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9. ABSTRACT

To assess the effectiveness of industrial research institutes in the developing countries, the world body of literature was reviewed and many such institutes were visited. In general, the institutes are not nearly as effective as they could be. Their main purpose is to stimulate and assist development and growth of private and public industrial enterprises in their countries. The chief reason why most such institutes are not performing this function very well is a lack of communications and interactions between the institutes, industries, the development banks, and government units. There is need for much more exchanges of views among these entities concerning their needs, capabilities, problems, priorities, etc. Industry, government, and development banks need to development mechanisms for maintaining a two-way flow of people, so that they can better understand the institute's potential for contributing to industrial growth and economic development. Institutes must acquire or train staff members who are experienced and interested in industrial problem-solving, and who are willing to go into the industrial environment to seek problems, learn about industry's planning, and relate these to the capabilities of the institute staff. Progress in solving these problems is being made at many of the institutes. However, the mechanism of using expert consultants who provide advice and counsel to institute directors is often not effective. The experts make a brief visit, offer advice, leave, and do not make follow-up visits to assist in the process of implementation. In all too many countries, industry is apparently not interested in using the services of research institutes. However, if institutes will follow the approach used by the Singapore Institute of Standards and Industrial Research (SISIR), such industrial reluctance can be overcome. That approach involves pursuing a course of aggressive and frequent industrial contacts, and providing

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services consonant with industry's needs. Formal linkages between advanced-country and developing-country insitutes, established around specific programs and training activities conducted for several years, are most important aids to improving industrial research institutes in developing countries.

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The Industrial Research Institute in a Developing Country:

A COMPARATIVE ANALYSIS

Agency for International Development
Washington, D. C. 20523

THE INDUSTRIAL RESEARCH INSTITUTE IN A DEVELOPING COUNTRY: A COMPARATIVE ANALYSIS

Submitted to

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PREFACE

This report is the result of many inputs from a considerable number of people--institute directors and their staffs, representatives of government entities, development banks, both public and private enterprise, chambers of industry, industrial associations, international assistance organizations, etc. I have not attempted here to record the verbatim comments of these people. Rather, my intent has been to present an overview of the situation and conditions which relate to the functioning of the industrial research institute within the microcosm of forces and constraints peculiar, with varying degrees, to the developing countries.

There are some who argue that a report of this nature should be an exposé of institute successes and failures. Indeed, I have talked frankly with many of the directors of institutes that I know, who are quite candid in recognition of their internal and external problems. I am of the opinion, however, that revelations of this type will not necessarily solve similar problems elsewhere, and can lead to unkind criticism which is unwarranted. Therefore, I have elected to generalize, in many instances, the problems that I have seen. This is not to say that these are invalid as a consequence, but rather that they are synopsized to meet several related situations.

I am pleased to gratefully acknowledge both the moral support and the financial support provided by the Director and staff, Office of Science and Technology, Technical Assistance Bureau, U. S. Agency for International Development. Similar thanks are due to the USAID Missions in the developing countries that I visited.

Also, it is important to recognize the patience which my wife, the Director of DRI, and my own staff in the Office of International Programs have demonstrated in the face of my continued procrastination in completion of this report.

James P. Blackledge
August 1975

CHAPTER 1

INTRODUCTION

Background

It has not been my intent, during the course of this study, to elaborate upon the rationale that led to the establishment of industrial research centers in many developing countries. Libraries are crowded with reports of this nature, prepared by far more eloquent authors. Perhaps a quotation by Dr. B. H. Singh of the CSIR, India, eloquently summarizes LDC interests in technology:

> In the developing countries, science and technology are looked upon as the means of the improvement of the lot of the common man. Unless science, technology and development are related to the basic problems and needs of the country in providing better employment opportunity and living conditions in the villages where proverty is at its dire extreme, the common man is likely to lose faith in the good that science and technology can do. The major problems of India and perhaps of the other developing countries are unemployment and underemployment, large population and galloping rate of its increase, low income, undernourishment and malnutrition, poor agricultural practices and production, insanitary villages without healthy drinking water or disposal arrangement for refuse, poor and inadequate housing, inadequate communication facilities by way of roads, lack of electricity in the villages, lack of school buildings and educational facilities for children and every other demonstrable evidence of proverty.[1]

