"A Science and Technology Center for Puerto Rico: Preliminary Feasibility Study"
Prepared by the Center for Energy and Environment Research, University of Puerto Rico, San Juan, Puerto Rico, January 1984. CER X-181

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"Contents"

"A Science and Technology Center for Puerto Rico: Preliminary Feasibility Study"
Executive Summary:
This is a preliminary feasibility study intended to set in motion the process that will culminate in the establishment of a Science and Technology Center in Puerto Rico. As such it is exploratory rather than exhaustive, tentative rather than conclusive. It presents options and recommendations for further analysis and refinement and suggests a mechanism to undertake these tasks.

Among the several key assumptions underlying this report, two stand out and serve as a guide in the discussion of the central theme and related topics. The first one is that it is essential, if not imperative, that Puerto Rico develop a science and technology capability of its own. And second, that the proposed center is feasible at this time and could play a major role in the development of an indigenous scientific and technological base for Puerto Rico. To be effective in the pursuit of its goals and objectives, a Puerto Rican Science and Technology Center must take

Taking into account local conditions, needs, and demands, it should have a multidisciplinary orientation and a broad institutional base. This is to attract the support of various meaningful sectors of society, such as government, industry, the academic and scientific community, professional associations, and civic/cultural entities. To sum up, as stated in the recommendations: A Science and Technology Center will help develop a scientific and technological base in Puerto Rico that will contribute significantly to economic development, create employment opportunities for skilled personnel, and help stem the brain drain that is depriving Puerto Rico of some of its best talent. The substantive sections of this paper discuss questions and issues relevant to the establishment, funding, and operation of a Science and Technology Center in Puerto Rico.

Experiences with other such centers in the United States and elsewhere are reviewed, as are the institutional framework, management options, and scope of activities. By and large, a center could be operated and funded by the government (federal, commonwealth, or combined), the private sector, or the academic community (public and/or private universities). With respect to the scope of activities, it should cover a broad spectrum, which could be subsumed under the three main headings of basic and applied research, training, and technical assistance and technology transfer. The activities of the center would be concentrated primarily in Puerto Rico but should also extend to the broader Caribbean and Latin America, specifically regarding technical assistance and technology transfer. Each of these options and possibilities is discussed at some length in the body of the report. This being a preliminary study, it is conceived as a point of departure toward the stated ultimate goal. Hence the recommendation that a Founding Board of no more than nine members, representing the various sectors concerned, be set up to conduct an in-depth study of the pertinent problems.

"Needs, questions, and issues arise as we make appropriate recommendations for the establishment and operation of a Science and Technology Center for Puerto Rico. The aim is for it to become operational by the middle of 1985.

INTRODUCTION

This document is designed to be a working paper to explore options for the establishment of a Science and Technology Center (SBTC) in Puerto Rico. Puerto Rico ties between two worlds. It is part of the United States federal system, but at the same time is also part of the Caribbean and Latin America.

As a result of forward-looking leadership and Operation Bootstrap launched in the 1940s, Puerto Rico is not typical of developing countries. It has an industrial base and free access to the United States market. It is the recipient of significant transfer payments and tax benefits from the federal government. However, it cannot yet be called a developed country.

1.1. Whatever form the ultimate relationship between Puerto Rico and the United States may take, it is essential that Puerto Rico develop an indigenous science and technology base of its own. Perhaps the most important reason is that any society which strives for development must nurture and maintain a science and technology capability, a necessary, though not sufficient, cause of development.

1.2. A second reason for the establishment of a Science and Technology Center here is Puerto Rico's potential for taking advantage of the various technological revolutions now going on—the creation of a single "information industry," the incorporation of microprocessors into existing equipment, robotics, lasers and fiber optics, etc. These revolutions have already spawned a host of new products suitable for manufacture in Puerto Rico because of their high value per unit weight and because they require a better trained labor force than low wage countries can provide. However, to take full advantage of this opportunity will require the upgrading and transformation of our educational system. A Science and Technology Center in Puerto Rico could..."

Help with 1. An earlier study views educational improvement as the vehicle for science-technology development: Committee on the Scientific and Technological Base of Puerto Rico's Economy, National Academy of Sciences-National Research Council, Science and Technology in Support of the Puerto Rico Economy, Washington, D.C., February 1981.

Teaching personnel and at the same time serve as an important promotional tool and attraction for the "new tech" industry.

1.3. Third, an expansion of science and technology capabilities will breed new, often unforeseen, opportunities. Consider for example the explosion of the bioengineering industry following the recent strides in the basic genetic sciences, advances in the computer industry following the development of the silicon chip, or the changes in many products with the advent of the microprocessor.

1.4. Fourth, as already noted, research centers tend to attract technology industries. There are numerous examples of this. The Harvard-MIT nexus has attracted many new industries. Similarly, "Silicon Valley" is in part a function of its proximity to Stanford and the University of California at Berkeley. Support industries have developed around the national laboratories. A well-known company, ORTEC, provides instrumentation for Oak Ridge National Laboratory (and the rest of the world). These industries are desirable because they tend to be profitable, employing well-educated and well-paid staff.

1.5. And fifth, the development of a science and technology capability could help stem the "brain drain" of some of Puerto Rico's best-trained and educated people because of the current lack of opportunities or opportunities which are under-challenging or underpaid. While Puerto Rico is beginning to retain many of its talented and well-trained people and while the private sector is staffing positions with a greater proportion of Puerto Ricans, a Science and Technology Center could generate even more opportunities for management, technical and engineering jobs.

