculty member, and lessen his or her teaching load during the academic year.

While SURP projects are primarily for faculty development and not to solve an immediate Sandia technical problem, an important aspect is that each project director (candidate) must find a technical sponsor at the Labs with whom he or she will work or to whom the research will be of interest. Once a project is selected after extensive committee reviews at both Sandia and the university, the candidate submits quarterly reports and a final report on his work. SURP funding has proved through the years to be a critical first step in helping faculty members to build successful research programs. Once the SURP contract is completed, the investigator is often able to obtain additional grant money from other industrial or governmental sources, frequently in much larger amounts than the original SURP grant. And, in several cases, there have been extended collaborations with Sandia technical organizations long after the SURP funding has ceased.

Sandia University Research Program - FY'88

New Mexico State University

Chemistry	-- Investigation of Coherent Forward Scattering Spectroscopy for the Determination of Refractory Metals at Trace Concentrations
Mechanical Engineering	-- Adaptive Multi-Level Solution of Large Elliptic Systems on Vectorized Computers - Phase II
	-- Pseudoinverse Control of Redundant Robot Manipulators in Real Time

New Mexico Institute of Mining and Technology

Chemistry	-- Thermal Response of Certain Monomolecular Explosives
Geophysical Research	-- Measurement of Direct Lightning Strikes

Materials/ Metallurgical Engineering	-- High-Temperature Bonding of Silicon Carbide
Explosives Technology Research	-- Shock-Induced Chemical Synthesis of Intermetallic Compounds

University of New Mexico

Chemistry	-- Immobilization of Metal Clusters and Complexes in Zeolites
Civil Engineering	-- Force Identification from Structural Responses
	-- Development of an Automated 3-D Finite Element Mesh Generator
Electrical Engineering	-- Nonlinear Lasers and Laser Arrays
Geology	-- Correlation of Organic-Inorganic Diagenesis in Sandstones Intercalated with Organic-Rich Sediments: Piceance Creek Basin, Northwestern Colorado
	-- The Formation and Evolution of Deformation Microstructures
Mathematics/ Statistics	-- Mathematical Study of a Multi-Phase Flow Model for the Combustion of a Gas-Permeable Reactive Granular Material
Physics	-- A Proposal to Study the Evolution of Spiral Galaxies
	-- Coherent Transport of Trapped Resonant Excitations

Sandia University Research Program - FY'87

New Mexico State University

Mechanical Engineering	-- Optical Diagnostics of Agglomerated Particles and Its Application on Flame Soot Studies
	-- Multi-Dimentional Inverse Heat Conduction

New Mexico Institute of Mining and Technology

Chemistry	-- Predicting Thermal Response of Certain Monomolecular Explosives
Computer Science	-- Empirical Investigations and Ada
Physics	-- Measurement of Direct Lightning Strikes

University of New Mexico

Biology	-- The Role of Microbes in the Chemistry of Geothermal Fluids
Chemistry	-- Bimetallic Metal-Metal Interactions in Zeolites
Chemistry/ Nuclear Engineering	-- Support Effects in Adatom Modification of Metal Surfaces in Bimetallic Catalysts
Civil Engineering	-- Force Identification from Structural Response
Computer Science	-- An Algebraic Approach to Highly Parallel Computing
	-- Indexing Compressed Data
Electrical/ Computer Engineering	-- Three-Dimensional Computer Vision
Geology	-- Paleomagnetic and Rock Magnetic Investigations of Cooling Histories of Igneous Bodies and Their Wall Rocks
Mathematics/ Statistics	-- Mathematical Study of a Multi-Phase Flow Model for the Combustion of a Gas-Permeable Reactive Granular Material
	-- Numerical Solution of Ideal Supercavitating Flows in the Plane and Around Bodies of Revolution
Physics/ Astronomy	-- A Proposal to Study the Evolution of Spiral Galaxies
	-- Coherent Transport of Trapped Resonant Excitations

Joint Appointments Program

Another Sandia-sponsored program at UNM that aims at faculty development through research is the Joint Appointments Program. This effort is part of a plan to build centers of excellence in a few specialties -- microelectronics, optoelectronics, computer science -- in UNM's College of Engineering. In this program, Sandia and UNM share faculty members, with the joint appointees working half-time on contract at Sandia and teaching half-time at UNM, with costs ($50,000 for Sandia's share in FY'87) split evenly.

The appointments are generally for two years and are directed at highly qualified PhD's, who join the faculty with the rank of assistant professor. Incentives include a tenure track at UNM and research opportunities at Sandia. There are presently two appointees in the program, with two others expected to join the program this year, and possibly two more next year. The program presents an opportunity to combine university research and instruction with work on advanced technical problems at the Laboratories. One current appointee, for example, is teaching in the Electrical Engineering Department at UNM while evaluating advanced synthetic aperture radar systems at Sandia, with a view toward developing new imaging techniques. The other appointee, teaching in the same department, is conducting research at Sandia on plasma deposition of materials and on high temperature superconductors. He is also working with the Center for High Technology Materials at UNM.

In a research program that would be somewhat similar to the Joint Appointments program, Sandia is participating in an effort to attract at least one world-class professor to UNM. The person in this Distinguished Professor Program would receive full-professor status at UNM and research funds from the Laboratories.

