Session II
S & T
IN REGIONAL DEVELOPMENT

SCIENCE AND TECHNOLOGY IN REGIONAL DEVELOPMENT

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Since the beginning of this decade states have been giving increasing importance to investing in technology development as part of regional economic development strategies.

Currently, almost every state has established at least one program that specifically encourages technological innovation. Programs range from limited managerial / technical assistance to industry to comprehensive, multi-million dollar programs. Some states have invested in only one type of technology program, while others have approached technological development by investing in a number of areas simultaneously.

The types of initiatives that states are investing in include:

Technology Offices. Thirty six states have boards, commissions, authorities, or offices that oversee or coordinate state technology initiatives. The most common type of structure is a public/private partnership comprised of representatives from private firms, academia and state government. Technology offices may operate as independent public agencies or private nonprofit corporations. States without a technology office may have a science and technology policy advisor. The duties and responsibilities of technology offices range from the administration of multi-million dollar technology centers to providing information dissemination and advisory services.

Technology/Research Centers. States enhance technological development through the administration of research or technology centers. These centers, also known as "Advanced Technology Centers" or "Centers of Excellence" are usually located at universities or affiliated with them. They also strive to increase cooperation between academic institutions and state-based industries. These centers generally concentrate on a particular field of research which draws on the strengths of a university and/or the major industries in the state. Technology or research centers assist in the creation of new firms through the development and enhancement of products and processes, attracting new industries to the state, and enhancing the competitiveness of existing industries through the application of advance technology processes or products.

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Research Grants. Research grants are a common component of many state technology development strategies. Grants are usually made to universities based on joint proposals from the university and a private sector sponsor. Most often, these grants require a certain level of matching funds from the private sector. Grant approval usually depends on its potential for economic development and future job creation.

Research Parks. Research parks are planned groupings of technology companies, often near universities, that encourage university/private partnerships. They draw industry to a particular location and provide incubator facilities and services which encourage the development of new businesses. Generally, states provide initial capital with the requirement that future funds come from private sources.

Incubators. Incubator facilities provide below-market rates for office and lab space for start-up companies. In addition, these facilities offer shared support for clerical, reception, and computer services. Generally, a company's stay in an incubator facility is limited. Once a company has progressed to a specified development level, it is expected to leave the incubator in order to allow the facility to accommodate new start-up companies. Incubator facilities are usually located in or near advanced technology centers and commercial research parks.

Technology Transfer. Technology transfer programs facilitate the transmission of new technologies from the laboratory to the private sector. These technologies can become the impetus for the creation of new businesses, the introduction of new product lines for established firms, or the revitalization of mature industries. Technology transfer is achieved through information exchange and active outreach programs which seek users for existing and newly-developed technologies.

Technical/Managerial Assistance. Twenty-nine states have programs which provide technical or managerial assistance to technology companies. Programs assist in the development of business plans and marketing strategies, advise firms on personnel, accounting and legal matters, and identify sources of financing. Professionals also evaluate product lines and manufacturing processes, assist in the use of state-of-the-art design and manufacturing tools, and identify special expertise at universities and other research centers.

Seed/Venture Capital. Seed and venture capital programs provide risk financing to early-stage companies that are unable to secure funds from traditional sources. Funding is provided to start-up companies whose projects have commercial and/or job creation potential. Seed capital is provided to companies that have yet to develop a marketable product. Venture capital financing is available to developing companies with established business plans and commercially feasible projects.

Technical Training. Some states have realized the significance of a skilled work force for attracting high technology businesses. As a result, various training programs have been developed to meet this need. States either sponsor programs through an institute for higher learning or provide financial assistance to private companies to implement their own training programs.

Information／Networking. Information／Networking programs act as clearing houses to provide a variety of business and technical information to state firms. These programs provide access to national and local database services, disseminate information on state and federal financing programs, and identify technological expertise at universities and other research centers. These programs may also attempt to develop cooperative programs among private companies, universities, and government agencies to work together in solving common business or technology problems.

Equity／Royalty Investment. States with equity or royalty investment programs provide risk capital to new start-up businesses and development firms. Funding is generally available to companies with commercially feasible products and processes. Typically, funds are used as working capital for land and equipment purchases organizational expenses, and research and development efforts. Equity investments provide a stake in the financial success of the firm. Royalty investments require a repayment to the state based either on a dollar amount per unit sold or a percentage of gross or net revenues.

Although state technology development programs are as varied as the states, the desired end result has generally been the same-economic diversification through the creation of new jobs, new firms, and a more competitive position for existing industries.

A recent study indicates that in fiscal year 1988, states allocated some $ 600 million for science and technology initiatives. While most of the financial resources for these programs has come from state general funds, some states have also used bond issues, state lottery funds, pari-mutuel gambling receipts, and state employee pension funds to support these activities.

Despite this relatively large investment, regional technology programs are relatively new to the economic development arena and questions still remain as to their effectiveness, and what they might be able to accomplish.

There are a number of critical issues being debated presently, which when resolved, would result in the establishment of more effective regional development policies and initiatives. Some of the more important issues requiring attention include the following:

1. **Can investment in science and technology contribute to the creation of employment and regional economic development? If so, under what circumstances?**
   In the U.S., technology development initiatives have been presented to government entities primarily as job creation programs. Technology initiatives are considered part of the economic development portfolio of programs which have job creation as their major objective.

   While there is much dissatisfaction with this approach, no other generally accepted mechanisms have been developed for measuring the benefits of such efforts within a region. Among the questions being discussed are the relative values of investing in either basic or applied research. More importantly, how does the state entity support and stimulate technology transfer, commercialization, and continuing product competitiveness?

   Do the goals of regional technology policies in Japan differ from those in the U.S.? Are Japanese objectives job creation, industry retention / expansion, investment in education infrastructure? Do objectives differ among regions and, if so, how are these differences accounted for?

2. **How should resources be allocated within a region? Should one build on comparative advantages or seize new potential opportunities?**
   Among the states the traditional view has been to support existing capabilities within a region. Few, if any states, have taken the riskier role of making significant investments in new fields or of concentrating their activities on a single area of technology.

   This again is not an entirely satisfactory position if one is to reap the full benefits of regional technology investments. Is there, in fact, a proper balance for allocating resources regionally, and what entity should make these decisions?

3. **What are appropriate vehicles for carrying out regional technology policies?**
   Traditionally, states have relied on major research universities to play the largest role in administering programs and implementing these initiatives. However, this issue is the source of a continuing debate. While universities are important resources for conducting research, some feel that the university role should be limited.

   A number of states have, in fact, established entities with representatives from both private industry and the academic community to manage technology development activities.

4. **What is the relationship between the "research vehicles" and other support and infrastructure considerations?**
This is one area where state programs, for the most part, have yet to develop effective coordinating strategies with other government agencies. Such diverse issues as the availability of an adequately trained work force and regulatory ingredients / stimulants to industry are under the jurisdiction of other governmental agencies which traditionally do not have much interface with technology development.

5. **To what extent are regional efforts dependent on Federal activities, policies and circumstances and what instruments are needed to maximize Federal-State (regional) interactions and achievements regarding economic development?**
In the United States, it is critical to recognize that the priorities of state government in establishing technology development programs has not been the same as the federal government. Within states, these initiatives have been classified under economic development. As a result, the focus historically has been on job creation and job retention. These are not, and should not be, the priority of the federal government in funding such initiatives.

   What may have turned out to be a good investment for one state may have had little or no impact on a national level, particularly as it concerns the development of new cutting edge technology.

   There has been a lack of focus and direction from the federal government pertaining to both science and technology policy. This lack of well-defined priorities has presented difficulties for state officials receiving requests from universities and other institutions to support major R&D initiatives.

   However, the states are much further along today than even a year ago in focusing their technology efforts and making an impact on a national level. Through the National Governors Association Working Group on State Initiatives in Applied Research, state representatives have been working with the Congress and the National Science Foundation to coordinate a number of their activities.

6. **What is the role of large multinational companies in regional technology development strategies?**
In recent years, a focus and emphasis of technology programs has been to help small companies become more competitive and grow.

> Within this process, however, is there a role for the larger company?

A final issue concerns international cooperation in regional technology development. This is not an area that has been seriously discussed in the past, perhaps simply because of the difficulties of establishing initiatives in a single region. Among the states, there is now increasing cooperation to develop not only effective measurement standards but to cosponsor R&D projects.

State programs have now been in existence for almost a decade and the next logical step would be to share our experience as well as our expertise on an international basis.

EMPLOYING SCIENCE AND TECHNOLOGY IN REGIONAL DEVELOPMENT: AN INTERNATIONAL COOPERATIVE APPROACH

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Introduction

This paper deals with the exploitation of science outcomes and technology to promote sub-national development. That is, the regions of interest are defined as being smaller than nations – such as aggregations of states in the United States, of prefectures in Japan or counties in the United Kingdom.

The principal focus is upon cooperation. While the interregional pursuit of science and of technology development will be considered, it is the cooperative exploitation and application of science outcomes and technological possibilities that hold center stage.

Why Focus on Regions?

At least where the United States is concerned, the country is so large in every dimension and its federal policies so much the result of political compromises that it has often proven difficult to establish and maintain science and technology (S&T) policies that, when applied nationally, serve very well the interests of either the nation or its individual components. Also, in an international context, cooperation related to S&T that is in any sense between nations has proven difficult, in part, because the country seeking a cooperative arrangement with the United States finds itself overmatched and this *per se* creates problems from the very beginning.

In sharp contrast, if the United States is viewed as being made up of a set of regions, each of which has certain internal common interests related to S&T, at once the U.S. cooperating unit finds a much wider range of counterpart entities in other nations – even entire nations – which are a much better match for the U.S. region in every respect than the U.S. as a whole can possibly be. Furthermore, regional interests are much easier to define in terms that are precise enough to support the sort of relationships that are necessary where cooperative efforts based upon S&T are concerned.

The focus on regions is also warranted by the fact that, across the

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developed world, every nation has regions which are growing at different rates in comparison with their neighboring regions. Given that the national welfare interests of a nation are served when the regions comprising a nation are in a similar state of prosperity, the focus on regional development and inter-regional cooperation is clearly warranted.

Cooperativé Development of Technology

Cooperation in the *development* of science or of technological possibilities is not a necessary condition for inter-regional cooperation in the utilization of S&T. However, it is probably true that if the cooperative activities pursued by regions include the development of the S&T raw materials for their subsequent cooperation, the overall process will be carried out in a more efficient and timely way.

Specifically, with respect to science and technology development, it is well to recognize that such efforts take place early in the process of innovation and, therefore, carry with them the highest risk, even though the relationship between risk and reward (however measured) may be entirely acceptable. Nonetheless, investments in science and technology development are just that, investments.