Suffice it to say that it became clear that indigenous technological capability and exploitation of foreign technology could be important to industrial growth and economic development. For example, Dr. Paul Rosenstein-Rodan has stated: "In accordance with studies conducted in industrialized developed countries it has been possible to show that 60 percent to 80 percent of the improvement in the standard of living can be traced to technological progress and only 20 percent to accumulation of capital."[2] Therefore, technology could be viewed as a key factor in development, which should either be

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[1] B. H. Singh, Remarks to Seminar on "Generation and Diffusion of Adaptive Technologies to LDCs," East-West Center, Honolulu, Hawaii, October 4 to 6, 1972.

[2] Economic Development and Technological Progress with Special Reference to Technology Transfer, Round Table on Scientific and Technological Development, Comité Interamericano de Educación, Ciéncias, y Cultura (CIECC), Lima, Perú, February 8 to 12, 1971.

generated internally in a nation or transferred inwards as soon as possible. Thus, developing country governments established industrial research or technological institutes, usually patterned after Western Europe or United States models, and then sat back to await the anticipated "harvest of technological impact" on their development process.

The idea seemed to persist that the research services of such technological centers would automatically be sought by contiguous industrial private and public sectors. It was visualized that contributions of these research centers would be directly and immediately applicable to the nation's economy through:

1. Exploitation of internal natural resources to replace or reduce imported raw materials or commodities;
2. Conduct of R&D which would substitute or replace imported technology, and which would strengthen the existing national industrial base; and
3. Creation of new processes, products or technologies from which would stem a number of new industries capable of meeting country domestic needs, increasing employment, and contributing to increased export commodities into the world market.

What then has happened in the intervening fifteen to twenty years since inception of these industrial research centers? Has there been a "harvest of technological impact?" Have the research centers met the needs of their contiguous industry? Have the research centers been able to solve industry problems? If not, why not? Are the research centers instruments of industrialization--or ivory towers, out of contact with the real world?

The general consensus seems to be that success with respect to the above questions has been marginal at best! Dr. Harrison Brown, former Foreign Secretary, U. S. National Academy of Sciences, has commented:

> As the role of science and technology in the development process is better understood, a point of weakness looms; the limited capacity of developing countries to organize research and apply it productively.[3]

The directors and senior management staffs in many research institutes themselves have questioned the accomplishments of their institutes, in accordance with their goals and objectives, which have actually been achieved. They are constantly searching for ways in which to improve their interaction with the private and public sectors. More importantly, they are attempting to assess, evaluate, and make more effective the technological and innovative contributions which their institutes can make to the industrial growth of their countries.

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[3]Harrison Brown, Research Management and Technical Entrepreneurship: A U. S. Role in Improving Skills in Developing Countries, U. S. National Academy of Sciences, Washington, 1973.

Perhaps with the passage of time, the research institutes have drifted away from their original goals, due to disappointments in lack of industrial support, low morale because of lack of staff incentives, inability to identify what national needs and national problems really are.

It should be noted that this process of self-assessment and search for better methodologies is by no means new; such deliberations have been key issues during UNIDO conferences on industrial research institutes--Beirut, 1964; Athens, 1967; Bogotá, 1971; Copenhagen, 1971; in the course of the WAITRO* Biennial Meeting in France in 1972; in a variety of workshops developed jointly between the U. S. National Academy of Sciences and developing country counterpart organizations.

General Scope of IRI Problems

Some problems inherent in the process of interaction between the industrial research institute and the clients it is intended to serve are, in actuality, beyond the control of institute management. I refer to barriers and constraints imposed because industry is often unsophisticated, or has little experience or understanding of the value and importance of technical problem-solving in improving their products or processes. There are also barriers which stultify incentive on the part of staff members: sub-marginal civil service salaries; a reward structure that recognizes meritorious performance on a par with mediocre performance. There is often little or no potential for training or upgrading of staff so that these will become innovative in their thinking, aggressive in their contacts with industry, and imaginative in the solution to industrial problems which they identify. Then, there are a variety of government interventions which relate to institute funding mechanisms, incentives for R&D utilization by industry, import subsidies, export tariffs, etc. All of these, and others, bear directly on the problem of interaction between research centers, public enterprise, and industrial sectors.