Research With Product Potential

A significant aspect of Sandia-sponsored research is the potential for development of products or processes that may impact the New Mexico economy. A current example is work on a new device, a semiconductor bridge (SCB), that has resulted from about five years of development and testing by a Sandia technical team working closely with University of New Mexico engineers and, more recently, with personnel from NMIMT. The SCB is a solid state device designed

to replace and/or extend the capability of small metal bridgewires -- commonly called hot wires -- used to electrically ignite small explosive charges for a variety of military, space, and civilian applications, such as in mining or construction. The SCB device is smaller, operates faster, and requires less energy to ignite than a conventional hot wire.

Work on the SCB is unique in that it now involves contributions from two of the Centers of Technical Excellence established at universities in the state. UNM's Center for High Technology Materials has tested and built most of the SCB chips, while the Center for Explosives Technology at NMIMT is engaged in packaging and testing the devices. A new company, organized with the assistance of the Technological Innovation Program at UNM, will produce the devices. As the effort matures, the Labs will work to help facilitate use of the new technology by commercial end-users. Sandia expects that its technical programs will also benefit from the additional research supported by commercial interests.

Collaboration on research with economic potential need not require funding of university researchers or necessarily be in one of the engineering or scientific disciplines. For instance, two efforts that could lead ultimately to commercial developments are under way between Sandia researchers and those at the UNM School of Medicine. In one project, a miniature radiation sensor is being developed jointly by personnel in Sandia's Microsensor Division and those in UNM's Cancer Center. The goal of the cooperative project is an implantable dosimeter that can give an instant, precise measurement of the dose rate and total dose that a cancer patient is receiving. A method has been developed for mounting the sensor (a radiation-sensing field effect transistor or RADFET) inside a standard medical catheter commonly used to implant radioactive pellets

in patients to treat certain types of cancer. The device has been tested at both Sandia and UNM and plans are under way to license the device to a commercial manufacturer.

In the other medical-related development, the possibility of using polymer foams developed at Sandia in artificial veins (vascular grafts) is being explored in collaboration with a professor at the UNM School of Medicine. UNM personnel have also suggested that the foams may have potential applications in nerve regeneration pathways, artificial skin, and several other uses.

Collaborations with the Medical School have been facilitated in recent years by a formalized information exchange -- Biologues (biology dialogues) -- between the School and several technical departments at Sandia. Joint UNM-Sandia work on the RADFET development ensued from this exchange.

Consultants

In addition to conducting research, university personnel serve as consultants to the Laboratories, providing expertise in a variety of fields. Sandia presently has contracts valued at approximately $375,000 with about 20 consultants from UNM and NMSU. Fees are paid directly to the consultant rather than the university.

ACTIVITY WITH EDUCATIONAL INSTITUTIONS IN NEW MEXICO

FISCAL YEAR ENDING 9/30/87

	Open Contracts*	Expenditures
University of New Mexico	$ 8,816,000	$3,154,000
New Mexico State University	1,229,000	569,000
New Mexico Solar Energy Institute (NMSU)	375,000	138,000
New Mexico Institute of Mining & Technology	102,000	92,000
College of Santa Fe	176,000	60,000
Albuquerque Technical Vocational Institute	66,000	5,000
Webster University**	13,000	10,000
	$10,777,000	$4,028,000

*Total value of contracts from time of placement to ultimate completion. Expenditures include tuition.
**Purchasing instruction on-premises.

Loans and Grants of Equipment & Materials to Universities in New Mexico

Each year Sandia grants or loans property and material to universities in New Mexico for research and other educational purposes. Grants, awarded under the Department of Energy's Energy-Related Laboratory Equipment (ERLE) program, consist of outright gifts of used equipment such as oscilloscopes, voltmeters, power supplies, etc. The items are for use in energy-oriented educational programs, with emphasis on the life, physical, and environmental sciences and engineering. Loans include spare or unused laboratory equipment that is required at one of the universities for immediate use on a Sandia research project or for some other application at the institution. The Laboratories markedly increased its grants and loans to the state's three research universities in FY'87, with grants totaling $153,614 and loans $1,548,181 vs $131,600 and $979,242, respectively, in FY'86.

GRANTS AND LOANS OF PROPERTY AND MATERIALS TO UNIVERSITIES AND COLLEGES

School	Grants of Equipment		Loans of Property & Material	
	1986	1987	1986	1987
UNM	$ 61,900	$ 19,791	$ 885,919	$1,374,271
NMSU	0	38,341	63,773	88,790
NMIMT	69,700	129,990	29,550	85,120
TOTAL NM	$131,600	$153,614	$ 979,242	$1,548,181
TOTAL U.S.	$811,000	$576,606	$8,000,000	$8,566,944

Temporary Employment Programs For Students and Faculty

Temporary employment of faculty members and students, including those from high schools, is an important facet of Sandia's support of education in New Mexico. Often this employment involves special programs (table, page 33) tailored specifically to the employee's career interests while, at the same time, he or she is obtaining on-the-job experience and funds to finance further education. Temporary employment also allows Sandia to become thoroughly acquainted with outstanding students who may be candidates for future full-time employment. Employment of students and faculty also enhances the Labs' reputation with educational institutions, making it easier to recruit outstanding employees.