1.6. In

In summary, we believe that an enhanced science and technology capability can immensely benefit Puerto Rico, its people, its economy, and therefore its future. There are several non-exclusive avenues Puerto Rico can adopt. These include greater emphasis on science and mathematics education from preschool through graduate studies; financial inducements to “high-tech” industry through tax and other mechanisms; local support for export industries; and a Science and Technology Center (SARE).

1.7. Science and technology centers can take on numerous identities and roles. They may engage in R&D, provide pedagogical services, operate information search centers, provide laboratory facilities, establish standards, operate museums, and so on. One purpose of this document is to explore that range of possibilities.

This document is divided into five sections. The first is this introduction. The second presents an overview of a variety of science-technology centers in the United States and elsewhere, and the lessons they may provide Puerto Rico. Third, we consider whether such a center should be affiliated with government at the federal or Commonwealth level, be associated with one or more

universities, or whether a private, non-profit entity might be created. There are pluses and minuses to each.

Fourth, the range of services, mandates and roles such a Center could assume are considered. Should it engage in basic science research, as the multipurpose national laboratories in the United States do? Should it compete with private industry? Should it provide specialized services to government, or to the private sector?

And fifth, we explore the “territorial scope” of the proposed center. Should it serve just Puerto Rico, or should its activities encompass the Caribbean, Latin America, small island states worldwide, and so on?

1.8. The sixth and final section offers a set of recommendations derived from the discussions of the first five. In essence, it asks three questions: * Should a center be established in the...

Near future? Yes. What management model, mandate, and territorial scope are recommended? Further study is required. How should the process get started? Set up a Founding Board of no more than nine people from government, the private sector, and universities conversant with the needs and problems of Puerto Rico. To establish the center, ask this Board to help provide the answers to the second question. We are convinced that Puerto Rico would benefit from a science-technology center. It is expected that this preliminary study will serve as a primer as we come to understand the best form that such a center should take.

LESSONS OF EXISTING SCIENCE AND TECHNOLOGY CENTERS

This section briefly explores the background, structure and operation of some existing basic and applied science and technology centers in the United States and elsewhere which might provide institutional lessons for the development of such a center in Puerto Rico. Science and technology centers are operated by a variety of entities, e.g., 1) government, 2) the private sector, and 3) universities. Some of these are hybrid; others evolved from one form of management to another.

2.1, Government managed institutions in the United States include various defense laboratories. By and large, however, management of government science and technology laboratories has been undertaken by contractors. Examples of government-owned-contractor-operated laboratories (GOCO) include Oak Ridge National Laboratory, operated at present by Union Carbide Nuclear Corp., Argonne National Laboratory, operated by the University of Chicago, and the Solar Energy Research Institute (SERI), operated by Midwest Research Institute. Most of the national laboratories and other agencies have had both a basic and applied scientific and technological focus. Of the national laboratories, perhaps only SERI has had an almost exclusively "applied" orientation. It is important to remember that, though many national laboratories and other

Agencies have supported basic scientific endeavors. However, most of their "applied" focus has been either on defense-oriented research or on energy. There are some important exceptions to the rule. The Tennessee Valley Authority (TVA) has been an important innovator not only in energy and flood control, but in agriculture and fertilizer technology as well. Not only did TVA develop the multi-purpose dam; its Muscle Shoals, Alabama, facility is the world leader in fertilizer research. TVA is an example of a federal agency (albeit an unusual one in several regards) which does its

own in-house research and development and plays an active role in the dissemination thereof throughout the United States and the world.

A second exception is the Synfuel Corporation, which constitutes an attempt to apply private sector management style and expertise to joint government-private sector projects. The need for federal management and capital stems from the perceived technical, environmental, financial, and other complexities associated with a risky, long-term venture. Third, the National Aeronautics and Space Administration (NASA) is clearly a government-funded and managed science and technology effort in an area until recently not attractive to private investment. NASA utilizes its own employees as well as a plethora of contractors to meet its specific goals. There are other important exceptions (e.g., NOAA), but two final examples have been aimed at the grassroots.

The first is the U.S. Agricultural Extension Service. Its agents are generally located at State land-grant universities. They engage in applied agricultural research appropriate to their region and have an outreach function as part of their mandate. They provide direct technology transfer from government and university to farmers and other agricultural workers.

The second is a variety of U.S. Department of Commerce programs, including the Business Services and Technology Commercialization Centers. These centers provide assistance in the

Development and marketing of potential new products span from technical evaluation and engineering through finding appropriate financial assistance. The federal government also stimulates science and technology via grants and contracts. The National Science Foundation (NSF) is foremost in supporting basic science and technology. Mainly providing assistance to universities, NSF promotes basic scientific research from science to applied policy analysis.

One NSF initiative to stimulate exchange between industry and academia is the University-Industry Cooperative Research Center. Recognizing that the value of scientific research in universities and technical innovation in the industry is often lost on each other, and coupled with the relative decline of the United States as a major scientific technical innovator amidst sagging economic conditions, institutional mechanisms are sought to co-stimulate science and technology.

Currently, there are ten active university-based centers receiving NSF support. It is anticipated that this number will increase. As these and future Centers become more self-supporting through their interactions with industry, NSF funding will decline. One center at the Massachusetts Institute of Technology is now self-supporting.

There are limited examples of state-operated applied research institutes. One notable example is the New York Energy Research and Development Agency (NYERDA), which provides grants and other assistance to researchers. Several states now seek to promote "high tech” industries in part by emulating the "Silicon Valley" in California and other spin-off industries.

One interesting example is the Tennessee Technological Corridor (TTC). Proposed by Governor Lamar Alexander, the TTC, located on a major artery between Oak Ridge and Knoxville, aims to take advantage of the combination of Oak Ridge National Laboratory, the Tennessee Valley Authority, the University of Tennessee, as well as the already existing “high-tech” industries.