In the period in which science outcomes are being pursued and technology is being developed, revenues are not expected to be generated. Thus, cooperative programs centered on development should only be undertaken where both parties recognize the true nature of the undertaking. Again, where there is the express intent to exploit the cooperatively-derived outcomes cooperatively in the two regions, it becomes possible to project revenues which make cooperative S&T development as attractive as can be. But since the generation of revenues are temporally far removed from the expenditures related to S&T development, it remains important that all parties to the cooperation understand the situation as it actually is. In fact, it is anticipated that, at least in the initial stages of the establishment of inter-regional technology-based programs, the stress will be upon technology exploitation more than technology development, largely because the returns to the former effort will come sooner and be more usable than those of the latter sort of effort.

Nevertheless, in shaping inter-regional cooperative programs involving S&T development, it is also important to recognize when the goal is the development of generic technology rather than technology that is other than generic. An appropriate example contrasts super-conductivity and the product embodying the results of successful research in that area, on the one hand with, say, the development of a new strain of hybrid corn on the other. This is not to say that the latter is less worthy of pursuit than the former, particularly if the context is regional and the regions are agricultural. The point is that generic technology programs are different from others. For example, such efforts usually cost more and take a greater period of time before returns, however measured, begin to flow. Consequently, in choosing S&T projects on which to cooperate, regions should not be drawn to a specific area of activity simply because it promises to produce the more glamorous and perhaps more highly-leveraged generic technology rather than technology which is more market-specific and can be deployed more quickly.

Cooperative Use of S&T Results

The *utilization* of science outcomes and technology typically involves a more straightforward and conventionally rewarding relationship than cooperation in the S&T development phases of innovation. This is not to say that cooperation in exploitation is either simple or guaranteed to be as productive as the parties anticipate. Still, it is important to recognize that successful cooperative exploitation of S&T produces not simply monetary benefits, but many others that have varying values, depending upon the party whose interests are being served. For example, cash payments related to licensing fees, royalties or consulting income seem to have greater value for private U.S. firms – even though this is often shortsighted and misguided – while much greater weight is given by public sector participants to job creation or retention and the improvement in a nation's balance-of-trade position, which, at least in the short run, are of little concern to private firms. This point is made in Figure 1.

It is also important to recognize that cooperative exploitation of S&T results represents an alternative to the direct investment of capital by a foreign country to acquire (in whole or in part) a firm having attractive S&T outcomes. And it is a better alternative because it confines the resources of two or more entities in pursuit of compatible objectives in each country, it produces far more equitable results, and sets the stage for more inter-regional, international cooperation.

Region-Matching

Where international cooperation related to S&T is concerned, the regions to be paired should be chosen with care. By no means does this suggest that the regions be identical in as many dimensions as possible; complementary resources and goals are sufficient to establish a basis for cooperation. At the same time, care should be expressed to avoid situations where the regions are too greatly mismatched – such as where one is heavily oriented to capital-intensive manufacturing and the other is largely agrarian. Short of that, especially where the orientation is towards the exploitation of technology, region-matching should not prove either difficult or a barrier to establishing cooperative programs.

In seeking to match regions, it should be recognized explicitly that the needs of a region and the ability to address those needs within the same region may themselves be very badly matched. In fact, this will often be the case. A region deriving its economic activity from mining, facing conditions under which it can no longer be an effective competitor in minerals markets, may also not possess the ability to generate the S&T which, in turn, enables it to transition to other activities. To the extent the region is in a position to import science outcomes and technology that accomplish such a transition, it may well represent an opportunity for cooperation with a region in another country where such S&T is being pursued. But this may involve at least a temporary net shift of capital resources from what is probably the poorer region in one nation to the richer one in the other, and this may require national-level intervention and support in the former's case if the basis for cooperation is to be established.

Especially where S&T-based cooperation focuses upon the exploitation of technology and the realization of early returns from the effort, the measures by which to judge a region's need include the extent to which there is unemployment and/or underemployment, the rate of change of population (certainly negative rates are a signal of trouble), trends with regard to personal income, net regional product and other aggregate measures of economic performance.

As to the means for determining a region's capabilities, these include the S&T infrastructure of the region, the quality of its labor force, the availability of capital for investment, the pool of entrepreneurial talent available to exploit the opportunities presented and the starting backlog of S&T results available for use both within the region and for export to others.

Once the data have been accumulated to enable the attributes of the region to be specified and the relative importance of the attributes determined, it then becomes possible to assess other regions in other nations as potential partners in cooperation. In ultimately choosing a region, there should also be some reasonable match between their aspirations in terms of social welfare, distribution of income, levels of employment and quality of jobs, particularly where cooperative exploitation of S&T is the goal as is most often the case, especially for inter-regional international programs in the early stages.

Motives for Using S&T as the Basis for International Cooperative Activities

While the focus of attention here is on inter-regional cooperation, it is appropriate to review briefly the motives underlying decisions concerning the international exploitation of S&T in the more general international case. Figure 2 catalogs the motives which are present for S&T which address other than defense markets.

Inter-regional cooperation, whether international or not, generates results in such areas as science, technology, product development, manufacturing and distribution that produce more benefits for every cooperating party than each could realize without such cooperation. While risks are being shared between the parties, especially where scientific research is concerned, the rewards realizable by any and all involved are not diminished through the cooperative effort and may, in fact, be substantially enhanced.

Of special importance in the present context, making S&T available for international exploitation cannot but spark the creation of cooperative research and development programs that cross national boundaries, many of which are most appropriately pursued in a regional context in both countries. Also, a precondition to the establishment of cooperative international, inter-regional activities based on S&T should be the expressed desire of all parties to make science outcomes and technological possibilities the subjects of international transfer and exploitation on an equitable basis. Without such a commitment, S&T-based international cooperation programs are not practically possible.

It should also be recognized that an inducement to international cooperation can arise out of unwise or unfair national policies in either of the two nations involved. For example, a spur to international cooperation is surely present where one nation blocks off the most direct means of exploiting imported technology and forces the owner of such intellectual property to seek another way of benefiting from making its technology available in that country. Notwithstanding the fact that barriers to full appropriability are undesirable under any circumstances, the reality is that they often exist and, under such circumstances, opportunities for international cooperation emerge (e.g., joint ventures).

Another condition leading to the same result is where one nation has a stricter set of regulations pertaining to the pursuit of science outcomes and the development of technology than the other. One example is the U.S. approach to the development of ethical drugs following the ill-conceived Kefauver Amendments of 1952 which handcuffed the U.S. pharmaceutical industry as far as developing ethical drugs and proving their efficacy is concerned. Science outcomes related to such products continued, however, and much international cooperation, formal and informal, results which surely would not have been present otherwise. Again, in the face of regulatory disparities, international cooperation becomes especially attractive.

Benefits Accruing to Regional Participants in International S&T Cooperation Programs

Figure 3 indicates the benefits available to regional participants in programs concentrating upon using science outcomes and technological possibilities as the basis for inter-regional cooperation on an international scale. While some of these benefits are obvious, others are not. For example, a properly conceived cooperative arrangement, involving a region of the United States, would likely call for the creation in both nations, of new joint venture enterprises with the partners being drawn from the cooperating regions. Furthermore, since small enterprises in the U.S. are such an important source of promising technology, and because the U.S. uniquely has relied upon such enterprises to generate the technological possibilities which underlie its industrial development, regions in other countries are able to gain the experience, insights and values which can be derived from exploiting U.S. small enterprise power through the participation of such enterprises in joint ventures established in their own regions. In fact, the proven value of the U.S. small enterprise sector should be a sufficient inducement to form cooperative arrangements based upon S&T results. At the same time, small U.S. enterprises will expect to gain access to further technological raw materials from which to fashion still more innovative goods and services addressing their markets.

Certainly, many of the benefits flowing from the arrangements being considered will inure to those beyond the boundaries of either of the cooperating regions. To the extent regions are made economically stronger, nations generally are advantaged as well. More specifically, however, inevitably some of the cooperative efforts will produce goods or services or capabilities which will improve the defense posture or the trade balance of the nations involved. While this could be the basis for recruiting resources from national governments to support cooperative arrangements cast on a regional basis, it may be enough that national governments tolerate or allow such arrangements, because it is recognized that benefits from them cannot possibly be contained entirely within the cooperating region of the nation.

The Concept of Equity and its Importance

In order to be maximally successful, any cooperative effort between regions must assure an equitable distribution of the benefits accruing to each of them. Such benefits can be distributed between the public and private sectors in each region in different proportions, but the overall benefits must be seen to represent fundamentally the same proportionate return on those resources committed in and for the regions involved.

Conceptually, for present purposes, equity represents a concept for sharing the benefits generated when science outcomes and technological possibilities are either developed or exploited cooperatively, or both. Incorporated within the concept is the notion that fair treatment will be accorded all the parties to such cooperation, public or private.

Heretofore, the United States has not typically enjoyed parity of treatment when its S&T have been the basis of industrial activity in other nations. This is especially true with regard to Japan. While this problem is finally being addressed at the national levels of the two countries, it must also be considered in the context of inter-regional cooperative S&T-based efforts. Indeed, it will prove easier to pursue equity where the basis for S&T cooperation and exploitation is regional in two countries than where nations as a whole are involved.

Evidence of equity in inter-regional cooperative arrangements is to be found in the agreements underlying them. Such evidence is indicated in Figure 4. First and foremost, the returns realized by the cooperative parties, however they are measured, must be commensurate with the individual and collective investments of resources in the cooperative activity. To the extent that technology is to be transferred between the regions, it is also important that the agreement establishing the cooperative activity assure that the value received by technology suppliers in one region is equitably related to the value derived by the entities to which such technology is being transferred. An important indication of this, in many instances, will be the presence of equitable grant-back provisions in technology sharing and transfer arrangements.

There must be reciprocity between the cooperating regions in other ways as well. For example, a supplier of science outcomes or technology from one region must be assured of the same rights and opportunities to appropriate the benefits of such technology in the other region, as are available in the case of technology flowing in the opposite direction. Again, guarantees must be present with regard to the parity of market access in the cooperating regions. Reciprocal joint ventures are among the best ways to achieve equity in this regard.

Any cooperative arrangement which is to be successful must establish principles of equity before the effort actually begins. This also serves to provide the greatest assurance that any attempt at cooperation involving S&T will be long-lived one and will encompass the appropriate range of activities from the generation of science outcomes to the production and marketing of products embodying technology which is to be cooperatively developed or exploited.

A Word about "Industrial Policy"

In the United States, there has generally been a disinclination to establish "industrial policy" on a national basis. Such a distaste for national-level planning to such a degree of detail probably serves the interests of the U.S. In other countries, including Japan, establishing explicit industrial policy is viewed as an entirely acceptable aspect of governance. In large measure, the contrast between the U.S. and Japan in this regard reflects the disparity of interests and capabilities found in the various regions of the United States, as well as lack of homogeneity across the full spectrum of U.S. geography and economic activity. In Japan, social cohesiveness and many specific comparative advantages are shared across the whole nation.