Typically about 300 students and faculty members are employed on a temporary basis each year at a cost approximating $2 million. Often more than half of these employees come from New Mexico high schools, colleges, and universities -- and in several instances the temporary programs are limited to New Mexico residents. The Work Experience Trainee and Youth Opportunity Trainee programs are almost entirely for New Mexico high school students, and serve as effective community outreach tools. They provide economically disadvantaged high school and post-high school students an opportunity to practice vocational skills and to earn money for further schooling. The Secretarial Skills Building program is targeted at minority candidates, who receive an intensive six-month in-house course designed to develop or polish secretarial skills. Applicants for the program, most from the state, are usually offered jobs at Sandia after successful completion of the course. This program is not currently populated because of recent hiring limitations at the Labs.

In FY'87, the Laboratories employed 307 students and faculty members, with about 60% of the 250 students and approximately 45% of the 57 faculty members being from New Mexico. Cost of the program was $2,022,101, exclusive of the Historically Black Colleges and Universities program, which was funded directly by the Department of Energy. Students received $1,247,649 of this amount, including $810,971 for state students. Faculty members received $774,452, with state residents receiving $356,247. The University Summer Faculty Program was the most expensive, costing $513,700, while the Outstanding Student Summer Program cost $442,543 and the Youth Opportunity Trainee Program $303,800.

A description of these temporary programs:

Career Exploration Program -- Gifted high school seniors are provided an opportunity to gain engineering experience at Sandia. Candidates are selected by Albuquerque Public School employees and work about 20 hours a week at Sandia.

Faculty Sabbatical Program -- Selected professors are brought on-roll as temporary employees, usually for one year, to work on research and development projects specified by Sandia organizations.

Graduate Business Intern Program -- Outstanding graduate business students from UNM are provided relevant work experience. Candidates are recommended by their faculty and placement office.

Graduate Engineering Intern Program -- This program enables highly qualified graduate engineering students to integrate their academic programs with related work experiences. It is an effective means of attracting outstanding students to UNM's graduate program. UNM screens the candidates and refers them to Sandia's Staff Recruiting office. The Sandia organization that can provide appropriate training and professional experience makes the selection.

Historically Black Colleges and Universities Program -- Funded directly by DOE, this program provides a significant summer work experience to outstanding black engineering and science students who attend historically black colleges and universities. Students are recruited nationally and must be recommended by faculty members.

Joint UNM-Sandia Appointments Program -- This program is designed to attract outstanding faculty to UNM by providing both academic and industrial research opportunities. UNM identifies the candidates, who are interviewed by both UNM and Sandia. Mutually agreed-upon candidates are hired by UNM and contracted by Sandia for services.

NMSU Summer Drafting Program -- This program provides first-year NMSU students work experience; Sandia drafting organizations recruit for this program.

Outstanding Student Summer Program -- Outstanding students in engineering and science programs at the junior level or above are exposed to Sandia's environment.

Secretarial Skills Building Program -- This program develops secretarial skills, targeting minority candidates for future employment at Sandia. Applicants are pretested and interviewed, then enrolled in a six-month intensive skills-building program.

Summer Teacher Enrichment Program -- New Mexico high school and middle school science and mathematics teachers upgrade their knowledge of science and technology through summer employment at Sandia. The program is coordinated by New Mexico Tech.

Undergraduate Engineering Co-Op Program -- Sophmore-,junior-, and senior-level students are provided work assignments in engineering and computer science. Work periods alternate with academic study periods. The program is coordinated with specified universities with high minority enrollments.

University Summer Faculty Program -- This program is designed to attract outstanding professors from universities throughout the country who will make meaningful contributions to the Labs' technical work. At the same time, the professors have an interesting and meaningful work experience. Two types of professors are sought: authorities in a technical field who are capable of performing important technical functions and of providing consultative and guidance services; and professors with outstanding qualifications for more specific, project-oriented assignments.

Work Experience Trainees Program -- This program provides part-time employment and job experience to economically disadvantaged high school and post-high school students enrolled in a cooperative education training program. Preference is given to applicants with economic need, high scholastic performance, and favorable recommendations from teachers.

Youth Opportunity Trainee Program -- YOT offers summer employment to economically disadvantaged high school and post-high school students, thereby providing valuable job experience and a source of income for further education. Preference is given to applicants with economic need, high scholastic performance, and favorable recommendations from teachers.

TEMPORARY EMPLOYMENT FY'87

Program	Number of Participants	
	New Mexico	Other States
Career Exploration	5	0
Faculty Sabbatical	2	3
Graduate Business Intern	2	0
Graduate Engineering Intern	4	0
Historically Black Colleges & Universities*	0	16
Joint UNM-SNL Appointments	2	0
NMSU Summer Drafting	2	0
Outstanding Student Summer Program	9	59
Pulsed Power Trainee	3	0
Secretarial Skills Building	0	0
Summer Teacher Enrichment Program	16	0
Undergraduate Engineering Co-Op	4	1
University Summer Faculty	6	28
Work Experience Trainee	32	11
Youth Opportunity Trainee	87	11
Student Intern	4	0
TOTAL	178	129

*Funded Directly by Department of Energy

SANDIA NATIONAL LABORATORIES PARTNERSHIP WITH EDUCATION IN NEW MEXICO
Expenditures, Equipment Loans and Employment Programs
Fiscal Year Ending 9/30/87
(Dollars in Thousands)