Now, the charters or codes which created such research centers in general have been focused more on research, and service to industry, with its practical connotations, has usually received less attention. In my personal view, this latter function should receive principal attention by the industrial institutes and, in most cases, can be shown to be more nearly in consonance with industries' needs. As

*WAITRO (World Association of Industrial and Technological Research Organizations) was organized in October 1970, and currently has 87 members. One of WAITRO's prime objectives is to improve the dissemination of information about industrial research institutes throughout the world and to facilitate exchange of ideas, sharing of problems and experiences, and to coordinate programs of a regional or global character which may benefit its members.

the U. N. Advisory Committee on Application of Science and Technology to Development has pointed out:

> The effective provision and use of research services are key elements in the scientific and technological development of industry. Such services may include, but not be limited to, technical information services, techno-economic studies, pilot plant and semi-commercial development work, industrial standards and specification surveys, and testing and quality control services, in addition to bench-type research.[4]

Unfortunately, many institute staff members and a considerable number of experts and consultants tend to disagree with such activities, particularly with regard to demonstration plant operation and semi-commercial development activities. One is left with the impression that operation of demonstration plants is "unprofessional" and that development corporations should undertake such tasks.

Even when research is undertaken, this should be largely adaptive in nature, thus capitalizing on the know-how and methodologies for utilization of technology already available in other developing or advanced countries, rather than to attempt innovative research which quite possibly will result in "re-inventing the wheel." And yet, during the course of visits to more than fifty industrial research centers, I have observed tremendous duplication of effort, valuable undoubtedly as a training technique to provide indigenous skills and experience, but costly in terms of replication of already available technology and diversion of scarce manpower from more urgent, unsolved problems.

Obviously, this replication clearly delineates the need for an effective communication network among research institutes, perhaps initially on a country or regional basis, but ultimately as a global network. This suggests the additional provocative proposal. Is it possible to tie research institutes into networks which are integrated around regional or global problem-solving, with a sharing of people and facilities, exchange of ideas, providing a resource for training, specialized centers of expertise, etc.? I believe that such an approach is feasible as well as highly desirable. The Denver Research Institute is conducting an experiment of this nature on a limited basis; six institutes in Africa and Latin America are involved, concentrating on conversion of agro-industrial wastes into animal feed supplements by fungal digestion.

The reports emanating from the above-referenced workshops, seminars, etc., have seemed to infer that industrial research institutes in developing countries suffer from a shortage of modern management skills, planning for the future, promotion and program development, internal project evaluation and fiscal controls. Most institute directors recognize these as urgent needs and are actively

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[4] "Appropriate Technology and Research for Industrial Development," United Nations Publication No. E.72.II.A.3, New York, 1972.

seeking opportunities to obtain practical technical and management assistance in these areas. Yet, their comments to me (and certainly confirmed in the course of a WAITRO survey of priorities[5]) reveal that the more serious problem relates to difficulty in "selling" research results or research services to a potential industrial user. The WAITRO study showed that industrial exploitation of R&D results and training in industrial applications of R&D shared the priority one and two spots, along with industrial training of technical personnel, as the most important and urgent need of the institutes surveyed. I have continued to observe a surprising degree of uniformity in the similarity of this problem, influenced perhaps by the level of country technological sophistication, but nonetheless a recurring problem to nearly all research institutes.

A host of additional problems beset the managers of developing country research institutes. Some of these derive from the fact that expert consultants arrive for the short-term, pass along advice and counsel without full appreciation of political, cultural, and other related but non-technical aspects of the industrial research institute's particular and often peculiarly constrained operational modes, and leave to survey and advise yet another research institute. All too often, attempts are made to cast the developing country research institute into the mold of advanced country institutes, again without due consideration to levels of industrial sophistication and recognition by industry of the need for technical assistance. A pattern of repeated and continuous follow-up, in my view absolutely essential to proper provision of technical assistance, seldom occurs.