A Modest Proposal

All things considered, there appears to be an opportunity to establish inter-regional cooperative S&T-based activities between public and private entities in one region of Japan with parallel entities in an appropriate region of the United States. A pilot program of this nature should be inaugurated at the earliest opportunity. Among the attributes of such an initial cooperative effort would be the following:

- Involvement of a single region in Japan and a properly-matched one in the U.S.;
- Principles established from the outset for the equitable sharing of the burdens and benefits of the cooperative efforts to be undertaken as well as the subsequent exploitation of resultant science outcomes and technological possibilities;
- Cooperative activities that include the formation of joint ventures in each region involving participation by enterprises in both regions; these joint ventures are intended primarily to develop and exploit technology on a truly collateral basis; they will often be formed by small business units from each region because of their efficiency in developing technology and the speed with which they can pursue new market opportunities;
- Over time, joint ventures in Japan based on U.S.-originated technology should approximately equal those in the U.S. based upon technology emanating from Japan.

In all events, what is required is a balanced program in terms of the size of the cooperating parties, the value of S&T provided by the parties to both individual cooperative efforts and to the overall program, the resources committed to exploiting technology and the benefits derived by both the individual cooperative parties and the regions as a whole.

Figure 1

Relative Value of Various Cash and Non-Cash Benefits

	Private Firm	University	Government & Public at Large
Cash Benefits			
Licensing Fee (e.g., Front-End Payment)	1	1	3
Royalty	1	2	4
Consulting Income	3	5	4
Sale of Tooling	2	NA	NA
Sale of Product	2	NA	NA
Non-Cash Benefits			
Joint-Venture Interest	2	NA	NA
Grantback Arrangement	2	NA	NA
Receipt of Technology (e.g., Trade)	2	4	3
Market Access	1	NA	NA
Share-of-Market Increase	2	NA	3
Job Retention/Creation	NA	NA	1
Balance-of-Trade	NA	NA	1
Support for University Research	4	1	2
International Education & Trading	2	2	3
Institutional Cooperation (e.g., University-Industry)	3	2	3

Legend

1 = Most highly prized; 5 = Least prized. NA = Not applicable

Figure 2

Why Make Science Outcomes and Technology Available for International Exploitation ?

- Maximize the returns achievable from a given investment in science, technology and product development;
- Trigger an additional product life-cycle in a geographically-separated and new market;
- Join forces with an "overseas partner" to develop a new product in order to bring to bear sufficient resources to accomplish the task;
- Derive benefits from the creation of new markets and/or the expansion of market share in a separate geographical area;
- Appropriate all the benefits that are potentially available from each science outcome and technology;
- Initiate a cooperative research or development program with one or more foreign enterprises;
- Use available technology to exchange for technology of equal value to be found in another country;
- Fund a second-best alternative to the domestic production and export sale of product-embodied technology where the recipient nation bars such an approach as a matter of policy;
- Escape regulatory and other constraints on product development in one country and eliminate the cost of compliance with such regulation.

Figure 3

Benefits Accruing to Participants in International
S&T Cooperation Programs

- New or expanded science or industrial capability;
- Additional scientific and engineering skills;
- Creation of entirely new business, especially small enterprise international joint ventures;
- Addition of jobs in the region;
- Expanded regional economic activity;
- Contributions to the nation's defense posture and trade balance.

Figure 4

Evidence of Equity

- Returns to the cooperating parties are commensurate with their individual and collective investment of resources;

- Where technology is transferred between regions, the value received by the suppliers of the technology is related to the value derived by the entities to which such technology is being transferred;

- The presence of grantback provisions in technology sharing and transfer arrangements;

- Assurances concerning the appropriability of benefits in the cooperating region by the supplier of technology;

- Guarantees of parity with regard to market access and other aspects of the supply of related goods and services in one region (or country) by producers in the other region (or country).

NEW JERSEY PROGRAMS SUPPORTING PRIVATE SECTOR SCI-TECH DEVELOPMENT

Edward Cohen*

I am most appreciative of this opportunity to share with you the objectives and programs of the N.J. Commission on Science and Technology. Above all, I wish to point out that there is a new spirit of cooperation occurring among our business, educational, and political leaders. This is giving rise to new policy directions in our state governments. These forces are converging around common goals of creating new wealth, new opportunity, and new employment. They hinge upon public-private partnerships organized around science and technology applications.

In less than a decade, the states have moved from ill-defined and distinctly secondary positions in our national life, to aggressive positions of helping to shape new research and industrial policies. New leaders understand the opportunities states have, to marry their traditional support of education, to the economic benefits of scientific knowledge and advanced technologies. They have created new programs of research, instructional support, and economic development.

While, historically, state governments always have been among the principal supporters of higher education in the United States, today they also fund many specific economic development projects. What is unique about our era—the so-called high technology era—is the joining of these two missions by the states — higher education, on the one hand, and economic development, on the other. The joining of these two missions by the states has even acquired a reasonably accurate, and certainly challenging title: "The second land grant revolution." Understanding it helps to explain the policies of science and technology development in New Jersey.

To provide a framework, let me note that our Commission's state budget appropriation for operating purposes has grown since FY 1984 from $ 4.5 million to some $ 27 million in FY 1990, which commences next July. Moreover, since that amount includes financing of a short-term note for the purchase of moveable equipment for our advanced technology centers, the de facto operating budget next year will amount to over $ 40 million. On top of this, two successive Bond Issues, in 1984 and 1988, to provide capital for construction purposes — bricks and mortar — amounting to $ 132 million, are being expended at the rate of some $ 15 million per annum.

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This represents an impressive state commitment – for a population of some 7 ½ million people – to promote economic development, and the creation of jobs, in industry and businesses based on science and technology. Moreover, business and industry, and the Federal Government, have responded magnificently. From FY 1984 through FY 1989 they will have matched our funding with more than 140 million.

Fostering multiple partnerships between industry and academia is that aspect of the Commission's overall program in which we make our largest investment, amounting to just over 90% of our budget. The resultant collaboration, between our state's five research universities, Rutgers University, New Jersey Institute of Technology (NJIT), University of Medicine and Dentistry of New Jersey (UMDNJ), Princeton University, Stevens Institute of Technology, and industry, occurs under three primary mechanisms.

The first we call an *Innovation Partnership* in such specific scientific fields as biotechnology and telematics. This matching research grant program is designed to bring academia and industry together on problems of common interest. For example, a team of university researchers from the New Jersey Institute of Technology and Princeton University currently are studying the connection between taste receptors in the mouth, and the corresponding "salt sites" in the brain. The results of their research is assisting Campbell Soup Company, their industrial partner, to lower the salt content of its products, without changing the familiar flavors that have won customer loyalty.

A second mechanism we use is the *Technology Extension (TEX) Center*, modeled after the federal government's success in agricultural extension dating back to the last century. In four disciplinary areas – polymer processing, information services, fishing and aquaculture, and cancer diagnostic and therapeutic techniques – these TEX centers offer advice, on a fee basis, to New Jersey businesses on how to use technology to become more competitive.

Our third – and perhaps the most significant, and certainly with 72% of our budget the best funded – mechanism for academic / industrial collaboration is the *Advanced Technology Center*, sometimes referred to in other states as a "center of excellence."

We presently support eleven ATCs, as we call them, covering four broad fields – biotechnology, telematics, environmental protection technologies, and advanced materials. At least 130 companies presently are industrial advisors and partners of the ATCs, each contributing up to $ 50,000 a year to their operations.

In *biotechnology,* we fund three ATCs:

– The *Center for Advanced Biotechnology and Medicine* is encouraged by New Jersey's strong pharmaceutical industry, and is jointly run by

Rutgers University and the UMDNJ – Robert Wood Johnson Medical School in Piscataway;

- The *Center for Advanced Food Technology* reflects our state's unique strength in food-processing and is run by Cook College of Rutgers in New Brunswick; and
- The *Center for Agricultural Molecular Biology* – also based at Cook, represents an effort to help the farmers of the Garden State, as well as established and emerging high tech firms, use modern biological technology to increase the value and productivity of crops and husbandry activity.
- I might add that, while not an official ATC, the recently established and now burgeoning Lewis Thomas Laboratory for Molecular Biology at Princeton University also was the recipient of generous capital funding through the Commission.

In *telematics* – our terminology describing the evolving merger of telecommunications and computer science – three advanced technology centers are funded.

- The *John von Neumann Center* for Advanced Scientific Computing (i.e., supercomputing) in Princeton is one of five national centers, and unites the strengths and interests of 13 of the nation's most prestigious academic institutions including MIT, Harvard, Princeton, Rutgers, Columbia, Brown, NYU, Colorado and the Institute for Advanced Study in Princeton. It will shortly complete the installation of the final phase of a machine which will constitute the most powerful computer in the world in a non-classified setting.
- *Computer Aids to Industrial Productivity*, based at Rutgers, is a center supported by New Jersey's strong computing and telecommunications industries which focuses on building new architectures and applications in the dynamic arena of parallel processing. And,
- The *Center for Manufacturing Engineering Systems* at the New Jersey Institute of Technology, reflects the importance of equipping our manufacturers to compete in an automated world.

The third broad area of center activity is in *environmental protection technologies.*

- The *Center for Hazardous Substance Research Management* is a unique five-school consortium based at NJIT in Newark, focusing scientific expertise on one of New Jersey's most troublesome issues.
- The *Center for Plastics Recycling Research* addresses a topic receiving strong industrial support from the plastics industry, and is based at the Rutgers engineering school.

The final area of ATC involvement is in *advanced materials*, supported currently by research at three centers.

- The *Center for Ceramics Research,* based at Rutgers Engineering School, is involved in research across the spectrum in this field whose applications are increasingly manifold, including superconducting materials. In addition, it incorporates what is probably the nation's most significant program in fiber optic materials, with a special emphasis on a Johnson & Johnson supported effort to discover useful applications in the medical field.
- The *Center for Surface Engineered Materials*, headquartered at the Stevens Institute, represents a departure from the traditional ATC mold. Its sophisticated analytical and processing equipment clusters and personnel will be distributed among four universities and the private David Sarnoff Research Center. The Center's research programs will concentrate on surface phenomena with the intent of solving such critical problems as corrosion, materials wear and fatigue. In particular, this Center will use sophisticated computer models in its efforts to analyze failure modes and to scale-up new processes for industrial applications.
- Recently, we approved the establishment of a *Center for Photonic and Opto-Electronic Materials*, based at Princeton University. We believe that, with strategic investments, New Jersey is poised to take advantage of the emergence of photonics as the technology of choice for telecommunications applications.

These Advanced Technology Centers are proceeding apace, with construction of laboratories and other facilities in some instances concluded, in all others under way or shortly commencing.

All of the programs which the Commission supports, and in particular, the Advanced Technology Centers – provide natural environments for graduate students, since all are housed on university campuses. Most of the ATCs are supporting additional special contingents of graduate students through research fellowships. For example, the Center for Ceramics Research funds 14 doctoral and 15 master's degree candidates.

Each of these programs are intended to meet industry's needs and interests, provide the basic and applied research for tomorrow's new and improved products, and leverage our Commission investments with cash and in-kind matching contributions from business and the federal government. Each of our programs, as they mature, are increasingly expected to spin off products and personnel, and thereby contribute to maintaining New Jersey as a prosperous host to an ever dynamic science and technology-based economy.