	UNM	NMSU*	NMIMT	College of Santa Fe	Webster Univ.	TVI	TOTAL
Expenditures							
Education of Sandia Employees							
Educational Assistance Program	$ 120			$60	$10	$5	$ 195
In-Hours Technical Education	40						40
Special Engineering Development Program	50						50
One-Year-On-Campus Program	9	$ 6	$ 2				17
Programs That Support Instruction							
25 Adjunct Professors	**						**
Instructional TV Assistance	**	**	**				**
Contracts for Research & Services							
Sandia University Research Program	360	60	90				510
Joint Appointments Program	50						50
Other Research Contracts and Services	2,525	641					3,166
Total FY87 Expenditures	$3,154	$707	$ 92	$60	$10	$5	$4,028
Equipment							
1987 Equipment Grants	20	38	130				188
Property On Loan	1,374	89	85				1,548
Total Resources Allocated to NM Schools	$4,548	$834	$307	$60	$10	$5	$5,764
Temporary Employment Programs							
New Mexico Students)							
New Mexico Faculty)High School & College							811
							356
Total							$1,167

Total Monetary Value of Expenditures, Equipment and Temporary Employment $10,959

*Includes New Mexico Solar Energy Institute
**Use of Sandia Employee Time in Educational Support

Senator BINGAMAN. Our final witness in this hearing is Paul Risser, the vice president of research at the University of New Mexico.

Paul, we appreciate your being here.

STATEMENT OF PAUL G. RISSER, VICE PRESIDENT FOR RESEARCH, UNIVERSITY OF NEW MEXICO, ALBUQUERQUE

Mr. RISSER. Thank you, Senator. I'm glad to be here. Let me add my commendation to you for being a leader in this topic and for gathering us together for this.

Being last is unenviable. The first point is that the university, I think, has, in a sense, reassessed its position and assistance vis-a-vis coming development and the commissions between the laboratories and the private sector. And that's being manifested in several different ways, perhaps the most obvious of which is a new program which we have called UNM-Business Link. This program is described in a multicolored brochure which you have as part of the record. This program recognizes that the university, throughout its activities, impinges upon economic development in a number of ways.

There are lots of activities which can help that process. We can notice education, as well as research and public service. These activities are organized under several different headings.

For example, a major activity is to recognize that the public, and especially the private sector, needs one entry point to the university to recognize all these sources of information and the kind of assistance which can be provided. So part of the activity is to provide one telephone number which allows you—that is, you from the business communities or from industry or elsewhere—to do this in an efficient manner. Second, the attainment in reverse, which is a sensitive topic of this morning's discussion, and that's ways in which we can take discoveries and ideas from the university to the private sector. The third part of this has to do with the research part. And I'll come back and make a few more comments about the research part, which is being developed. This is a physical thing, where we combine the business communities with the educational community. The fourth part has to do with data networks and data bases. That is, the university has taken a lead in making data bases which can be useful to the business community organizing those data bases, and that's another part of the Business Link. There is a part of the Business Link which represents the general business assistance in terms of providing advice to small businesses, which is an activity which is modifying our educational program.

So the first of the four points I want you to understand is, in fact, the Business Link is operational now. And I think it will be a welcome addition to the State in a way in which the university can be responsive to the business community while maintaining the guise of the university.

The second point has to do with the sense of technical manufacture and particularly the technical programs. Those programs provide Senators with a major role in encouraging those activities. In a technical sense, they have been unquestionably successful. The

commercialization of those products—and in a sense, we're just beginning that—is a logical progression from research to commercialization.

The point which is sometimes not always presented is—Gary Smith hit it—it has, over the past 4 years, been involved with the initiation of 500 new bases and has acquired or helped acquire $25 million in terms of venture capital. So that program is a success and has been a success.

The third point I want to raise is the idea of a consortium. This has been a theme throughout these discussions, which suggests that obviously it is a process whose time has come. It builds on the point that I've said before; that is, it builds on, for example, the activities that we have had in the past. It builds on the successes of the Technological Innovation Program, and it now combines, in a realistic sense, the private sector and the laboratories and the research organizations of the State. So without providing more detail on the consortium, my point, of course, is that it falls logically from the history we have set.

The last of the four points I would like to make was addressed essentially by Arlyn Blackwell; that is, the relationship between the university and the Federal laboratories—we use the term "Federal laboratories" because we deal with both—and the kind of activities which are important there.

However, I think there are some other points which are equally relevant; in particular, the interchange between the laboratories and the universities. Those are interchanging or intensifying, essentially, by the day. That is, there are the very tangible joint research cooperative programs that were mentioned. There are also proposals like SEMATECH. There are cases where the university has acquired funding and has laboratory staff members as a part of that project. Those are not funds through DOE, but rather independent funding. And there is an ARCH proposal to the Science and Technology Center, which involves the laboratories, as well as the university. There is a new microelectronics-microengineering facility, which has the approval of the National Science Foundation. That involves the University of New Mexico. It involves both national laboratories, and it involves the private sector. Here is a program that combines all three of those entities that are actually crucial to us.