A plethora of papers, documents, reports, etc., in the world body of literature gives advice to the research institute director and his staff on the "how to do it" of logical planning, of successful interaction with industrial clients, of mechanisms for staff development, etc. The goal of the United Nations suggests that developing countries increase their expenditures on R&D and endeavor to attain, by 1980, a minimum average level equivalent to 0.5 percent of the GNP, as compared with an average expenditure of 0.1 to 0.2 percent of the GNP at the present time.[6] But how does this type of information directly influence the research institute manager in his day-to-day operational functions, or assist him in "long-range planning?"

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[5] Priority of Needs of Industrial Research Institutes in Developing Countries, Publication No. 3, World Association of Industrial and Technological Research Organizations, Vancouver, Canada, pp. 2-3, June 1972.

[6] Appropriate Technology and Research for Industrial Development, A Report of the Advisory Committee on the Application of Science and Technology to Development, United Nations Document E. 72. II. A. 3, New York, p. 22, 1972.

Similarly, the World Plan of Action[7] projects a need for an average 15 percent per annum growth rate in developing country research and development expenditures during the decade of the seventies, and discusses the need to recruit 400,000 new scientists and engineers! But the research institute manager is already beset with severe problems of how to recruit skilled people in competition with industrial needs and much higher salaries. A parallel problem has to do with how to retain good people, if he is fortunate enough to attract them to his institute.

Within the context of the above, it must be seen that increased expenditures alone are not going to solve the problems. Drastically new and innovative approaches and tactics must be devised--for training, for problem identification, for innovation and incentives for the use and application of R&D, for means of effective interaction among the government planning bodies, the development banks, the private and public industrial sectors, the universities, the industrial research institutes, and other related segments of the developing countries.

The developed countries must marshall and adapt their extensive experience in research and technical management to provide appropriate guidance, management counsel, and technical assistance which are germane to the above. As Harrison Brown has stated so succinctly: "We are not as aware as we should be of the cultural and other constraints that impede the assimilation of technology by developing countries."[8] Lord Blackett, in his introduction to a most valuable book by Graham Jones, commented that: "...in recent years important advances in understanding have been made, both in the DCs and in the LDCs, of just how the process of innovation takes place--meaning by the word 'innovation' the whole process from scientific discovery or invention to the final emergence of a marketable product, or a social service."[9]

It is extremely important to identify just where in this process of innovation the developing country research institute must focus its efforts. Should the institute attempt to be all-inclusive in its activities? Should the institute become involved in practical implementation of research results? In my view, major emphasis should be exerted at the product end of the innovation process, but this is a viewpoint only infrequently shared by many of my colleagues in industrial research institutes.

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[7] World Plan of Action for the Application of Science and Technology to Development, United Nations Document E.71.II.A.18, New York, pp. 56-57, 1971.

[8] Research Management and Technical Entrepreneurship, op.cit., p. 2.

[9] Graham Jones, The Role of Science and Technology in Developing Countries, Oxford University Press, London, p. ix, 1971.

Parenthetically, it is pertinent to note in this respect that the United States Government is concerned by the lack of utilization of R&D by American industry. As a consequence of this, a program has been established by the U. S. Department of Commerce and the National Science Foundation to study experimental incentives which will motivate industrial use of R&D. This five-year program is intended to find ways in which the U. S. Government "...can stimulate the development, fabrication and marketing of new products and processes for consumption by private industry, individuals, and public service institutions leading to increased national productivity, an improved balance in international trade, greater employment opportunities, and the enhancement of the quality of life of all citizens. The program is supporting a series of experiments and studies to determine ways in which governmental action can affect the innovation process and, from these experiments and studies, derive alternative strategies for increasing the conversion of new or underutilized technologies into socially and economically viable products, processes, or services."

The program statement goes on to say: "...it is assumed that innovation is inhibited by a variety of barriers such as inadequate capital, lack of appropriate information, or poor marketing strategies, and that these barriers, at least in part, can be surmounted by incentives originating in the policies and operations of the Government."

Understanding gained from a study of this nature could provide valuable background for the establishment and provision of practical and appropriate technical assistance to developing country research institutes. We also must begin to realize that tactics for implementation of technical assistance to, say, the Singapore Institute of Standards and Industrial Research, may not be at all applicable to, for example, the Federal Institute of Industrial Research in Nigeria. Some developing countries have a stronger technological base than others. Some are more technologically advanced. Some countries have industries that are becoming skills-intensive, while others are still attempting to generate labor-intensive activities.