We also engage in a variety of other programs which are less costly, but rather labor intensive in comparison to the aforementioned activities. Three deal with our efforts:

1. to help strengthen the reality and perception of New Jersey as a good host to sci-tech based industry by eliminating tax and regulatory policy disincentives;
2. to foster a greater awareness – technological literacy – among our citizenry that science and technology will continue to be a key player in our economic well-being, and itself harbors the solutions to our many environmental problems;
3. to encourage efforts to strengthen our educational systems generally – from grammar school to post-doctoral education – in recognition of the fact that without an available, well-trained work force, science and technology based firms cannot survive and prosper.

While I will not expand upon the first two of the above, the third is of such overwhelming important and concern in our country, that I must give it some further emphasis. We all know that the supply of labor will not keep up with the demand, unless well-trained workers are added and/or worker productivity increases. Moreover, certain demographic shifts in the projected labor supply makes it imperative to find ways to bring previously under-represented groups, in particular blacks, Hispanics and women, into full participation in the labor force.

Let me annotate some more foreboding statistics for you on our situation:

- Almost no science is taught in elementary school in our country, and less than a quarter of high school students are qualified to do college-level science, math or engineering. Even fewer actually pursue technical majors, far short of the needs of industry, government, and academia.
- If we were to follow an average cohort of high school seniors beyond graduation, we would find that:
  - Only 25% of them had taken at least three years of math and science in high school;
  - Of those who went to college, only 5% entered the science, math, engineering pipeline; which is to say, they started out intending to major in these areas;
  - After four years of college, only 2½ % of the original cohort received a science or engineering degree;
  - Finally, less than one percent of them went on to graduate school.

Demographers also tell us that . . .

- The supply of new science and engineering graduates is expected to decline over the next decade because of an expected decrease in the college-age population.

And given that this population of science/engineering talent had previously been represented in the majority by white males, the decline of that group in the college-age population does not bode well that the needs of industry, government, and academia will be met.

The statistics showing the underrepresentation of blacks and Hispanics are rather horrendous. In 1986, for example, blacks received only 33 of the 4800 Ph.D.'s granted in the Physical Sciences. That number is less than one percent of the total. Hispanics were slightly more than one percent, with 64 doctoral recipients in this field. Similar findings obtain for engineering – where combined, blacks and Hispanics accounted for 59 of 3300 Ph.D.'s – and in the Life Sciences, with 182 out of 5700 degrees.

And while women now comprise more than half of all undergraduate enrollments, they account for only 12% of full-time engineering students, and 40% of those in science.

In addition to these absymally low numbers, there is also something very disturbing about the quality of the technical education our children are receiving.

- Internationally, the nation's 10-year-olds placed 8 th out of 15 countries in science achievement; the 14-year-olds finished further back, placing 14th out of 17. Comparatively, Japan was ranked 1st and 2nd in these two groups.
  - A recent study conducted for the National Science Foundation of U.S. science education teaching practices revealed that, starting in elementary school, teachers spend more time lecturing about science, and less time doing science in the classroom – precisely contrary to what scientists and science educators recommend.
- Mathematics achievements, internationally, show similar dismal trends. In a comparative study of Chinese, Japanese, and American children, the Americans were found to lag behind the Japanese as early as kindergarten, and by the fifth grade, were surpassed by both the Japanese and Chinese.
  - A report released last year entitled – "The Mathematics Report Card: Are We Measuring Up?" – resoundingly indicated that we are not. The U.S. Department of Education sponsored study found that math instruction is "dominated by teacher explanations, chalkboard presentations, and reliance on textbooks and workshops. More innovative forms of instruction, such as ... small group activities, laboratory work and special projects remain disappointingly rare." This finding is not unlike that describing the status of science teaching.

The combination of demographic shifts, poor science and math education, and the ever-increasing demand for higher order skills, cry out for new approaches to teaching and learning, in elementary and secondary schools and beyond, as well as for new players in the process. Our Commission may well become one of the new players in New Jersey, under a program plan adopted in January 1989. Candidly, however, our activities will at best represent a modest response to the difficulties we confront, and our state and nation have yet to match our rhetoric with efforts commensurate to the challenge.

Finally, I shall discuss in some greater detail our efforts to assist smaller companies and entrepreneurs. We support only one program – the so called Bridge Grant Program – that actually provides modest amounts (theoretically up to $40,000, but in practice averaging more like $15,000) of working capital, on the condition that the recipient has completed a Small Business Innovation Research Program (SBIR) Phase I Final Report and applied for Phase II funding.

The federal Small Business Innovative Research Program (SBIR) mandates that any federal agency that spends more than $100 million in contracted-out research devote 1.25 percent of their budget to small businesses, and that they publish a solicitation at least once a year detailing their requirements. They must divide their awards into two Phases: Phase I lasting six months and funded at not more than $50,000; and Phase II lasting eighteen months and funded at not more than $500,000. There is no funding between the two phases while the government is deciding on the Phase II award. Since this can be a critical period for a small company, the New Jersey Commission devised the Bridge Grant program.

The purpose is, of course, to effect tangibly the probability of the company staying alive until the federal government decides on an up to $500,000 second award. Another purpose, of almost equal importance to us, is that our award creates a relationship which enables us to work with the company.

With our SBIR Bridge Grantees, and most all other small sci-tech businessmen with whom we come in contact, we nine out of ten times take the opportunity to explain the importance of a business plan.

Uusually they will write one, which can then be reviewed at the Commission-sponsored Entrepreneurs Forum. Based at Rutgers University's Graduate School of Business, and modeled after the MIT Enterprise Forum, the Forum is a group of current and retired business people and academics, many of whom have reviewed the plan before the stand-up presentation. The spontaneity from the audience is balanced with the more pointed and researched probes from those who have analyzed the plan, and the result is a usually intensive critique of the effort. There is no cost to the entrepreneur.

Another of our programs is called the Venture Match, a sort of "dating game" between entrepreneurs and "informal" venture investors. In recent years, the professional venture capital market had veered toward later-stage financings, and often into business activities quite distant from their earlier almost exclusive focus on science and technology based enterprises. As they grew more cautious, and the number of attractive – to them – deals became scarcer, this unfortunately has not meant that money was freed-up for seed financing. The simple reason for this is that due diligence is not reduced as a linear function of a lower level of investment; indeed, it only rises moderately for even an order of magnitude increase in funding. In other words, it is usually not cost-effective for venture capitalists to look at the smaller deals.

On the other hand, the "informal" venture capital marketplace is alive and flourishing. In terms of money invested in any given year they are about equal to the professionals, but in the number of deals, they outdistance the full-time venture capitalists by four-to-one.

But tapping this fragmented source is not easy, primarily because almost none of the players considers themselves investors. They will always identify themselves as whatever produces the essential family income. Investing is purely discretionary, often not intellectually-based, and in many cases not really expectant of achieving a return. "Taking a flyer" best describes this group that, I must repeat, funds four times the number of deals as the professional venture capitalists.

The task facing the Commission was to try and formalize this fragmented network, and we settled on a slight variation of a system originally developed in New Hampshire. We call our approach Venture Match; others have referred to it as a "computer-dating" because its summarizes briefly and accurately the function of the system in matching entrepreneurs and informal investors through a computer search and match of the salient features of each.

Still another of our programs deals with the availability of Incubation Space. Aside from a host of other evidence, including the experience in other states, our work with the balance sheets of the scores of small companies who have applied for our SBIR Bridge Grants, showed us that rent was the major controllable cost for most of them. This led us to begin promoting business incubators. We have spent almost $ 300,000 in the last two years to pay for three feasibility studies and provide common equipment for three sites (Stevens Institute of Technology in Hoboken; Egg Harbor Township in Atlantic Country; and the New Jersey Institute of Technology in Newark), which are beginning to house their first tenants. Following behind we are hopeful that Rutgers and Princeton Universities will soon announce their plans. It should be understood that an incubator is more than just inexpensive space. We are convinced that if a controllable cost like rent can be kept to a minimum, and a business-like environment created, with a research university nearby to provide intellectual interaction and support, we can shorten the odds from four-to-one in favor of failure, to four-to-one in favor of success, after three to five years. That favorable survival ratio appears to be the experience at successful incubators around the nation. This is a good return for a relatively modest investment from the State, and with incubator sponsors themselves breaking a little ahead of even, on the overall operational costs.

Finally, I'd like to mention our latest innovative program. While working capital can sometimes be arranged for research or production-related expenses, and somewhat more easily for equipment, it is virtually impossible on the modest sums informal investors may provide an enterprise, to have cash – and above all the time – to perform the *Marketing Function* properly.

For this reason, we currently contract with a small firm to provide marketing services in Washington, D.C. for our current and potential SBIR applicants, and dissemination services in New Jersey to the entire entrepreneurial community that could benefit from the SBIR program. We are the only state engaged in this activity, and through it attempt to put our small companies on a par, from the marketing viewpoint, with major corporations who maintain elaborate offices to advance their interests.

As you will have observed from the above account of New Jersey's major programs – and many of the other states are equally active and ambitious – we have come a long way during the decade of the 80's. The most marked and continuing failure of the states and federal governments lies in the sphere of education, and hopefully the concentration of expressed public concern will now begin to diminish even that problem. We are gradually making an impression on the sociology of our academic and industrial organizations, not least with respect to their interactions and mutual respect and support. At the same time, the new role of the states is retaining and buttressing a characteristic American strength – that of decentralization of effort, investment and intellectual thrust. The end of the century may well tell us whether these efforts have been sufficient.

SCIENCE AND TECHNOLOGY IN REGIONAL DEVELOPMENT: THE NSF ROLE

Richard Ries *

Introduction

Prior to the early 1980s, economic development policy for U.S. states, regions, and localities revolved around the traditional factors of production: labor, capital, and land. Science and technology were acknowledged as that part of growth that the three other factors failed to explain – called the "residual effect" – by economists. For the most part, new knowledge – science and technology advance – were treated as university programs or federal policy, not state development strategies. There were notable exceptions, of course, such as Research Triangle Park in North Carolina and industrial extension programs of a few universities, but no state had a comprehensive science and technology policy.

Some History

Historically, for the United States, the relationship between the Federal government and the states in science and technology (S&T) started during the Civil War when President Lincoln signed legislation establishing the U.S. Department of Agriculture. In 1862, the Morrill Act granted the states Federal land for the establishment of what have became known as "land-grant" colleges and universities.

Almost all states became active in the support of new agricultural knowledge and its dissemination to agricultural users. The Federal government contributed to this through the Department of Agriculture's Agricultural Research Service (ARS), with its network of research facilities throughout the U.S., the Cooperative State Research Service (CSRS), and through the Agricultural Extension Services. Agricultural research provided an early model for intergovernmental, as well as university and industry cooperation in support of science and technology-based economic development.

A second phase for state programs came shortly after World War II when state programs became eclipsed by the rapid growth in Federal S&T programs and agencies. Yet Federal support of science and technology, especially for defense and space, had considerable impact on regions.