Technology for Energy Corporation. With direct state government support, environments conducive to high tech industry may develop. Mexico's National Council of Science and Technology (CONACYT) provides a very interesting model for countries and regions with a developing scientific-technological infrastructure. In such an environment, a former director general of CONACYT states, "The political decision to develop science and technology requires shifting a considerable share of the government's expenditure to education and research." See Edmundo Flores, "Science and Technology in Mexico--Toward Self-Determination," Science 219 (March 25, 1983), pp. 1398-1401.

Over a long period, to promote a greater scientific and technological base in Mexico, CONACYT has promoted education through scholarships. It has developed links among industry, the scientific and technological communities, and the government through its National Indicative Program. Industry is assisted through the Shared Risk Program with joint funding to reduce private sector risk. CONACYT has aided in the establishment of more than twenty centers and has provided funding to expand those already existing.

Many other governments intervene directly in the development of science and technology. As already noted, some of these methods include support for education, establishment of research centers, outright grants to academic and private sector researchers, and direct participation in science-technology efforts. There are also indirect methods, which need only be mentioned in passing here. Some of these include development of favorable tax environments, support of joint or cooperative private sector R&D, and direct purchase of technology.

Private sector management of science and technology is an important element. Generally, the private sector supports applied research development and engineering designed to result with some probability in new or improved products. Many, usually large, firms maintain their own research and

Development capacities are crucial. A large number of smaller high-tech firms base their existence on a limited product line. They must also maintain ongoing research and development efforts. Some of these smaller firms may become industry leaders and grow to a considerable size. Consider, for example, IBM in computers, Polaroid Land in instant cameras, Xerox in reproduction, and so on.

1. Flores, p. 1398.
2. Ralph E. Gomory, "Technology Development," Science 220 (May 6, 1983) pp. 576-586.

There are a number of private research firms ranging from very small standards laboratories to Underwriters Laboratories. In addition, very important work is done at industry laboratories such as Bell Labs, whose work often includes basic research in areas of potential interest to the firm. Firms may also pool resources to establish joint research entities. Because of antitrust legislation in the United States, these efforts are often limited to regulated monopolies. Examples include the Electric Power Research Institute (EPRI) in California and the Gas Research Institute (GRI) in Chicago.

Currently, there are a number of bills in Congress, including one supported by the Administration, to ease the antitrust constraints on R&D undertaken in the private sector, to redefine the limits of

acceptable collaboration, and to minimize penalties for restraint of trade. Such pending legislation could have a profound impact on the structure of private sector science-technology efforts by U.S. firms.

Two trends are emerging in the industry-university nexus. First, the Stevenson-Wydler Technology Act of 1980 (PL 96-480) mandates federal support for industry-university cooperative efforts. In addition, many corporations are now partnering with universities to focus research efforts on mutually beneficial areas. Examples are the Center for Integrated Systems at Stanford University, corporate funding at Carnegie Mellon and Purdue Universities to study robotics, and Monsanto's agreement with Washington University.

University to Focus on Proteins and Peptides. The industry has not only begun to become a major supporter of university research, but it is also participating directly in that effort. Innovations in molecular biology, as well as other areas, have led to the creation of numerous "spin-off" industries. These generally occur when university or government researchers develop commercially exploitable technology or knowledge. Examples range from DNA laboratories and policy consulting firms to electronics corporations.

This often results in a shift in research focus from basic science to applied technology and management arts. Lastly, attention must be given to the consulting industry. This industry ranges from the one-person offices to corporate giants like Arthur D. Little and Bechtel. The range of expertise and interests varies, but each contributes to technological innovation on an "on-demand" basis, serving both private industry and government.

2.3. Universities participate in the SAT effort in a variety of ways. In some disciplines and for some individuals, the individual approach is preferred. Others engage in joint research, sometimes employing scores of graduate students. University centers may be formed to engage either in highly specialized or multidisciplinary research. There are also research organizations which lie outside formal university lines.

An early example of this is the Stanford Research Institute, now SRI. SRI is no longer part of Stanford University, but a private entity employing many members of the Stanford faculty as consultants. Another interesting example, still within the organizational umbrella of its universities, is the Research Triangle Institute (RTI) in North Carolina. RTI is a not-for-profit organization founded in 1958 by Duke University, North Carolina State University, and the University of North Carolina at Chapel Hill. It performs contract research. Its clients include government, commercial and industrial interests, and not-for-profit concerns. RTI is now

The text is entirely self-supporting, although it did receive a start-up grant of $500,000 and has been the recipient of equipment and other grants from the State of North Carolina and other donors. For more on RTI, refer to Luther J. Carter's article, "Research Triangle Park Succeeds Beyond Its Promoters’ Expectations," published in Science 200 (June 30, 1978), pp. 1469-1470.

RTI maintains a 26-member board, thirteen of whom are representatives from its parent institutions. The RTI president is an ex officio member, while the other twelve are drawn from the business and professional communities. Its regular staff now exceeds 900 persons, housed in fifteen buildings.

The research program is divided into four major groups: (1) chemistry and life sciences, (2) energy, (3) engineering and environmental sciences, and (4) social and statistical sciences.

A noteworthy example is the East-West Center in Honolulu, Hawaii. Created by the Mutual Security Act of 1960, this federally-funded organization is associated with the University of Hawaii. Although it is independent of the University, it answers to a non-profit public corporation established by the State of Hawaii. The U.S. Department of State also has a legislative mandate to oversee the Center, which has sometimes led to ambiguity in lines of authority. Its focus is on Asian-Pacific relations of all kinds-- anthropological, educational, linguistic, cultural and scientific-- between the United States and Pacific Basin countries. It awards approximately 1800 grants per year to individuals from within the region for study, training, and research.