This is not to say that the problems of the various institutes are so dissimilar, but rather that the approach to the solution of these problems must stem from a thorough understanding of the political, cultural, and economic considerations as well as availability of human resources and knowledgeability regarding industrial needs. At best, experiences with one institute can only serve as guidelines in establishing relationships and providing technical assistance to another. Dr. Harold E. Hoelscher, former President of the Asian Institute of Technology, has pointed out that: "While the argument favoring development through technological change is not, on the surface, clear by analogy, the attractiveness of industrialization is very real and more a matter of when and how, than if. Thus, there is an urgent need to understand the cause-and-effect relationship between industrialization and technological change within the context of the developing countries (of Asia). We need to understand the existing industrial systems and the potentials of industries

to be developed from or by technology in terms of the existing socio-economic systems of these nations as to so guide and speed the process of their rational technology-based development."[10]

A brief comment about linkages between institutes is appropriate here, although the topic is sufficiently important to receive considerable emphasis in a later chapter. Earlier, I alluded to the importance of continuity in providing technical and management assistance and the follow-up so essential to assure that progress is occurring in appropriate directions. Perhaps no tactic for providing both assistance and follow-up can be more successful than through creating linkages between an advanced country research institute and a counterpart institution in a developing country. Notable examples are: the Battelle Memorial Institute linkage which created the Korea Institute of Science and Technology (KIST), the linkages between the Denver Research Institute and the Instituto Centroamericano de Investigación y Tecnología Industrial (ICAITI) in Guatemala, the Instituto de Pesquisas Tecnológicas (IPT) in São Paulo, the Instituto de Investigaciones Tecnológicas (IIT) in Colombia, the Pakistan Council of Scientific and Industrial Research (PCSIR), and the Nigerian Federal Institute of Industrial Research (FIIR), and the linkage between ICAITI and Instituto Dominicano de Tecnología Industrial (INDOTEC).* Such linkages provide opportunities for two-way flow of people, rapid assistance for a variety of problems, exchange of technical and "how to do it" information, and conduct of R&D projects of mutual effort. The developing country institutes benefit materially from such an arrangement, particularly when they are able to point out to potential industrial clients the backstopping services available from their linked partner. Also, technical assistance and other services can be achieved much more rapidly and effectively through a DC-LDC linkage than is possible directly from the various international assistance agencies.

Objectives of the Study

I initiated this study of selected multi-purpose industrial research institutes in a few developing countries in early 1970, with the hope that a pattern of operational characteristics, similarity of problems, and a uniform approach to technical assistance--a comparative analysis of these institutes--would emerge. The purpose behind this effort has been to provide relevant information which will help research institute managers and their senior staffs achieve stronger programs of interaction with industry, through sharing the experiences

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[10] Private communication.

*ICAITI was retained by the Banco Central of the Dominican Republic to design plant facilities, specify organizational requirements, and provide management and technical assistance to INDOTEC during its initial period of operation.

and problems of other developing country institutes confronted with similar situations. Further, it has been my hope that the study will assist interested persons, institutions, and organizations in the advanced countries to better understand the unique although complex problems facing the developing country institutes, and thus devise more appropriate and meaningful programs of assistance.

The objectives of the study, simply stated, have been to:

- Analyze a variety of approaches to industrial research which have been tried;
- Identify those factors which have contributed or inhibited effective coupling of industrial research institutes with industry and developmental interests;
- Differentiate between those types of constraints to development of viable institutes which are country-specific and those common problems which have limited the value of these institutes regardless of their geographical location.

During the course of the study, some 50 research centers in 20 countries have been visited for periods ranging from one to several weeks. In many instances, more than one visit has been made in order to obtain additional information, observe organizational and other changes, etc. In the case of institutes in Brazil, Colombia, and Central America, close working relationships have existed with the directors of these institutes, dating back to 1968.

Selection of the institutes to be visited was based on prior knowledge as well as available information regarding these centers and discussions with representatives of USAID, UNDP, UNIDO, the OAS, the World Bank, the Interamerican Development Bank and others. The selection process was particularly influenced by representative differences in modes of origin and financial support and in levels of country technological capability. Since it is impossible to evaluate an institute without examining its interrelated microcosm, representatives of development banks, government ministries, chambers of industries, universities, etc., were interviewed to the extent possible.