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Federal funds for research, and the education of World War II veterns, contributed to the very rapid growth of institutions of higher education, and some schools emerged as significant national research institutions.

Industries supporting defense and space research were often attracted to the supply of talent at universities or to the governmental installations themselves (e.g., California, Texas, and Florida for space programs; California, Massachusetts, and Washington for defense programs). But North Carolina, in establishing its Board of Science and Technology in 1963 was probably the earliest state to explicitly promote regional development by capitalizing on the network of public and private universities around Chapel Hill in what has become known as the Research Triangle.

In North Carolina, a strong tradition of public support for higher education, was expanded into an explicit attempt to use academic expertise for "high tech" development. New York, Massachusetts, and New Jersey were also activist states, and early supporters of high-tech industrial development.

Over the next two decades, a few intergovernmental activities in support of S&T were initiated. In the 1960s, under the State Technical Services Program of the U.S. Department of Commerce, some states created S&T commissions and foundations, and some appointed science advisers to the governor. The National Science Foundation initiated in the 1970s an Intergovernmental Science and Technology Program.

The Program supported the formation of organizations to provide S&T information to state governments and helped in the establishment of state S&T advisors and boards. For example, in California, an Innovation Group was established to provide S&T communication among California cities, and to other municipal innovation groups in areas such as Ohio, Alabama, and New England. As another example, a Science Advisory mechanism to the New York State Legislature was created to provide S&T support to legislative planning.

Most of the advisory bodies, established by the NSF Intergovernmental Program, were located in state legislative branches. A few of these offices still survive, but remain separate from the state S&T institutions of the 1980s. These new units are mainly executive branch agencies, some of which are in the governor's office itself.

In the late 1970s, William D. Carey (now-retired Executive Director, of the American Association for the Advancement of Science) in testimony before the U.S. Congress (Joint Economic Committee, October 20, 1976) characterized state and local governments as a "Fourth World" in the politics of U.S. S&T. The other three worlds were the Federal Government, industry, and the university sectors. In somewhat simplified form, the Federal Government determined the objectives and provided the funding for R&D. Industry performed most of the developmental work, sharing applied research with Federal R&D centers, and the universities (including State-supported) institutions did most of the basic research.

State and local governments, as such, were excluded since they had nothing to offer except an interest in the location of R&D facilities, and the geographic distribution of research grants. In a sense, these factors did serve as an implicit intergovernmental S&T strategy. Valuable R&D assets were concentrated in favored states and regions, notably Massachusetts and California. However, while the economies of these states gained from these decisions, it would be very hard to make a case that the benefits resulted because of the interest or effectiveness of these state governments in economic development activities, or any explicit intergovernmental policy on the part of the Federal government.

The 1980s: The Growing Interest of States in S&T-Based Regional Develpoment

Beginning in 1980, the interest of states in S&T – based regional development grew rapidly. In 1980, according to a survey by the Congressional Office of Technology Assessment (OTA), nine states had established agencies to promote S&Tdevelopment. By 1983, OTA identified 150 programs in 22 states designed to promote technology as a major factor of the states economy.

In 1984, The Wall Street Journal reported that 33 states had spent or were planning to spend $250 million to enhance the growth of high technology. The National Governors' Association (NGA) and OTA identified over 200 State and local economic development initiatives in 1984 with at least some features directed toward high technology development.

A 1985 analysis by the NGA indicated a continuing of that trend. Other studies report that by 1985 forty states had technology development initiatives. Fourty-one technology research centers had been established since 1979 to aid economic growth in 13 states. Two additional states were proposing the founding of nine centers. Cumulative funding for such centers was reported at over $1.3 billion.

Several factors can be identified behind this growth of state-level institutions for S&T in the 1980s:

- Economic dislocations in some states forced them to search for models for economic growth based upon S&T. The objective was to create and attract knowledge-intensive industries to replace those declining because of new technologies, reduced markets, or foreign competition.
- The new state initiatives reflected changes in the Federal approach to S&T investments. Federal programs, including NSF initiatives, began to require state and/or industrial matching funds. States became aware of the size and potential impact of some large new S&T enterprises like DODs SEMATECH and MCC located in Texas, and the need for coordinated efforts involving state, industrial, and university resources in competing for these new initiatives. An-

nouncement by the Federal government of the Superconducting Super Collider (SSC) project also stimulated the interest of many states.

- Change in the nature of scientific and engineering research itself, requiring not only the construction of very large scientific instruments but also new institutional forms for cross-disciplinary work, such as the NSF Engineering Research Centers (ERCs), brought greater political attention to how these awards were made. In efforts to build capabilities for S&T in specific institutions, and as a result of intense lobbying by universities themselves, the U.S. Congress began inserting specific line-items for research facilities in appropriations bills.

The NSF Response

As states and localities moved to view S&T as a means to economic development, the NSF increasingly took steps to strengthen communication with state policy makers and to encourage the development of partnerships with state groups. Summarizing the NSF strategy in a speech in February of this year, Mr. Erich Bloch, the NSF Director said: "Federal funding alone won't keep a state competitive in research. Nuturing the research infrastructure will keep a state competitive."

EPSCoR. As early as 1980, the NSF launched the Experimental Program to Stimulate Competitive Research (EPSCoR). EPSCoR was designed as a partnership between participating states and the National Science Foundation.

This program was an effort to:

- help universities in states that historically did not compete effectively for NSF research funds; and
- broaden the research and training base for U.S. science and engineering.

Initially, five states (Arkansas, Maine, Montana, South Carolina and West Virginia) received awards with NSF providing from $ 2.5 to $ 2.9 million per state, over a period of five years. Each state also provided its own matching funds. Research advance and development of new instrumentation were some outcomes of the program. In addition, Arkansas established a new state Science & Technology Authority to foster basic research and contribute to economic development as a result of the program, and the University of South Carolina's chemistry department was selected as one of the six most improved departments in the U.S. South Carolina, also moved from 46th to 28th position among all states in receipt of NSF grants.

NSF awarded a second round of EPSCoR grants in 1986 to: Alabama, Kentucky, Nevada, North Dakota, Oklahoma, Puerto Rico, Vermont, and Wyoming. Each received a five-year award of $ 2.5 to $ 3.0 million. Although the Foundation did not set any required level for matching funds, non-Federal sources actually provided amounts ranging from $ 2.5 to $ 20.9

million per state. Total matching funds for the eight awards amounted to $ 84.3 million.

Through EPSCoR, the NSF has seen significant accomplishments for relatively few Federal dollars. The EPSCoR traditions – close cooperation between public and private sectors, careful assessment of research and development activities, and competition through merit review for R&D development funds – were incorporated into many state-supported programs.

NSF CENTERS & STATE S&T. In the early 1970s, the Federal government began to pay increased attention to support of industry-university cooperative efforts. The overall objective was to find ways of stimulating non-Federal investment in research and development and of improving the application of research and development results. NSF responded with several programs involving university-industry interaction, among which a major one was the University-Industry Cooperative Research Centers Program established in 1973.

Cost sharing was required. As NSF support is phased out within a period of five years, all centers must increase non-Federal support for their research programs. While most of the cost-sharing funds for the Program over the years have come from U.S. industry, in recent years, states have begun to play a role. State governments began to realize the opportunity and potential of the Foundation's Industry-University Cooperative Research Center concept not just for technology transfer, but for regional industrial development. An example of a highly successful project is the Center for Ceramics Research at Rutgers University in New Jersey.

Twenty-seven industrial firms and the New Jersey Commission on Science and Technology participate in sponsorship of the Center. New Jersey initiated a bond issue for $ 90 million for this kind of industrial development program and vested the authority for the administration of the program in the Commission for Science and Technology. Now there are five centers in the state, each addressing different technologies pertinent to New Jersey industry. As for the industrial firms participating in the center at Rutgers, each of these contributes $ 35,000 annually. These funds are matched by the Commission for operating the Center, with additional funding available for capital improvements. The center has grown so in reputation that participation in an international program with Sweden is now underway.

NSFs Small Business Innovation Research Program (SBIR)

The Small Business Innovation Research Program was initiated by the Foundation in 1977. In 1982, the U.S. Congress passed the Small Business Innovation Development Act, and the NSF Program became a model for a national SBIR Program. With the growth of state support of new, technology-based businesses in the 1980s, strong interaction between the national

SBIR program and state efforts to encourage small business began, and continues at a high level.

Some understanding of the Federal (and NSF) program is necessary to appreciate this small business aspect of intergovernmental activity. The Small Business Innovation Development Act mandated that each federal agency with an external research and development budget exceeding $100 million spend a specified percentage (up to 1.25 percent) of such budget via a special SBIR program. Since 1983, twelve federal agencies have conducted SBIR programs. For 1987, the approximately 2500 new awards under the national program totalled about $240 million. NSF made somewhat over 200 awards under the program in that year amounting to about $20 million.

Under the program, federal agencies request proposals from small businesses outlining their research and development needs. After evaluating the proposals, each agency awards grants for determining the technical feasibility of the research and development concepts proposed. These awards areas are Phase I funding – up to $50,000 for six months. If assessed by the federal agency to be feasible, the firm can apply for Phase II grant – up to $225,000 for two years – for full scale research and development. Once Phase II work is finished, the firm is expected to obtain Phase III funding, that is, funding to commercialize research results from non-federal sources.

States have aggressively promoted the program to their small business communities by advertising the program, holding workshops to acquaint small business with proposal submission guidelines and strategies, and distributing agency solicitations for proposals. On its part, NSF staff participate fully in state-organized workshops, such as a 1989 Kentucky Cabinet for Economic Development meeting to familiarize firms in Kentucky with the program. Two federal high-technology conferences are held every year which attract about two thousand people.

Several states have established their own SBIR grant programs to provide funds to firms which are either applying for or have received SBIR awards. One state approach is a "bridging" grant. New York was the first state to establish an SBIR grant program. To qualify for a "bridging" grant, the applicant must have completed Phase I research, and submitted its Phase II proposal. These grants allow the firm to continue work during gaps in federal funding between Phase I and Phase II. Gaps result from the time (sometimes, as long as one year) NSF and other federal agencies require to perform adequate evaluation of Phase I results and assess Phase II proposals. New Jersey also supports an SBIR Bridge Grant Program, and similar programs in Connecticut and Kansas are in the process of becoming operational.

In addition to "bridge" grants, some state SBIR programs provide planning grants to be used in developing applications for Phase I grants. Finally, while, with the exception of the NSF program, the SBIR program is relatively new, for companies which have completed Phase II, states are working to link these firms with potential funding sources through such mechanisms as venture capital organizations, licensing agreements, or by taking the company public. New York, New Jersey, and New Mexico are at the forefront of such efforts.

NSF/NGA Agreement on Science and Technology Centers.

Another approach to increasing collaboration and cooperation between the states and the NSF was initiated in Fall, 1988. The NSF and the National Governors' Association (NGA) reached an agreement under which the Foundation shares with interested States, subject to the approval of proposal authors, high quality but unfunded proposals submitted under NSF's Science and Technology Research Centers Program (STC).