In conclusion, there are a wide variety of systems in government, the private sector, and the university to manage science and technology. Some are mission-oriented, others emphasize basic research. Some provide funding, others engage directly in the process itself. The appropriate model for Puerto Rico will depend on the decision made, the scope of the institution, its reach, and its role. After considering the...

Various science and technology centers might be useful to examine more closely, such as CONACYT in Mexico and the Research Triangle Institute. Although neither is precisely suited to Puerto Rico's situation, both offer potential models that could be adapted locally. A hybrid model between CONACYT and RTI might provide the institutional framework and dynamism necessary for the development of a Puerto Rican center. A not-for-profit organization with ties to the university system is one recommended model. Recognizing that Puerto Rico will face many of the same challenges as Mexico, the Mexican experience could be useful in establishing and operating the Puerto Rican center.

III. ALTERNATIVE MANAGEMENT AFFILIATIONS FOR THE CENTER

This section addresses two questions:

First: Should a Puerto Rican Science and Technology Center be affiliated with the government (Commonwealth or U.S.), the academic community, or be a private entity?

Second: What organizational form should it take?

3.1. Affiliation

Association with the government, academic community, or the private sector would provide a Science and Technology Center with differing sets of opportunities and impediments.

3.1.1. There are two key advantages to a federal relationship, similar to that of the East-West Center in Hawaii. Such a center would have a solid financial base as it would be included as a line item in the federal budget. In the case of the East-West Center, this has provided the stability which allows for long-term planning and program development. The federal relationship, if ambiguous, may lead to institutional frustration. However, a federal relationship is likely to protect the institution from local political pressures. In a politically intense environment such as Puerto Rico's, some

insulation could guarantee institutional independence, even existence. There are several significant drawbacks to a federal center, however. First, because policy would originate in Washington,

The center might not be responsive to local needs, requirements, and interests. Secondly, the center might not be enthusiastically accepted by local or regional governments, businesses, or scientific/technical institutions, especially if it were perceived as an instrument of U.S. foreign policy. Some may feel professionally threatened by an entity over which they have no control. Others might perceive a center as a source of professional or business competition.

There is a third drawback, closely related to the last considered. A Center of Science and Technology in Puerto Rico could be defined as a Caribbean regional entity. It may or may not provide as wide a range of services in the Caribbean as it would in Puerto Rico, but it almost surely would have a regional presence. Many Caribbean states are newly independent, and even the not-so-new ones are experiencing strong nationalistic sentiments. Rightly or wrongly, such sentiments oftentimes take on an anti-imperialistic flavor. That can be translated as opposition to U.S. (or other metropole) intrusion in their internal affairs.

A Center funded and sponsored by the U.S. government might be seen as a possible vehicle for such interference. Lastly, a federally funded center would indeed be subject to changing federal policies. Such policies may have significant impacts on a federal science and technology center in Puerto Rico. Would, for example, such a center be free to participate in activities involving Cuba or Nicaragua? Could the center work with United Nations agencies which include these countries?

In sum, while there are certain advantages, there are also serious disadvantages to a federally funded Science and Technology Center in Puerto Rico. There are equally valid reasons both in favor and against the establishment of a Puerto Rican government-sponsored Science and Technology Center. It could be more responsive to local needs and more able to respond to government policies to promote...

Industry or to coordinate with private sector efforts to build a "high-tech" infrastructure in Puerto Rico. Such a center would also directly and indirectly create employment. Stimulation of the science and technology sector could contribute significantly to the growth of a well-trained, well-paid workforce. It would provide opportunities for Puerto Ricans who have found it necessary to leave the Island to fulfill their career expectations.

At the same time, the perception of a Commonwealth-sponsored center in the rest of the Caribbean could be more positive than that of a federal one. Great care should be taken to select a director well-respected throughout the region. This would make it more difficult to accuse the center of being a mere extension of American foreign policy, and should make program development and coordination much easier.

There are several potential difficulties associated with Puerto Rican government sponsorship. These include: (1) the susceptibility of the center to local, changing politics; (2) constraints on manpower development imposed by government wage and other administrative guidelines; (3) such a center might be inadequately responsive or flexible to industry needs; (4) it may not be able to act with sufficient speed because of bureaucratic difficulties; and (5) would a government-run center be able to garner adequate trust from both the industrial-commercial and academic sectors?

3.1.3. An industry-sponsored center can provide assistance to its industry sponsors. Some industry groups have taken advantage of pooled resources to develop research facilities. Good examples are the already mentioned Electric Power Research Institute (EPRI) and the Gas Research Institute (GRI). These tend to be industry-specific. However, these centers can work well but there are drawbacks. A research center serving more than one enterprise could encounter antitrust problems. Those problems may be relieved by proposed federal legislation. Even so, a research center of

This sort might be responsive to only a limited industrial scope, performing, for example, research in pharmaceuticals to the exclusion of all other sectors. A consequence of such limited scope would be a research center unlikely to be responsive to new and emerging industries and possibly unable to assist processes on the edge of development. Moreover, such a center might not be inclined to support or engage in basic research, since it would have an inherent preference for applied research.

Finally, as the child of industry, a science and technology center would be entirely reliant on its parents for funding. That would further tie its mission to the short-term interests of management. It might also render the center more sensitive to economic downturns.

3.1.4. A fourth alternative is to place a science and technology center within the institutional structure of the state university system. There are four important advantages to this approach. The first is that much of the talent and facilities a science and technology center would draw upon are already available within the university. Second, because of the broad interests of faculties and graduate students, a university housed center can maintain a general orientation. Third and closely related, there would be no constraints built into its mandate. Fourth, because of an almost universal tradition of academic freedom and independence from government coercion, university-based centers may be in a better position to provide outreach functions outside of Puerto Rico.