In terms of that kind of activity, the new facility at Sandia is obviously important in bringing together those entities—the research part, which will also bring together facilities from the university, from the laboratories and essentially a neutral ground where the lab brings the community together. And some of our ideas are, in fact, to instruct entities on that research part, which are very influential in making that transition occur.

I echo Jeff Nathanson in terms of the activities already going on there.

So let me summarize the fourth point I have; that first of all, in terms of the activities of the university, there is more than that—not only for the university to integrate its activity, but to allow people from the outside to have access to its facilities.

Second, we build on the success of the centers of technical innovation and the TIP program. It builds a good record in terms of re-

search and in terms of development in some cases, and there are instances in which those centers have combined with the TIP program and with private industry.

Third, the notion in terms of looking at the kind of activities that we have and the consortium arrangements, I think, has great promise.

And then, fourth, the notion that the university and laboratory is building strong bridges with the laboratory, those bridges bring economic development, as well.

So let me take, again, a moment to thank you for convening us and for, in fact, arranging this discussion. Thank you.

Senator BINGAMAN. Thank you very much.

[The prepared statement of Mr. Risser, together with the brochure referred to, follows:]

PREPARED STATEMENT OF PAUL G. RISSER

I appreciate the opportunity to address the Joint Economic Committee about the important topic of nurturing start-up and young firms, and about the ways in which the University and the Federal Laboratories have collaborated to foster research and technology development in the private sector.

My presentation will include two parts: (a) discussion of barriers to start-up firms and the response of the University of New Mexico to these barriers, and (b) description of barriers to technology transfer from the Federal Laboratories, and again, the mechanisms by which the University and the Laboratories have begun to address these barriers.

Start-Up and Existing Businesses

Start-up and beginning small businesses begin with many challenges, e.g., the need to develop ideas from the proof of concept to prototype devices and then to the stage of commercial value, necessity for capital, and the obligation to plan and operate a business. These challenges require a collection of talents normally not encompassed by one individual. Expansion of existing businesses may also require new ideas, capital, and business management strength, but also a trained work force, available markets, and in the case of high technology firms, research collaborators.

The requirements of developing businesses and the products of research universities are very simmilar. An important consideration is a strong university with well-qualified students and faculty. Although I could pursue this point, let me focus on two activities of the University of New Mexico which are designed specifically to address these barriers or challenges.

First, because of the need to combine many skills for developing new businesses, the State of New Mexico, with the Senator's assistance and strong subsequent encouragement, began the Centers of Technical Excellence and the Technology Innovation Program. These organizations had components elsewhere in New Mexico; let me focus on the University of New Mexico. Here there are two Centers of Technical Excellence: Center for Non-Invasive Diagnosis and the Center for High Technology Materials. Both of the Centers have received state funds as well as University funds. From this investment, two excellent research centers have developed with the consequent benefit to the University's academic program. In addition, both Centers have been involved with small business start-ups and collaborative research with Federal Laboratories and various larger firms. In one instance, the Center has operated as an incubation center, providing both facilities and technical expertise. Thus, this is a collaborative effort among the University, Federal Laboratories, and the private sector.

The Technology Innovation Program was designed to assist the development of new businesses, especially though not entirely in the area of high technology. Furthermore, this Program was designed to assist with transfer of technology from the Centers of Technical Excellence to the private sector--a process which is operating today. After about five years of effort, the Technology Innovation Program here at the University has been involved in the initiation of approximately 50 new businesses and has raised more than $25 million in venture capital.

Second, realizing the many ways in which the University interacts with economic development and specifically with technology transfer, we have just established an ambitions new program. This program, called the UNM-BUSINESS LINK, organizes the activities on campus which have the most direct effect on economic development. These activities are organized according to several categories.

Coordination with other private, State and Federal activities in economic development

Research transfer and the topic of additional discussion given below

Research Park which has begun development on the south campus

Data network, the organization of and making information available through various electronic techniques

Business assistance to start-up and small businesses

International affairs, particularly combining international business experience with education

Education and training through which the needs of the business community are addressed by specific curricula and by delivery systems such as televised instruction

All of these activities are organized under one institutional structure. This permits the entire constellation of activities, which are located throughout the campus, to interact with each other and to develop joint programs in response to the needs of the business community. Furthermore, one telephone number will connect anyone to all of these activities.

Interactions between the University and Federal Laboratories

Barriers to technology transfer from the Federal Laboratories are reasonably well-known and the list contains few surprises: national security and the perhaps necessary hindrance to the timely release of technical information; preferential treatment and the potential for favoritism; unpredictability and cumbersomeness of dealing with intellectual property rights; relationships between the Laboratories and their managing institutions and institutional headquarters; and some restrictions in terms of appointments with universities. Then, of course, there is the absence of a well-developed structure for moving ideas into the market place. However, the Laboratories in New Mexico have taken this responsibility seriously and have developed active offices to encourage and expedite this technology transfer.

Let me again describe two responses of the University and to some degree the Laboratories, to these barriers. First is the idea of a consortium which would combine resources from the universities, Laboratories and other not-for-profit research organizations to provide a full complement of the requirements for technology transfer. The notion has been discussed throughout the State and is the topic of testimony by Mr. Gary Smith, who is Director of the New Mexico Research and Development Institute, Office of Technology Commercialization. The concept will provide the Laboratories with a neutral partner in transferring technology, thereby eliminating the favoritism issue. Also, because of the great expense of maintaining the full cadre of expertise required for technology transfer (e.g., technical scientists and engineers, financial experts, business management advisors), this consortium will enable each Laboratory to have an economic and effective access to this suite of talents.