Under the STC Program, NSF can provide support for only a limited number of campus-based centers aimed at performing cross-discliplinary research activities that cannot be undertaken by scientists working alone, that need stable support over an extended period, that require large facilities or instrumentation, or that need researchers of diverse experience and expertise.

The STC Program has generated significantly more highly qualified proposals than NSF has the funds to support, and the NGA Working Group on State Initiatives in Applied Research expressed an interest in making those proposals available to interested states for consideration for funding, provided the proposers approved.

Erich Bloch, Director of NSF, called the agreement "...a significant step forward in Federal-State relations and a good experiment in Federal-State cooperation."

"We know that NSF can do a merit review on a national level that no state could easily duplicate. In addition, this information sharing helps States avoid duplication of effort in the lengthy and costly process of merit review, assures them of the high quality of the proposed centers, and helps them make decisions regarding research that may be conducted by institutions within their borders."

Recently, NSF conducted an informal survey of State officials about the STC experiment. New Jersey, New York, Utah, and California indicated consideration of support of several STC proposals. Several other states (including Illinois, Minnesota) indicated that if state funds become available in the next fiscal year, the STC proposals from their state would be eligible to compete in the state program.

All the states contacted indicated that they were pleased to receive the information from NSF on highly rated STC proposals, and were in favor of continuing the agreement.

Extension of the STC Centers Experiment.

To encourage cooperative efforts between NSF directorates with respect to States, an Interdirectorate Working Group on State Initiatives was established, under the leadership of the NSF Office of Legislative and Public Affairs, which reports directly to Mr. Erich Bloch. One objective of the Working Group is to extend the NSF/NGA Agreement on Science and Technology Centers to other activities. The Engineering Research Centers Program, Science and Engineering Education, programs to improve S&T opportunities for women and minorities in the Division of Research Initiation and Improvement, and the Small Business Innovation Research Program are represented in the Working Group, as well as other NSF offices.

Building on the positive response by state officials to the STC Centers Experiments, extension of the experiment to other NSF activities – human resources development, Engineering Research Centers, and small business – is very likely.

Science Indicators About State Programs and State R&D Spending.

NSF, through the Division of Science Resources Studies, has a broad mandate in developing indicators of science and technology activity in the United States, and throughout the world. *Science and Engineering Indicators 1989* will include an in-depth look at State S&T programs designed to enhance technological and competitive capabilities.

To better understand the efforts of the states in supporting R&D activities, NSF is funding a study to collect information from all 50 states for the year 1987 and 1988. Data on state support for research and development activities have not been collected on a national scale since 1977. The results are expected to be available this year. Other studies have been commissioned to develop more qualitative indicators of the growth in State involvement in S&T over the decade.

Preliminary results indicate that state involvement in science and technology in terms of new organizations have grown significantly over the decade, and participation in university-industry relationships has intensified. Results also show wide variation in growth of funding of R&D by States over the same period. Some analysts predict that when the final figures are in, they will show that nearly $ 1 billion is being spent by States on S&T initiatives to promote economic development. Others question whether budgetary growth in S&T by the States has matched institutional development and involvement, and doubt if States can be considered more than minor players in U.S. funding for R&D.

Some Future Prospects

As this is written, towards the close of the 1980s, S&T has become an integrated part of Federal-State-local relationships in the United States. Intergovernmental relations in S&T deepened and diversified considerably during the 1980s, and innovative agendas for the 1990s have been set by several Blue-Ribbon Panels. An especially carefully thought-out set of goals has been set by the Southern Growth Policies Board, with representatives from both legislative and executive bodies throughout the South. Both the National Science Foundation and the Carnegie Corporation of New York supported the effort.

These goals include:

- Technically Proficient New Entrants in the Labor Market.
- Upgraded Skills in the Current Work Force.
- Improvement and Expansion of Research and Development.
- Commercialization of New Ideas and New Technologies.
- Rapid Development and Effective Utilization of Technology.
- Integration of Science and Technology into State and Regional Policy.

To begin to accomplish this agenda represents the challenge faced by intergovernmental cooperation in S&T for the 1990s.

NOTES

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3. The author would also like to thank the following NSF staff for their contributions to this paper: Lawrence Burton, Margaret Grucza, Michelle Hainbach, Bruce J. Reiss, Donald Senich, Roland Tibbetts.
4. Documents which provided background for this paper include the following:
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SCIENCE AND TECHNOLOGY AND REGIONAL DEVELOPMENT IN JAPAN

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1. Introduction

In this paper, the author presents a historical review of Japanese policy for industrial promotion since the end of World War II, especially its response to changes in the economic and social situation in Japan and the world, which motivated the Technopolis plan. An outline of the Kumamoto Technopolis is presented as a case study. Some comments on further promotion of industry and regional development are also included.

In Japan, "regional development" is a concept to be contrasted to so called "one point concentration". As is well known, in one point concentration, the social activity and consequently the population is extraordinarily concentrated in a giant capital like Tokyo, and this tendency of concentration is, although not so rapid as in former times, still continuing in Japan. Such a concentration is not an entirely unexpected result, but rather the natural result due to the Japanese policy of promoting industrial growth since the end of World War II. In consequence, the Japanese government is now trying to change the undesirable condition of concentrated industrial and population growth. However, this attempt has just begun, and the government is now surveying the ramifications of the Technopolis plan, and will refine it corresponding to internationally changing conditions.

2. Japanese Policy for Industrial Promotion and Regional Development

2.1 Historical review since the end of World War II.

At the end of World War II, Japan was confronted with two major tasks. The first was to reestablish food self-sufficiency, and the second was to rehabilitate industrial productivity to its former state, which was severely damaged by the war. But food sufficiency was inherently impossible because of limited arable lands and a vast population. On the other hand, industrial productivity was rapidly rehabilitated. At the beginning, the heavy industries such as ship building, petrochemical plants, etc., recovered their productivity; then massive production of assembled goods such as cars, electronic appliances, etc.; and finally high technology products such as Japanese

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computers which are now exported throughout the world. As a result of these industrial developments, Japanese demography patterns changed dramatically. Previously developed industrial zones (i.e. Tokyo, Nagoya, Osaka-Kobe and north-Kyushu) and also newly developed industrial zones (e.g. Pacific Ocean belt, Seto Inland Sea belt, etc.) absorbed many employees, while on the other hand, in the farming and fishing provinces undesirable depopulation resulted. To improve the economic and civil imbalance due to these over- and under-population problems, the MITI (Ministry of International Trade and Industry) proposed in 1980 the Technopolis (high-technology industrial complex) plan.

2.2 Proposal for the Technopolis plan and its background

As mentioned beforehand, the principal motive for the Technopolis plan was to activate under-industrialized regions by relocating older industries and developing new industries locatable in regional zones. Thereby, the new industrial areas would have characteristics different from previous development. The new zones would not be noisy, unhealthy, unsanitary and unsightly as in the case of the former industrial zones. They would be desirable combinations of active industry, an intellectual and academic community, and comfortable habitation zones, to ensure a balanced setting of goals for social, economic and cultural development.

At the time of this proposal, besides the social situation mentioned above, there was another reason which forced the government to establish such a policy. This was the pressure to transform Japan's industrial base during the "Oil Shock", i.e., the change from heavy industry to light industry, or to say, from heavy, thick, long and large products (e.g., giant electric generators, mammoth tankers etc.) to light, thin, short and small products (e.g., highly integrated electronic circuits, high precision assembled goods as audio and video equipment etc.).

In addition to this situation, there was the impact in Japan of the industrial development of so-called Newly Industrializing Economies (NIES) countries in the 80's. Japan was being further forced to modify exportable production to high technology.

To establish new production areas for high technology products, the regional development zones had few handicaps, particularly in the case of material and product transportation and of factory construction.

3. Explanation for Governmental Policy for Technopolis Construction

In the reports and documents prepared by MITI, especially by the relevant bureau, Industrial Location and Environmental Protection Bureau, the principal items of the Technopolis plan were explained as follows:

3.1 City planning as a combination of industry, academic and residential spaces

A Technopolis is a city to be newly created as an organic combination of industry, academic and housing space defined as:

(1) Industry: a group of industries centering on electronic machinery and other high-technology industries.
(2) Academic: colleges or universities of technology, central research institutes of private organizations, etc., which sustain the development of industries.
(3) Residential space: city planning for a pleasant, more relaxed life style.

This is a new form of a regional development promoted at the initiative of the local communities concerned with emphasizing regional characteristics. The Technopolis plan is aimed at creating these cities by 1990 as Japan moves toward the 21 st century.

3.2 Significance of the Technopolis

(1) Basis for an independent regional economy.

There is a tendency for people living in small cities or rural regions to remain rather than moving to big cities. Under such situations, it becomes imperative for these communities to positively respond to those industries providing employment opportunities where the population's competence can be used effectively. Local economics, meanwhile, are entering into a new stage – getting out of their vulnerable dependence on public investment and finances, and aiming at self-supporting development using their own resources. This redevelopment requires decentralization of production, establishment of research and development in high technology industries in local areas, and revitalization of indigenous enterprises through assistance to them to create new products and technologies.

The Technopolis will be the center for the development of technology and its dissemination to local enterprises, and will play the role of activating local economies and promoting independence.

(2) Promotion of the Techno-State.

There would be no sustained growth of the Japanese economy without the promotion of technology-intensive, internationally competitive industries, such as semi-conductors, computers, information and communications, and biotechnology.

Stable and long-term growth of these high-technology industries depends on positive deployment of their production and research and development functions in an area which offers an excellent environment for creative research and development activities with easy access to sufficient plant sites, water, and human resources.

The Technopolis plan is intended to spread high-technology industries to small cities and rural regions in an effective way to further promote Japan as a Techno-State.

(3) Self-motivated regional development.

The Technopolis plan, which features the initiatives of each local community concerned and the utilization of private sector vitality, is aimed at making effective use of the knowledge and cooperation of the community.

The Technopolis plan is expected to play the role of initiating the process of community revitalization through decentralization of high-technology industries.

4. Contribution of the Ministry of Education, Science and Culture (Monbusho) to High-Technology Regional Development

Among the various contributions of Monbusho the most important are:

(1) Rapid extention of higher education, especially in schools of engineering, promoted not only by the enlargement of existing schools, but mainly by new efforts in almost all prefectural capital cities.

(2) Financial management to promote research in colleges and universities, especially the establishment of a support system for scientific research and sustained enlargement of the research system.

(3) Establishment of a representative body of research specialists to promote cooperation among academic institutions, public and private organizations, and industries.

5. The Kumamoto Technopolis as a Case Study

At the " International Association of Science Parks" symposium held in Kumamoto, the relevant department of the government of Kumamoto presented the following outline of the Kumamoto Technopolis plan:

The plan for the Kumamoto Technopolis consists of two areas, the Techno Gallery and the Metropolitan Core, with a land area of 95,000 hectares and a population of 738,000:

Metropolitan Core (the area of Kumamoto city and surrounding urban sphere) — 1 city, 9 towns.