There are equally persuasive objections to university centers. One of the more important is the inter-jurisdictional jealousies within and among universities. A decision placing a science and technology center at the University of Puerto Rico, for example, could result in objections from the major private universities on the island. Within the UPR system, other but similar problems could result. Which campus should house it? Will any specific department dominate it? Will

Does the center director answer to the Rio Piedras or Mayaguez Campus Chancellor, or to the President? Secondly, most large universities have developed long-standing procedures. These have been developed to generally support undergraduate education. As commendable as these goals are, the regulations that support them often conflict with the pursuit of other academic objectives. Therefore, pedagogical procedures may hinder the work of a science and technology center within the university, which is bound by university rules and regulations.

A third significant problem is whether an organization based in a university would be acceptable to the private sector and government. University faculty often have significantly different priorities than their peers in industry and government. This could lead to conflicts between academic and "real" timetables, or the fulfillment of one agenda over another. Academics are often accused of using

research as a training ground for graduate students, contributing to missed deadlines. Lastly, there is often a distinction drawn between the "real world" and the "ivory tower." Those outside the academic world sometimes perceive the academic's work as ephemeral and possibly interesting, but with no immediate impact on the "real world."

3.2. Four possible forms for a Science and Technology Center for Puerto Rico have been considered. While each has positive attributes, they also have several negative characteristics that may render them ineffective. An alternative model that should be considered is the Research Triangle Institute (RTI) in North Carolina, which has already been mentioned. RTI is not a model that could be entirely adopted in Puerto Rico, but it provides guidance. One advantage RTI has over the four models described above is that it is not constrained either by governments or the parochial interests of any particular industrial group. It can draw upon the human and laboratory resources of its parent organizations when needed.

Needed. Yet, it has its own dedicated research staff and facilities unconstrained by the teaching needs of the three universities. A Science and Technology Center for Puerto Rico should be a not-for-profit organization and could take several forms. It could stand alone, independent of 211 other organizations. Or it could be associated with an already existing organization. Whatever its faults, the university system would probably provide the best umbrella organization for an S&TC in Puerto Rico. One alternative is to have its board directly answerable to the Council on Higher Education (CHE). As CHE bridges both the public and private higher education systems, neither system would be favored to the detriment of the other.

Association with CHE would also provide a Science and Technology Center the institutional stability and credibility it will require in its start-up years. Should it be found desirable later on, the center could follow the example of SRI, formerly Stanford Research Institute, and move from the university system into the private sector.

Housed under CHE, the S&TC could take several forms. It is premature to prescribe the form, partly because the question of center mandate has not been decided. Moreover, this form should be the responsibility of its Founding Board. The question of mandate is discussed in the subsequent section. Some thought on the proposed center's board follows.

Clearly, the board must represent the constituencies the Science and Technology Center would seek to serve. These are the private sector, government, and universities. Representatives should be invited from both large and small enterprises, and from those headquartered both in Puerto Rico and elsewhere. This representation should include industrial, commercial, and financial talents. The various professional organizations, e.g., Camera de Comercio, Colegio de Ingenieros, Asociacion de Industriales, etc., should be asked to participate. Government must also be asked to participate. Perhaps certain

Seats on the board should be reserved on an ex officio basis. For example, positions could be held by the Administrator of Fomento, the Secretary of Commerce, the Director of the Governor's Office of Science and Technology, etc. Additionally, representation from the federal government might also be considered. Perhaps one island-based and one Washington-based individual could serve.

In the same vein, university systems should be represented. There are several potential candidates

for this, including the President of CHE, the President of UPR, other university presidents, chancellors, and distinguished members of the science and engineering faculties.

Finally, public interest representation should also be considered. This could be sourced from a variety of areas including service organizations, churches, civic groups, unions, and other community groups. The extent of participation should depend upon the "public impact" of the center. The greater the impact, the greater the need for public participation.

The method of choosing the composition of the board is highly dependent on the form, role, and institutional placement of the Science and Technology Center. However, it is possible to broadly outline the areas from which participation is deemed necessary.

IV. ALTERNATIVE CENTER MANDATES AND ROLES

There are a variety of functions which centers for science and technology perform and that such a center in Puerto Rico could perform. This section explores several of these alternative functions.

It should be borne in mind that this list is not exhaustive and science and technology centers could perform any or all of these functions.

4.1. Science and technology centers can assist in the transfer of technology. Technology transfer implies the acquisition of technological knowledge by one group from another. This may occur at universities, through the purchase of patents, from the study of professional journals, and so on. The role of science and technology centers in technology transfer can be diverse.

4.1.1. An

The important technology transfer function of a science and technology center is the cataloging of local talent and facilities. There may exist a wide array of talent and facilities in any locality. If there is no central catalogue, those seeking people with the desired skills have to look elsewhere. No central catalogue exists today in Puerto Rico, perhaps limiting the opportunities of local scientists and technologists to consult with industry.

4.1.2, Science and technology centers can develop or coordinate formal training programs. These programs may include the granting (or assistance in granting) advanced degrees. This is a fairly limited function and is generally associated with university centers or major research museums. A center should, however, not seek to replace the role of the university but to complement it. It should concentrate on training outside the traditional curriculum of the university and it should coordinate with the appropriate faculties whenever possible.

Part of this training activity is often continuing education for the professional. These services are generally designed to improve the already existing skills of practicing professionals. Generally, this function takes the form of short courses or workshops.