Second, the University and the Federal Laboratories in New Mexico have developed a number of bridges across these barriers. For example, there are:

-numerous joint research programs involving laboratory scientists and university research;

-joint recruitment and employment programs where the University and the Laboratory jointly advertise for a scientist or engineer who is then selected, funded by both organizations, and who works both at the University and the Laboratory;

-joint research proposals either submitted jointly, or in the case of the National Science Foundation, where the proposal is submitted by the University but on which Laboratory scientists are key scientists;

-joint research institutes, for example, the newly established Center for Micro-Engineered Ceramics; and,

-a rich academic interchange of University faculty, Laboratory staff, students and curricula.

Future collaborative activities will involve expansion of current projects to commercialize technologies. Also, as the University Research Park develops, we anticipate facilities which operate on this neutral territory to combine the research and development activities of the University, Laboratories, and the private sector.

It has been my pleasure to speak with you today. The barriers are not insignificant and some of the solutions will be found in the Federal agencies and in Congress. But, as you can see, we here in New Mexico and at the University, have adopted several strategies to minimize these barriers and to foster cooperative technology development and transfer to the business community.

DATA NETWORK

This effort of the UNM-Business Link will provide an inventory of computerized and hardcopy information sources which might be helpful for various aspects of economic development, and will also encourage development of data networks of particular interest to the Link.

BUSINESS ASSISTANCE

Through this activity, the Link will enhance the role of such efforts as the Technical Innovation Program (TIP) and other programs which provide New Mexico businesses with professional and technical assistance, and will prescribe mechanisms for increased success from these programs with larger numbers of clients.

INTERNATIONAL AFFAIRS

The Link will identify international marketing efforts throughout the state, analyze the results of various contacts with foreign countries, and help match observed marketing needs in these countries with New Mexico firms.

ENTREPRENEURIAL AFFAIRS

Under this activity, the Link undertakes the purpose of fostering innovation and broadly considers ways in which New Mexico's economic status can be strengthened.

EDUCATION AND TRAINING

The UNM-Business Link will [illegible] the current education and training needs of New Mexico businesses, [illegible] to anticipate these needs over the [illegible] decade, and then develop an educational program that will [illegible] business [illegible] and in the [illegible].

[illegible]

Through this effort, the Link will ensure that all its activities [illegible] balanced way to the mission of the University as well as meeting the business and economic needs of the state.

Because of the breadth of the University in activities related to economic growth, UNM has a special role to play and a unique responsibility to shoulder. Thus, the UNM-Business Link will assist communication among all the economic development activities within the state, and will bring the collective experience and expertise of the University to the New Mexico business community. Through this kind of coordinated, comprehensive effort the economy of New Mexico can be encouraged to fully flower.

For more information, call or write:
UNM-Business Link, [illegible] NE
The University of New Mexico
Albuquerque, NM 87131
Tel. (505) 277-5950.

UNM-BUSINESS LINK—
[illegible]

WAITS AN
ECONOMIC GARDEN. . .

OF BUSINESS GROWTH OPPORTUNITIES.

If New Mexico is to enjoy the harvest of a bright economic future, the state's high-tech and other resources must be more fully cultivated.

As with any garden, achieving this development depends on bringing together the right conditions to create an economic greenhouse: financial and technical soils in which new businesses can take root and existing businesses flower; proper light in the form of high-quality educational institutions; the growth inducing influence of a receptive socio-political environment; and the nutritional balance of an attractive quality of life.

Of all the institutions in New Mexico, the University of New Mexico can contribute to the broadest number of activities necessary to cultivate a flourishing economy.

These contributions include training and research in science, engineering, business, medicine, law, and many other disciplines. Thus, a bold new approach is needed to combine the strengths of the University with the New Mexico business community.

The UNM-Business Link, established within the University, enables the business community to interact more readily with UNM in developing stronger economic growth.

Implementation of the UNM-Business Link is taking place through a series of nine coordinated areas of activity:

COORDINATION

By providing a single telephone number and address through which individuals or firms can obtain directions to specific programs, combined with a computer accessible file of economic development organizations and activities throughout the state, the Link will greatly enhance the ability of these various efforts to work together to maximum effect.

RESEARCH TRANSFER

The Link will identify potentially fruitful research on the UNM campus capable of assisting business development in New Mexico, and will also determine specific business and industry needs that can be solved by innovative research conducted on campus.

RESEARCH PARK

The Link will help cultivate relationships between UNM, businesses, and the developer of the University Research Park in order to attract firms to the park and derive the highest benefit from it for the University, the city, and the state.

Senator BINGAMAN. Let me just ask a few questions.

First, Steve Lazarus, let me ask you about the way ARCH operates. As I understand your description, you are emphasizing the startup of new companies. Does this create a bias against the integration of Argonne and the university with existing firms that would like the advantage of your research? Is there a bias that an existing firm could legitimately complain about?

Mr. LAZARUS. Well, the quick answer is yes, and one has. But it's not really a bias. It's a priority scheme.