Techno Gallery — 1 city, 3 towns, 2 villages.

The Techno Gallery is an area designed for high technology industrial manufacturing and for research and development supporting production, as well as a place of permanent residence for the workers employed there.

On the other hand, the Metropolis is an area offering various services and information; the primary purpose is to provide support to services in the Techno Gallery. The location of the Kumamoto Technopolis has the following excellent conditions:

(1) Enterprise activities:
The technological enterprises such as automation, biotechnology, computers, and data processing are very active in research and development. Moreover, the cooperation of industry, academics, and administration is an asset to further stimulate research and development.

(2) Industrial sites, industrial water and residential sites:
Industrial water and residential sites are easily secured. Land use (1981) is agricultural, 34%; forest, 37%; roads, etc., 14%. Suitable land for factory sites is approximately 121 hectores in scattered areas.

(3) Education:
There are five institutions of higher education in industry and economics in the Technopolis area:

Kumamoto University – school of medicine, pharmacy, engineering, natural science, etc.
Kumamoto Technical College – department of applied biotechnological industry, etc.
Kyushu Tokai University – school of engineering, agriculture, etc.
Kumamoto Commercial College – research department for computer software, etc.
Kumamoto Radio and Communication College – department of computer technology, electronics, etc.

(4) Transportation:
Easy access is available to high speed transportation facilities:

Kumamoto airport – 3000 meter runway, five flights a day to Tokyo and Osaka , one flight a day to Nagoya, Takamatsu, and Okinawa.

The Trans-Kyushu expressway, Kumamoto and Mifune interchanges are easily accessable and before the end of 80's a highway between Yatsushiro and Hitoyoshi will be open.

There was also presented the details of the goals for the industrial complex, the resources and means to accomplish the planned goals, and the present status of Technopolis construction:

(5) The main institutions of the Techno Research Park already opened are:
Technopolis Center of Kumamoto Prefecture.
Applied Electronics Research Center of the Kumamoto Technopolis Foundation. Regional Cooperative Research Center of the Kumamoto University.

6. Themes for Further Promotion of Regional Development

Recently the regional newspaper *Kumamoto Daily News* reported the present status of Kumamoto Technopolis and the problems to be solved for further promotion of regional development, under the title "Technopolis Now". The problems presented are also applicable to all 25 Technopolis plans across Japan. The national government (MITI) has a plan to set up a new committee, "Committee for Technopolis 2000" (tentatively, advisory to the MITI Industrial Location and Environment Protection Bureau) to study the present status of Technopolis construction and to refine Japanese policy for regional development.

In my opinion, the most important tasks for further promotion of regional development are the followings:

(1) Broader cooperation of academic institutions and industries beyond the boundaries of the individual Technopolis.

(2) Establishment of a data base to promote the above cooperation.

(3) Active consultation between public and private sectors to promote further cooperation.

CONTRIBUTION OF THE NIPPON STEEL CORPORATION TO SCIENCE AND TECHNOLOGY IN REGIONAL DEVELOPMENT

Makoto Tezuka *

1. Summary

Japanese economic activities have tended to concentrate in metropolitan areas since the postwar economic restoration and the high growth age. Especially in recent years, there is intense concentration in the Tokyo area. In addition, the Japanese economy is in a slight recession because of the rapid appreciation of the yen since 1985. To cope with these problems, the government has planned and promoted various regional development projects. There are two kinds of projects: large-scale construction projects such as the Trans-Tokyo Bay Highway, Great Akashi Strait Bridge and New Kansai International Airport, and R&D projects related to various science and technology developments aimed at promoting regional industries. Nippon Steel Corporation has participated in these projects with its steel products and advanced technology.

2. Introduction

Recent economic activities in Japan have been concentrated in metropolitan areas, especially the Tokyo Area. Regional economies on the other hand, such as those of Tohoku, Chugoku, Shikoku and Kyushu are depressed because of the decrease of population and the decline of regional industries. This tendency is seen especially in production, research and development and information services. In Japan, 45.7% of the research and development departments of private industry are located in the Tokyo Area, and 55.9% of those engaged in the information service industry are based in the Tokyo Area.

To achieve balanced development in the 21st century, it is necessary to rectify the concentration in Tokyo. For this purpose, the government has planned and promoted various regional development projects. There are two kinds of projects: those aimed at stimulating the economy by setting up regional traffic networks to expand living and economic areas, and those aimed at establishing and strengthening high-level functions in regional

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areas. The government has been carrying out projects, mainly in pivotal local cities, to establish public research and development facilities for special purposes such as new materials and biotechnology research, and to establish areas with service facilities commonly used by various organizations to invite and promote growth of such industries as software and data processing. I will comment on the current status of regional development activities and the contribution of Nippon Steel.

3. Outline of Nippon Steel Corporation

Nippon Steel Corporation (NSC) is the world's largest steel producer. It has about 60,000 employees, and produces 28 million metric tons of crude steel a year at nine steelworks located throughout the country from Hokkaido to Kyushu. The Central R&D Bureau consists of three central research laboratories and research laboratories located in each steelwork. A total of 1,200 people are engaged in research and development. In addition, about 7,000 technical development engineers in each steelwork are engaged in development of steel materials and production technology.

The steep rise in the value of the yen against the U.S. dollar since 1985 is forcing Japan to revise its industrial structure and advance aggressively into new businesses in answer to the new needs of industry. In response, NSC plans to have diversified by 1995 to the stage where materials, including steel, new materials and chemicals, will account for 60 % of sales – with steel accounting for less than 50%. The electronics division and information/communication systems division will chalk up sales of 20%, while engineering and urban development or infrastructure projects will account for 10% each. Research and development in biotechnology, in which the greatest growth is seen from now to the 21st century, have already been started. As a result, total company sales in fiscal 1995 are forecast at around ¥ 4 trillion.

According to this strategy to diversify its business, NSC is transforming its business structure, presently centered on steelmaking, into one that encompasses new businesses for the prosperous future of the company, through the maximum use of its abundant managerial resources. In steelmaking, NSC plans to reduce annual crude steel production capacity from 34 million metric tons to 24 million metric tons by 1990. As a result, the number of integrated steelworks will be reduced to four: Kimitsu, Oita, Nagoya and Yawata works. Others will become small works for rolling operations. According to its business diversification strategy, NSC is positively taking part in various regional development projects to promote regional industries, utilizing its steel engineers.

4. Large-Scale Construction Projects

To stimulate domestic demand and revitalize the Japanese economy, the government launched several mammoth projects in 1986 in cooperation with the private sector. These included: ¥ 1 trillion in a 15-km-long tunnel-bridge system which will cut across Tokyo Bay (Trans-Tokyo Bay Highway); the ¥650 billion Great Akashi Strait Bridge which will form part of the link between Shikoku Island in western Japan and Honshu, the main island; and the ¥1 trillion New Kansai International Airport in Osaka, NSC has participated in these projects as a supplier of advanced steel materials and as structural engineers.

4.1 Trans-Tokyo Bay Highway (TTBH)

The Trans-Tokyo Bay Highway is a part of the Tokyo Bay Coastal Highway Project, and will directly link Kawasaki City in Kanagawa Prefecture with Kisarazu City in Chiba Prefecture, a distance of about 15 Km. The purpose of this project is to develop industry around Tokyo Bay and to create new housing and recreational areas. The highway will be constructed by the private sector. This project, in particular, will bring to reality a 20-year-old vision of redeveloping the Tokyo metropolitan area and unifying the greater Tokyo Bay area. Kawasaki, a high-tech industrial city south of Tokyo, will be linked with Kisarazu, a recreation and port city across Tokyo Bay, by a combination tunnel-bridge route which includes two man-made islands. It is envisioned that one of the islands will form the hub of a communications network in the future. The TTBH will cut the travel time from Kawasaki to Kisarazu – presently a long route around Tokyo Bay – to one-sixth, from 90 to 15 minutes. This ten-year project is not without its challenges: the bay's soft soil and topography require expert civil engineering and scientific technology. The occurrence of earthquakes must also be take into consideration. NSC has contributed to this project by providing civil engineering technology and supplying such materials as corrosion-resistant pipe piles and sheet piles. These piles are coated with polyethylene or urethane resin to provide long-term corrosion resistance in splash and tidal zones.

4.2 Great Akashi Strait Bridge

The Great Akashi Strait Bridge will be built on the Kobe-Naruto route as one of the bridges connecting Honshu and Shikoku along the islands of the Inland Sea. The suspension bridge will be built between Kobe City and Awaji Island. It will be 3910m in length and have a center span of 1990m. Its towers will be 330m high, making it the largest suspension bridge in the world. Its construction, which started in 1986, is expected to take 13 years. By building the bridge, the time required to travel from Kobe to Tokushima will be reduced from the current 3 hours and 12 minutes by sea to 1 hour and 40 minutes. It is expected to have large economic effects by linking the business and residential areas of Kansai and Eastern Shikoku. Steel wires of high tensile strength (180 kg/mm 2) developed by NSC will be used for the bridge. In the past, the maximum strength of high tensile steel wire was

160 kg／mm 2. If this wire were used for the Great Akashi Strait Bridge, it would be necessary to have two wire strands for each side. The NSC-developed wire (180 kg／mm 2 in strength), permits a single wire strand for each side, reducing the cost and time for construction.

4.3 New Kansai International Airport

A joint government-private sector project to construct a New Kansai International Airport on reclaimed land near Osaka, Japan's second largest city, was launched in March 1986. The new airport is expected to be in operation in 1992 on 500 hectares as Japan's first 24-hour terminal and, upon completion, will occupy 12,000 hectares of reclaimed land five kilometers offshore.

This project is being carried out by a private corporation, called Kansai International Airport Co., Ltd. established on October 1, 1984. The company is capitalized at ¥5.1 billion, ¥3.4 billion of which is invested by the government, ¥850 million by six prefectural and municipal governments, including Osaka prefectural and municipal governments, and the rest by 34 companies including NSC. The airport plan envisages the construction of two 4,000 m runways and one 3,400 m auxiliary runway on a man-made island – the first such airport project ever attempted in the world. First-phase work calls for a 3,500 m runway on reclaimed land which is presently about 20 m under water. The airport capacity, after the first-phase is finished, is expected to be between 130,000–160,000 annual takeoffs and landings, more than the New Tokyo International Airport's 65,000 and figures will eventually increase to 260,000 when the entire project is completed. As Japan's first airport to offer 24-hour service, the Kansai International Airport is expected to play a vitally important role in expanding the nation's air cargo distribution network not only in and around Osaka and Western Japan, but throughout Japan. The amount of steel structure used will be about 200 thousand metric tons. NSC is contributing to this project by providing steel products and civil engineering technology.

4.4 Space World Project

I would like to mention the Space World Project, although it is not a large national project. NSC is promoting diversification of its business, as explained in the outline of NSC. Space World Project is part of this strategy. On July 11, 1988, NSC established a new company to manage Space World, the space-oriented training and leisure theme park which is to be constructed within its Yawata Works in Kitakyushu City. Space World Inc. will operate Space World's astronaut training facilities, museum, library, exibition pavillions and space flight simulation facility, and will also be in charge of souvenir sales and catering services.