One interesting example of technology transfer through training of professionals was developed between the Association of Caribbean Universities and Research Institutes (UNICA) and the UPR Center for Energy and Environment Research. Following the selection of three sites of excellence,

training programs were carried out in solar, wind, and biomass energy to familiarize other Caribbean energy researchers with the state-of-the-art.

Science and technology centers can also provide technical training for technicians in a variety of skill areas. This might include equipment handling, repairs and maintenance, manufacturing skills, and so on. This can be an important function for improving the general skill level of the labor pool as well as providing trained professionals.

Personnel to meet industry demand.

4.1.3 - Another important technology transfer function is the information clearinghouse. There exist several computerized, online databases (e.g., Lockheed, NTIS) which provide abstracts of the scientific and technical literature. Some specialized databanks concentrate on patent information. Upon request, the clearinghouse, through its computer link, can search the files of these various databases. Clients may submit very specific or very general requests for abstracts and quickly receive abstracts of the appropriate literature. This service permits the commercial, industrial, government, and academic specialists access virtually to the universe of information (non-classified) bearing on his/her subject or interest. Parenthetically, data are not limited to the physical science and engineering, but may include business, legal, economics, and social science literature as well. This service would be tied to already existing databases and libraries. No need would, therefore, exist to create these anew.

1. See Juan A. Bonnet, Jr. and Wallace C. Koehler, Jr., "Development of Alternative Energy Science and Engineering in the Caribbean," IT Simposio Interuniversitario de Energia, Proceedings, Vol. 2, Santiago de Chile, November 1983, pp. 15-28, 23.

4.1.4 - Scientific or technologically oriented museums and zoos serve as mechanisms for a more general, public form of technology transfer. Some, like the American Museum of Science and Energy in Oak Ridge, Tennessee (formerly the American Museum of Atomic Energy) maintain elaborate outreach facilities. Many museums have joined together by forming the Association of Science and Technology Centers. The ASTC assists museums in program development and similar functions.

4.2 - A second function of science and technology centers is to provide technical assistance. This can be provided in several ways.

4.2.1 - One important technical assistance function a Science and Technology Center in Puerto Rico could provide is...

Performance is the adaptation of technologies to conditions in Puerto Rico and the Caribbean. For a variety of environmental (e.g., increased insolation, salt, heat, etc.) or cultural reasons, some technologies require modification or adaptation before they function optimally. A science and technology center with experience in the region could provide the expertise to help make such modifications. Moreover, processes sometimes profit from modification. Rather than calling in outside talent, industry could solicit assistance from the center.

In a similar vein, the existence of a center with technology modification and adaptation skills might

attract and help establish new industries. Some industries might be reluctant to enter Puerto Rico or the Caribbean unless there is adequate infrastructure to service their needs. A science and technology center could contribute to the infrastructure by providing both facilities and a skilled labor force. New industry, in turn, would create new, well-paid employment. At the same time, the center could assist in the evaluation and development of local inventions and technical modifications.

There are examples of such centers. The U.S. Department of Commerce has funded several Technology Commercialization Centers through its Minority Business Development Program, including one in Ponce. Similarly, the Canadians have established industrial innovation centers. Each of these centers will evaluate the technical as well as commercial merits of inventions. If they deem inventions meritorious, the centers will assist in their development and testing, seek to secure venture funding, and so on.

Thirdly, a science and technology center could provide consultation in quality control and process control to a wide variety of industries in Puerto Rico. This service would most likely assist smaller concerns, for the larger ones are more likely to have that service in-house. The center might also provide product certification. Similarly, the center might provide test function.

Standardization, equipment calibration, and other highly specialized services are provided to the industry in Puerto Rico and throughout the Caribbean. There is a wide array of technical services that a Science and Technology Center (S&TC) might perform.

Science and Technology Centers engage in research, development, demonstration, and at times, dissemination (RD&D). Some of these functions are subsumed under outreach assistance or adaptation. Research can be an important function of Science and Technology Centers. It should be borne in mind that in order to conduct research, there must be laboratory facilities. Adequate equipment and facilities already exist throughout the island. An initial responsibility of the center could be to coordinate interaction among these facilities to ensure their most efficient use.

Science and Technology Centers might engage in basic research without overt consideration of its application. This is usually the reserve of universities and national laboratories. S&TCs might more fruitfully engage in basic research only when there is a need to bridge the gap between the current research state and knowledge needed for local applications. Likewise, basic research may be conducted in the same way as it is done at Bell Laboratories. Although there are no explicitly stated goals, general goals are implicitly understood and internalized by the research staff.

The Science and Technology Center might also undertake applied research. This could take two related forms. The first might address areas of general concern, e.g. waste disposal. Waste disposal itself is a complex issue. The center might explore means in general or it might focus on a specific range of problems. For example, it might consider means to manage biological wastes for the pharmaceutical industry in Puerto Rico. More specifically, the Science and Technology Center might focus its talents on specific problems. It might assist a given firm in the redesign of a process, or it might assist in the engineering of some new design.

Product 4.4: There is one final, yet important, function that a science and technology center might perform. It could provide an environment where people in industry, government, and academia could discuss problems of mutual concern, in a general sense, without fear of anti-trust or other

impediments. Thus, it could serve as a locus for the exchange of experiences and observations among and within all three groups.

4.5: In conclusion, there are four major roles a science and technology center can play: (1) applied research, (2) pooling of resources, (3) education and training, and (4) technology transfer. These are not mutually exclusive, but each will require sometimes separate infrastructure and staff to provide the service. Therefore, much thought should be devoted to determining the range of services most appropriate for a Science and Technology Center in Puerto Rico.