As the flow of discoveries come through—and I should emphasize that there are just no shortages of discoveries from either institution, there's a plethora of good discoveries—we ask ourselves, "Do these have the characteristics of the core of a business start?" This is not to say that once we start, we won't join with a large business, say, to distribute or to do heavy manufacturing. The item I showed you a moment ago is being discussed with three major health-care companies and is being shown in order to use their business channels.

So it's in no way a bias that excludes large industry or existing companies. It's just that we want to preserve for the laboratory and for the university a larger portion that's larger as compared with licensing—which is normally 3 to 5 percent in most cases—a larger portion of the economic return in order to stimulate and incentivize further movement of discoveries into the mainstream economy. So we start looking to see if we can start a new company. If we can't, we drop back to joint ventures, such as the one on the monolithic solid oxide fuel cell; and failing that, we look to license.

Senator BINGAMAN. I think we have sort of two tracks that are being discussed here. Tommy Thompson has described the effort that Riotech is launching, which would tend to make available to existing firms the research that is going on in the labs. It would try to improve that interface and see to it that that contact is made.

The thing that Gary Smith is talking about, as I understand it, is the new startup firm, which would take an idea and actually grow a new enterprise. That enterprise then might combine with something else or joint venture with something else.

Gary Smith, am I right? Are there two strains?

Mr. SMITH. You are correct that there is usually a distinction made between big versus small, or startup, business. But I guess I would submit to you that both could benefit by improved relationships and having the impediments removed. I believe the impediments to big business or small business are the same; that the methods by which it would be commercialized are probably different; and that the large company would already have the resources to bridge that technology development gap. So there is an advantage there. And I believe that most products, afforded the opportunity, would probably fall one way or the other fairly clearly. But we have found in an example at Sandia where, through the Technological Innovation Program, the technology that Glenn Kuswa mentioned in his testimony was offered to big industry and the distinction between big versus small isn't clear. A broad-based symposium was held. The presentation was made primarily with the academic or the research perspective in mind. It was not a business proposal that was made, per se. The large companies said, "Hey,

there's not enough there yet. The intellectual property rights are not packaged. The cost is too high. When you get it further along, then come back and see us." There was also a question of the proprietary aspects of whether or not you should give exclusive rights to a company.

So a small company was formed here in New Mexico with our assistance, and we have gone through the process of getting the waiver and packaging the intellectual property rights. Now that those are in place, we can go back to the big companies. Now we're trying to joint venture with them because at this point we don't have the manufacturing capabilities.

And so what I'm finding is that whether it's big or small, there is still the need for identification, evaluation, packaging, and figuring out where we're going to go. The big question is, Should that responsibility fall on the laboratory, or should it fall to some kind of an adjunct organization, whether it be Riotech or whether it be some other organization, to interface with the private sector?

I agree wholeheartedly with Tommy Thompson. It should be market driven. The point I was making is that we don't have the choice of going and asking the marketplace first what they want and then having it developed at the lab. It's pretty much driven toward what we have, and then the effort should be market driven. I still think that the packaging, putting the organization in place, the evaluation, the intellectual property rights, the people issue, and the facilities' issue all need to be resolved in a nice package so that it will facilitate the transfer to either big or small.

Senator BINGAMAN. I guess I'm hearing that there is a need for both. ARCH does one of them. ARCH has opted to put its priority on the creation of new startup companies. And at the same time, there is a need for this interface with the larger existing companies——

Mr. SMITH. Yes.

Senator BINGAMAN [continuing]. Which sometimes will take presentations and sometimes will come along after there is more to a package that can be sold. Is that an accurate statement?

Mr. LAZARUS. Reasonably so. I wouldn't want to characterize ARCH as 90 percent on the one side and 10 percent on the other, because we play this intermediary role to a very large extent. And I want to echo the point that large companies do not easily take technology from either a national lab or a research university. They're not set up to do so. They have difficulty looking at entities of $10 million or less. They have priority structures which militate against it. And it's very important that there be an intermediary mechanism or entity that gets the idea market ready for the large company.

Senator BINGAMAN. Anyone else have a comment on this?

Tommy Thompson.

Mr. THOMPSON. Yes. I understand the startup company and I think that approach is good and is important. And I suspect that we have a fair amount to learn, and there's a semi-infinite variety of ways of putting together a business. If you look at businesses, about the only thing that's common about them is the letter of incorporation you get from the State.

But now, as far as existing business is concerned, what they bring to the process is a lot of muscle. Now the question is, can we find some way to couple that muscle up with some of this technology in a reasonable way?

On my board there is a man that has successfully interacted with four national laboratories and one university. Now he may be the only human being in this world that's managed to do that, but he has. As a matter of fact, he isn't the only human being; he's just a stellar example of it.

Well, I suggest that if you're going to work with existing companies, and I worked for one of the larger ones, you should recognize that they do, indeed, have all the attributes Mr. Lazarus gave for them; but the beauty of them is that they have lots of muscle. They have technical muscle, market muscle, and distribution channels. The question is, Can we work with them? I'm not suggesting that we work with them to the detriment of the startups.

For example, I have told several people here in New Mexico that if, in the process of working on an existing company problem, I run across an opportunity that is easily recognizable as a startup opportunity in particular, if I run into somebody that looks like he or she just absolutely can't wait to start a business, then let's package that. Put a cocoon around it and package it, because that's a perfectly good way to commercialize technology, too.