The NSC group invested 51% of the capital (41% from Nippon Steel, 5% from Nittetsu Shoji Co., Ltd. and 5% from Nippon Steel Life Planning Co., Ltd.) Kitakyushu City and nine local companies involved in the promotion of the project invested 10% and 8.5%, respectively, while another 5% came from the government's Facilitation Fund for Industrial Structural Adjustment. As for the remaining amount, 15% came from a group of four major trading companies and 10.5% from a group of 16 others, including the Industrial Bank of Japan, Ltd. Construction of the Space World project started last October on the 27-hectare site for a scheduled opening in the spring of 1990. The initial investment will amount to around ¥20 billion. When completed, Space World is expected to attract upwards of two million visitors a year. NSC's experience in construction engineering gained in building steel plants is being applied to the construction of Space World.

5. R&D Projects

Recently, there have been considerable developments in science and technology. In Japan, the private sector, the educational institutions and the government are cooperating to promote research and development projects. To support such projects, the government organizes the supporting systems such as the New Energy and Industrial Technology Development Organization (NEDO) and the Japan Key Technology Center. If promotion of regional industries and these research and development activities for science and technology can be coordinated, it will rectify the overconcentration in the Tokyo Area and help well-balanced development of the country for the 21st century. As NSC recognizes that reduction in the scale of steelworks, due to reorientation of the steel business, will have considerable effect on regional economics, we are taking part in research and development projects in each region in which steel works are located.

5.1 Examples of Research and Development Projects Supported by the New Energy and Industrial Technology Development Organization (NEDO).

There are several kinds of NEDO projects, but I would like to mention the projects to establish large-scale research facilities necessary for research and development in advanced fields. These projects are both to establish the above-mentioned research facilities and open them to Japanese and foreign researchers. The private sector will establish and manage the facilities, and NEDO will provide funds to the private sector. Other funds necessary for the projects will be provided by investments from local governments and loans from such institutions as the Japan Development Bank. This is discussed in Taketoh [1989]

Examples include:

(1) Micro-Gravity Technology Center

(i) Establishment: February, 1989

(ii) Location: Kami-Sunagawa Machi, Hokkaido

(iii) Outline of the project:

This Center will focus on such activities as creating new materials by taking advantage of various phenomena caused by microgravity. Currently, experiments in states of microgravity can be done during space flights, inertial navigation by rockets and aircraft, and freefall from towers. However, as these methods have various limitations, it is necessary to establish a facility to perform experiments on earth easily and frequently. By using a former coal mine which has a shaft about 800 m deep, a vertical descent facility will established to create a good state of microgravity for about 10 seconds.

(iv) Total investment: ¥5.2 billion (1988~1990)

(v) Investor: NEDO, Hokkaido prefectural government, Kami-Sunagawa Machi municipal government, 34 private companies including NSC.

(2) Research Center for the Industrial Utilization of Marine Organisms

(i) Establishment: January, 1989

(ii) Location: Kamaishi City, Iwate Prefecture and Shimizu City, Shizuoka Prefecture

(iii) Outline of the project:

Creatures in the sea, the source of all life on earth, are of greater variety than those living on land. The purpose of this facility is to determine their life systems and to apply them to such fields as the production of fine chemical products.

(iv) Total investment: ¥6.0 billion (1988~1989)

(v) Investor: NEDO, Iwate & Shizuoka prefectural governments, Kamaishi & Shimizu municipal governments, 25 private companies including NSC.

(3) Ion Engineering Center

(i) Establishment: November, 1988

(ii) Location: Hirakata City, Osaka Prefecture (Kansai Culture and Science Research City)

(iii) Outline of the project: Materials are ionized and irradiated to substrates for surface-modification, surface-processing, vapor-deposition, crystal growth and creation of new materials on the substrates at this facility. Application of ion beam technology to various industries will also be studied.

(iv) Total investment: ¥7.8 billion (1989~1991)

(v) Investor: NEDO, Osaka prefectural government, 46 private companies including NSC.

5.2 Examples of Research and Development Projects Supported by the Japan Key Technology Center

The Japan Key Technology Center, founded in October 1985 as a government approved center for the overall promotion of private-sector research and development of fundamental technologies, focuses on means to facilitate research, and thereby contributes to economic development and enhanced quality of life in Japan and abroad. Japan's technological development has lagged behind that of industrialized nations in terms of basic research, and more than 70 % of all R&D expenditures in Japan comes from the private sector. The Center was founded to enhance joint governmental, industrial and academic R&D and concentrates on the fields of new materials, biotechnology, microelectronics and telecommunications. The Center is supported by both the government and private sector. This is discussed in Takenami [1989]

(1) Tohoku Intelligence Cosmos Research Organization (ICR)
  (i) Establishment: March, 1988
  (ii) Location: Sendai City, Miyagi Prefecture
  (iii) Outline of the project: A large research area was established in Sendai to develop the Tohoku Region. Various organizations such as companies in the Tohoku Area participate in the project, and Tohoku University is taking the lead. Under ICR, several R&D companies will be established. Currently, four R&D companies have been established. NSC is participating in the Amorphous Magnetic Device Laboratories. One NSC researcher has been assigned to the laboratory.
  (iv) Initial investment: ¥2.3 billion
  (v) Investor: Japan Key Technology Center, 27 private companies including NSC.

(2) Colloid Research Institute
  (i) Establishment: February, 1987
  (ii) Location: Kitakyushu City, Fukouka Prefecture
  (iii) Outline of the project: Research and development the production technology of fine ceramics by the sol and gel method is being accomplished. Two NSC researchers have been assigned to the project.
  (iv) Initial investment: ¥450 million
  (v) Investor: Japan Key Technology Center, 4 private companies including NSC.

5.3 Examples of Other Research and Development Projects

(1) International Superconductivity Technology Center (ISTEC)
  (i) Establishment: February, 1988
  (ii) Location: Tokyo, and Nagoya City, Aichi Prefecture
  (iii) Outline of the project: Research and development of superconductivity on an international scale is being performed. The Superconductivity Research Laboratory was established, for research on ceramics and non-ceramics materials, development of advanced manufacturing of superconductive materials and evaluation technology of material characteristics. Two NSC researchers have been assigned to the project.
  (iv) Research period: 1987–1997
  (v) Investor: 110 private companies including NSC as of April, 1989.

(2) NSC R&E Center

Although it is not a national project, I would like to mention the NSC

R&E Center established to develop steel materials and processing techniques for the 21st century.

(i) Location: Futtsu City, Chiba Prefecture

(ii) Outline of the project: NSC will centralize research which has been dispersed throughout the country, add plant engineering and technology functions, to establish the R&E Center. It is now under construction at Futtsu City in Chiba Prefecture, the city adjacent to Kimitsu Works, the largest steel works of NSC. While initially the R&E Center will be concentrating mainly on steel, in the future new fields, — new materials, for example will be added, with the aim of making the Center an advanced R&D/engineering base. Steel related research functions which are now divided into fundamental research (R&D Laboratories — I), product research (R&D Laboratories — II), and process research (R&D Laboratories — III) would be integrated into the Center. Liaison between research and engineering would be strengthened, and to raise the quality and efficiency of the operations of the Plant Engineering & Technology Bureau, this Bureau will be integrated into the Center. NSC envisions the Center as having a broad range of functions which will enable the company to better respond to its customers, to establish more direct ties and information exchanges with academic institutions and other companies, and to adopt more readily to the internationalization of research work.

(iii) Construction period: It is scheduled for completion in June, 1991.

6. Problems to be Solved in the Future

As projects for regional development in Japan have started just recently, it seems too early to evaluate them. However, with the cooperation of the private sector, the educational institutions, the government, and academics and businessmen, it seems that regional development activities are steadily getting off the ground. In order to further develop these activities, it will be necessary to promote large-scale resort development and convention service industries according to geographical conditions, and construct regional economics with software and hardware in harmony.

The transfer of technological development to regional areas, as explained in this paper will not only diversify industries but also diversify consumption patterns in regions. This will contribute to the development of regional cultures.

In doing so, the important point is not to apply what has been planned and has developed in metropolitan areas, such as Tokyo, to regional areas in the same form, but to plan and promote technological development which makes use of the unique characteristics of the region. It is said that the Japanese are people of a homogeneous race or culture, and that they are apt to think or act in the same way. To develop a truly affluent country for the 21st century, it is an important task to promote regional development which makes full use of regional characteristics.

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COMMENTS ON SCIENCE AND TECHNOLOGY AND REGIONAL DEVELOPMENT IN JAPAN

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This paper makes brief comments on the Technopolis plan. In particular, my remarks reflect on the Technolopolis plan, as presented in the Kimikazu Matsuyama paper in this volume, "Science and Technology and Regional Development in Japan."

My first comment is on the importance of capable research leaders in the establishment and promotion of research organizations. In Japan, following the 1985 implementation of the "Law for the Facilitation of Research in Fundamental Technologies", the Japan Key Technology Center (Japan Key-Tec) was founded as a center for the overall promotion of private-sector research and development of fundamental technologies. One of Japan Key-Tec's services is to provide up to 70% of capital investment in private-sector R&D companies, jointly with other companies.

For example, in the Kansai district, the advanced Telecommunication Research Institute International (ATR) was established. ATR has 4 research companies and all four companies are capitalized by many companies and Japan Key-Tec. Perhaps most important the Nippon Telegraph and Telephone Corporation (NTT), Kokusai Densin Denwa Co., Ltd. (KDD), Japan Broadcasting Corporation (NHK), and the Radio Research Laboratory of the Ministry of Post and Telecommunications sent capable talent to these companies to serve as directors.

Also, in Sendai, the Intelligent Cosmos Research Institute (ICR) was established and has 3 research companies, such as the Small Power Communication Systems Research Laboratories and Amorphous Magnetic Device Laboratories associated with it. Famous academic research leaders, Dr. Jun-ichi Nishizawa and Dr. Tsuyoshi Masumoto from Tohoku University, played very important roles in the establishment process.

The activities of such research and development companies are, in my opinion, strongly affected by the foresight of their research leaders. Many companies were eager to join and send their researchers in these two cases. This demonstrates the importance of research leadership.

My second comment is directed at development of municipal research institutes and experimental stations. Regional private-sector research organizations will not necessarily contribute directly to regional industries

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because research and development are often driven to be competitive in a world-wide context. On the contrary, regional colleges and universities, and municipal organizations such as the Industrial Research Institute, Agricultural Experiment Stations and Forest Experimental Stations can play more important roles as direct promoters of regional industries. However, because of the promotion system of municipal organizations, research specialists tend to become managers as they go up the seniority ladder. Thus a "two ladder promotion system", which is commonly found in private-sector organizations, could be installed to promote research and development in such organizations.

Lastly, it may be necessary to further develop National research institutes which have a strong influence on municipal research institutes. A more abundant governmental budget for this purpose may become necessary.