V. TERRITORIAL SCOPE

A Science and Technology Center in Puerto Rico could serve any of three geographical constituencies: (1) Puerto Rico, (2) the Caribbean, and/or (3) Latin America. Before deciding what the territorial scope of a Puerto Rican STC might be, it would be useful to consider the range of demand for services and for which services. In part, any decision on scope will depend upon the services provided by the center. Technology transfer through training or abstracting might be appropriate for the entire Latin American region, while some of the research might not be.

5.1: An important consideration to be borne in mind in the formulation of plans for a science and technology center is Puerto Rico's past experience with institutional arrangements for regional cooperation, especially since the launching of President Truman's Point Four Program in which Puerto Rico played an important role. Historically, these efforts have focused on education and training and socio-economic development, primarily but not solely in the Caribbean and Latin America. In this sense, the proposed Science and Technology Center would not...

"Breaking new ground" is not the focus here, but rather building on earlier foundations. 5.1.1. In retrospect, at least seven schemes have been identifiable since the 1940s, when Puerto Rico first reached out to the Caribbean. These include:

(1) The war-time Caribbean Commission established in 1942, which evolved into the Caribbean Organization (1961-1965);

(2) The U.S. sponsored Point Four and its succeeding technical cooperation, educational, and cultural exchange programs;

(3) The establishment in 1957 of the Puerto Rico Nuclear Center (PRNC) as a training center for Puerto Rico and Latin America on the peaceful uses of atomic energy, including nuclear medicine;

(4) The Caribbean Economic Development Corporation (CODECA), created in 1965 as a Puerto Rican public corporation to continue the work of the dissolved Caribbean Organization, including the operation of the Caribbean Regional Library (today under the UPR Rio Piedras general library);

(5) The Puerto Rico-Dominican Republic Joint Commission, established in 1967 to promote closer economic, technical, educational and cultural cooperation between the two countries;

(6) The North-South Center for Technical and Cultural Interchange (1971-75); and

(7) The current Puerto Rico-Jamaica educational and technical cooperation arrangements under the framework of the Caribbean Basin Initiative (CBI).

5.1.2. Only two of the original arrangements (plus the Puerto Rico-Jamaica scheme) are still in existence today. Some of them, like the Caribbean Commission, evolved into something else; others, like the Puerto Rico-Dominican Republic Joint Commission, ceased to exist.

For a thorough review of these and other schemes, refer to "Contemporary Caribbean Issues" edited by Angel Calderon-Cruz (Institute of Caribbean Studies, UPR, 1978). The following two chapters are particularly relevant: A. Ualdestncereny's "Las relaciones exteriores del Estado Libre Asociado de Puerto Rico," pp. 29-60, and L.A. Passalacqua-Christian's "Puerto Rico y el Caribe: Cinco etapas de una relación," pp. 61-61.

The Joint Commission was left to languish and die from inactivity. Others, specifically CODECA and the North-South Center, were liquidated due to partisan political reasons by successor administrations. The two existing entities are the AID-sponsored technical cooperation and educational exchange programs administered by the Commonwealth government, and the UPR Center for Energy and Environment Research (CEER). The CEER, established in 1976 as a successor to the Puerto Rico Nuclear Center, has a redefined disciplinary orientation and research objectives, which include technology transfer activities. Of these, only CEER is a scientific and technological R&D center. The 25-year research and training record of PRNC/CEER would be particularly relevant to the proposed Puerto Rican Science and Technology Center. The longest-lasting and most successful of these efforts have been the aforementioned technical cooperation and educational exchange programs, which started more than 20 years ago and are still ongoing, albeit on a more limited scale. The implementation of these programs has been accomplished through a concerted effort involving all departments and agencies, including the University of Puerto Rico and such units as the Institute of Labor Relations, the School of Public Administration, and the Institute of Caribbean Studies, as well as various departments and specialized units of the Medical Sciences Campus and Mayaguez Campus (particularly agricultural sciences). Since the inception of these programs in 1950, about 40,000 people from all over the world (some of whom went on to become ministers, ambassadors, and heads of state) have visited Puerto Rico. This federally-sponsored program is still administered by the Commonwealth Department of State. The most recent exchange program was started in 1982 with the government of Edward Seaga in Jamaica. It is mainly funded by the U.S. under the Caribbean Basin Initiative and coordinated by the Puerto Rico Department of State. This is primarily an educational program.

Technical exchange program which involves several local government agencies, among them Forento and the Department of Education. At least one unit of the UPR System—the Mayaguez Campus—is providing technical assistance and training in agricultural sciences to Jamaican personnel. The Jamaica program is specifically conceived and run in the context of the CBI as a Puerto Rican contribution to regional development.

5.1.3, Apart from and preceding the CBI, the UPR has been a promoter and active participant in educational and technical development activities in the Caribbean region through the Association of Caribbean Universities and Research Institutes (UNICA). The UNICA-UPR link has afforded the Center for Energy and Environment Research an opportunity to exchange with Caribbean institutions and government agencies state-of-the-art knowledge and technological know-how in alternative energy sources. UNICA's Science and Technology Commission has undertaken several

meaningful projects. For example, under joint sponsorship of CEER, UNICR and NSF, from December 1981 to June 1983, three alternative energy workshops were held—on wind energy in Barbados, December 1981; on biomass in Puerto Rico, April 1982; and on solar energy in Florida, June 1983—with ample participation of personnel from UNICA member countries.

5.1.4, The University of Puerto Rico System is especially equipped to undertake initiatives in designing, establishing, and operating a science and technology center to primarily serve the needs and interests of Puerto Rico. However, it also has an external component that would facilitate the sharing of scientific and technological knowledge and advances through cooperative arrangements with Caribbean and Latin American countries. And within the UPR System, such units as CER, the various professional schools and research institutes of the Mayaguez, Rio Piedras, and Medical Sciences Campuses could play specific and key roles in the overall effort.