About a year from now, I may sing a different tune. But by the end of this year, I have an ambition to have enough experience—and that really means enough success, because without success to talk about and discuss, you're not doing anything useful—that we can make a series of observations and, for example, come to the senatorial delegation of this State and say, "OK. Working this problem, we've run into these concerns." These concerns may match very closely some of the concerns that the folks run into when they work with startup companies. And then you will have obtained virtually 100 percent of the votes.

Senator BINGAMAN. That's a year from now.

Mr. THOMPSON. Yes. Well, sorry about that. But you will have obtained 100 percent of the input. "Everybody has the same problem, and will you please please fix it"; all right?

Senator BINGAMAN. Let me ask on one other theme that I think I'm hearing throughout this discussion. The availability of facilities where you can get the laboratory people and the university people and the private-sector/private-company people together to work problems seems to be a major part of the process. Arlyn Blackwell, you referred to this new facility that you're building, which I gather will not be in a classified area or in a secured area. I assume it would be available for some of this interface with the private sector. Is that intended to meet some of that need?

Mr. BLACKWELL. This facility has just been resited by us just before we start the construction in an area where it is adjacent to our radiation hardened integrated circuit lab with the idea in mind that someday we may involve more outside people in cooperative relationships. It is being built and will be built inside the security area. But we are always reviewing where the fence line should be and could be, and so I think that is an evolving situation.

Senator BINGAMAN. Paul Risser, did you have thoughts? You mentioned your industrial park.

Mr. RISSER. Yes. Actually, we always called it a research park rather than an industrial park. But the point is that as an example of an idea, in terms of computer programs—especially computer programs which run on large machines—some of those programs which would be really valuable for the private sector, they could use those models or those programs. So one notion would be a research park, which would then facilitate the research-park efforts of the university to help the educational part of the university and could also be a direct link with the private sector. So that is a way in which a research park would be quite helpful. There will be things which don't belong in a classified area, but nevertheless could be used jointly by laboratory scientists, the private sector, and universities. So it is, in fact, the same thing.

Senator BINGAMAN. Steve Lazarus, I gather from your description that the input and the involvement of graduate students has been a major factor in the successes that you feel you've had so far. Is something like this necessary in order to accomplish those successes?

Mr. LAZARUS. Yes. In our case, it's just been critical in our ability to do several programs at once. And if we didn't have that there—they're terrific. We call them "The Kids," but they average 27, 28, 29. They have undergraduate or graduate technical degrees. They have become emotionally involved with the businesses. They are highly acceptable to the investigators, and they really drive those programs once they get into them, both at the university and at Argonne. It's a real serendipitous aspect of that.

Senator BINGAMAN. Gary Smith, as you contemplate some of the activities you describe, what role do you see graduate students playing?

Mr. SMITH. It's important, but it should not be the driving factor. In discussions that I've had with Mr. Thompson, he has pointed out that we're talking about business here and not education. So it shouldn't be the driving factor. Any effort to commercialize technology should be driven more by the market need and by the need to be profitable. It should not be forever funded by public-sector members. If we're not successful within a certain timeframe, we don't get paid next month.

So it needs to have a businesslike environment. And in this, I do believe that the graduate student—because that is how I got a lot of the staff support myself—is useful, but should not be the driving factor behind how you deliver your services.

Senator BINGAMAN. Steve Lazarus, let me ask one final question, and then I'll let everyone go. You referred to this patent amendment that you worked out which Argonne has with the DOE. Could you describe that a little more? Is that the only one of its kind, as far as you know?

Mr. LAZARUS. No. My understanding is that the field offices in the patent organization at national headquarters are rolling through. I think they're starting with the nonweapons' lab, but rolling through the national labs, and essentially laying down the ground rules for when there is a discovery at Argonne, it is automatically waived to the University of Chicago as contractor for se-

lection. ARCH acts as agent for the University of Chicago. So I'm able, on a single piece of paper, to say, "Yes, we want it. "No, we don't." That one piece of paper can bring it to us, and we start protecting it. And——

Senator BINGAMAN. I understand that this amendment is being incorporated into all their contracts.

Mr. LAZARUS. On a rolling basis. That's my understanding.

Senator BINGAMAN. As those contracts come up for renewal?

Mr. LAZARUS. Well, actually, ours was amended prior to renewal. We are now just going into the renewal stage. This amendment was negotiated from about the fall of 1986 to July 1987.

Senator BINGAMAN. Yes, Mr. Smith.

Mr. SMITH. One last comment. Having been in this business of technology commercialization since 1981, I feel we've done enough experimentation. We've been addressing it from a slightly piecemeal fashion. I believe we're ready now to ascertain what we've accomplished, where we need to go from here, how to measure that, how to put the right resources in place and either put the program in place now or quit doing this. I mean, if it's not economically viable, then we shouldn't be forcing it. But I think now is the time to put something more in place—no more piecemeal.

Senator BINGAMAN. Thank you all very much. I think it has been very useful, and I appreciate the time and effort it has taken to put the testimony together. We will try to follow up on some of the ideas here and continue to be helpful where we can. Thank you very much.

[Whereupon, at 1:35 p.m., the subcommittee adjourned, subject to the call of the Chair.]

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