5.1.5, In summary, the proposed Puerto Rican Science

The Technology Center should include an external component. The nature and scope of such a component, as well as its subject areas of activity and its funding sources, are subject to analysis, refinement, and recommendation by the S&TC Founding Board.

5.2. Understanding that geographical scope is a function of center roles and services, it might be best to begin in Puerto Rico with a defined set of services and functions, without attempting at first to provide those same services throughout the Caribbean or Latin America. Instead, a selected set of services might initially be offered on an appropriate basis. For example, the center might act as an information clearinghouse or provide technical assistance to individuals, but not seek to support the Pan American industrial establishment. With experience, a better understanding of its enhanced role could be developed.

5.3. The establishment of a science and technology center might also provide a vehicle for cooperation with similar centers. The Puerto Rican center might establish links with, for example, the Caribbean Industrial Research Institute in Trinidad and Tobago or the proposed Technology Research Centre in Jamaica. In this fashion, the shared experiences of all may work to the mutual benefit of each.

5.4. An SRTC with a mandate to reach out into the region might also serve a larger institutional role. There have been periodic proposals to establish a North-South or Hemispheric Center, modeled after the East-West Center in Hawaii. In fact, the same legislation establishing the East-West Center (Mutual Security Act of 1960) contained a provision for a North-South Center (see Section II of this paper for further reference to this point). A North-South Center for Technical and Cultural Interchange, created in 1971 under Puerto Rican legislation, was abolished four years later after a brief and somewhat ineffectual existence. (See references cited in footnote on page 27.) Should a North-South Center be re-established, the Science and

The Technology Center could assume the science and technology responsibility of the larger entity and essentially become a division of the larger entity. Alternatively, it could expand to assume larger functions, with science and technology becoming a major division.

5.5. The experiences of Puerto Rico have applications beyond the Caribbean and Latin America. There are a large number of subtropical and tropical islands in the Pacific and Indian Oceans.

Some of these, such as Mauritius, are independent states, while others are dependencies of other states, such as Guam and the Marianas. Therefore, the impact of Puerto Rico could have wide-ranging consequences.

5.6. The geographical mandate of a Science and Technology Center should not be confined to Puerto Rico. However, no attempt should be made to impose a set of international functions on the center. Instead, the range of services should evolve and be dependent on user demand. Similarly, there should be no restriction on the geographical outreach of the center, limiting it to the Caribbean Basin. There are a variety of other constituencies, i.e., small islands worldwide, that the center might also serve.

6. RECOMMENDATIONS:

6.1. A Science and Technology Center should be established because it would help develop a scientific and technical base in Puerto Rico. This, in turn, would contribute to economic development, create employment opportunities, and help stem the "brain drain."

6.2. Two possible models for a Science and Technology Center in Puerto Rico are considered:

6.2.1. University-associated, answering through a board to the Council on Higher Education.

6.2.2. An independent not-for-profit institution answering solely to its board.

6.3. The range of services a Science and Technology Center could provide is broad. These services should largely be determined by demand.

6.4. The geographical scope of the proposed Science and Technology Center (STC) should not be limited. However, consideration needs to be given to the range of services which might be provided outside.

Puerto Rico, to the Caribbean Basin, Latin America, and elsewhere.

6.5. A blue-ribbon Founding Board should be established to explore the relevant issues and make appropriate recommendations.

6.5.1. The Board should consist of no more than nine members drawn from government, the academic community, and the private sector. Possible candidates for the Founding Board might be:

-President of the University of Puerto Rico

-Administrator of Fomento

-Chief executive officers of major industries

-President, P.R. Association of Independent Colleges and Schools

-President of a banking institution

-President of the Chamber of Commerce

-President of a professional organization

-A member from the scientific community

-President of the Puerto Rico Manufacturers Association

-Director, Governor's Office of Science and Technology

6.5.2. The Center for Energy and Environment Research of the University of Puerto Rico (CEER) could provide staff support and secretariat services to the Founding Board.

6.5.3. The Founding Board would be asked to consider the format the Science and Technology Center in Puerto Rico should take by reviewing the need and demand for services. The Board should recommend the format the S&TC should take and the services it should offer after studying the structure and operation of similar centers in the United States and elsewhere, particularly in Latin America.

The Founding Board should address several fundamental questions, among them:

(1) What is the center for?

(2) How is the center to be established?

(3) How is the center to be managed?

(4) How is the center to be funded?

(5) Other items they might deem relevant.

6.6. Upon recommendation of the Founding Board, the Puerto Rican Science and Technology Center might seek start-up funding from the government of Puerto Rico, industry, and other sources. The Board could explore the appropriateness of using "936" funds as well as private foundations. Although the center should be established as a not-for-profit organization, it should be self-supporting after a certain period.

Period of three to five years.

6.7. The following timetable is recommended for the development of the proposed Puerto Rican Science and Technology Center:

- Refers to provisions of Section 936 of the U.S. Internal Revenue Code, providing special investment incentives to U.S. corporations doing business in Puerto Rico.

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- Obtain financial commitments no later than April 1984 for the establishment of the Founding Board in order to fund its activities.
- Prepare a final report by December 1984 in the form of a proposal for submission to government or foundations.
- Submit a request for start-up funding. Initial funding should be operational. The center should identify and employ already existing structures and facilities in Puerto Rico and should therefore not require new equipment or infrastructural funding.
- Identify and appoint a director and recruit staff.
- Start operations by June 1985.

6.8. One final caveat. The center must secure broad support from as many sectors as early as it can. This is essential in order to provide the best possible service to Puerto Rico as well as to ensure its initial acceptance.

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