Classification of IRIs

It is difficult to classify the institutes that I have visited in other than a rather arbitrary matrix, since almost without exception, the institutes receive government financial subsidy (I distinguish between institutional subsidy and contracted services with government agencies, a common mechanism for support in the United States). I also have taken some liberties in the classification utilized, categorizing, for example, the Indonesian Ministry of Industry research institutes as a research institute system, although these could also have been included under civil service institutes. Also, while my original plan contemplated only multi-purpose institutes, I have elected to include some single-purpose institutes who are diversifying in order to meet local or regional changing needs, as well as a few

applied research centers in universities, particularly where these are aggressively seeking contracted services support from industry. Classification of these research centers is shown in Table I.

I must emphasize that this study and comparative analysis are far from complete and the study will continue although at a less rapid pace. I regret that I have not been able, to date, to visit every technological institute in every developing country, but time and financial constraints have made this impossible. It is particularly important to note that research institutes in Eastern Europe, many of which are strong and viable, have not been included in this study, nor have the institutes of the Arab States and Israel been included, although there is every reason to believe that these should be. It is likewise impossible to include here other than cursory comments regarding the Indian Council of Scientific and Industrial Research. This great system of technological institutes is extremely large and complex. Thirty-four separate research units--national laboratories, institutes, regional laboratories--along with 65 field stations, operate under the CSIR umbrella and are located at various sites throughout India. In addition, there are 14 research association laboratories. It would be naive indeed to attempt to assess the abilities and experiences of the CSIR without considerably more time for such a purpose. Hopefully, such an in-depth survey of the CSIR can be undertaken at an early date.

I should also emphasize that the observations and opinions expressed herein are my own, although certainly influenced by the multitudinous number of conversations with colleagues, institute, government, and university representatives, with satisfied as well as unsatisfied institute clients. I anticipate that some of my comments will be controversial--not only to the managers of developing country research institutes who need assistance, but also to the institutions and organizations in advanced countries who might be expected to provide assistance.

It is appropriate, at this juncture, to quote from my good friend, colleague, and mentor, Dr. Lawrence W. Bass who, in a paper which summarizes his extensive knowledge of technological institutes, has commented:

> Study of the management of institutions in many developing countries... leads to the conclusion that there are several directions for improvement. If they are to live up to their potential as unique sources of technology for local industry, they should strive toward this ideal: an autonomous multipurpose organization with techno-economic competence, deriving some funds from public sources for non-sustaining activities such as service to small enterprises, but rigorously oriented toward direct service to the industrial community.[11]

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[11] Lawrence W. Bass, "The Role of Technologic Institutes in Industrial Development," World Development, Vol. I, No. 10, October 1973.

TABLE I

Classification of Selected Developing Country Industrial Research Institutes

Government Corporations

Center for Research and Development (CEPED)
Executive Commission for the Economic Recuperation of Cação Region (CEPLAC)
Technological Center of Minas Gerais (CETEC)
Technical Institute of Rio Grande do Sul State (CIENTEC)
Applied Scientific Research Corporation of Thailand (ASRCT)
Institute for Industrial Development (INDI)
Research Institute for Estate Crops (BPPB)
Marmara Scientific and Industrial Research Institute
Nuclear Reactor Center (NRC)
Building Research Institute
Metals Industry Research and Development Center (MIRDC)
Venezuelan Institute of Scientific Research (IVIC)

Separately Incorporated Institutes

Shri Ram Institute for Industrial Research (SRIFIR)
Institute for Technological Research (IIT)
Singapore Institute of Standards and Industrial Research (SISIR)
Korea Institute of Science and Technology (KIST)
Foundation for the Development of Scientific and Technological Research (FICITEC)
Institute for Industrial Technological Research and Technical Standards (ITINTEC)
International Rice Research Institute (IRRI)

Regional Institutes

Central American Research Institute (ICAITI)
East African Industrial Research Organization (EAIRO)

University Applied Research Centers

Bandung Institute of Technology (ITB)/Institute for Industrial Affiliation (LAPI)/Development Technology Center (DTC)
Middle East Technical University (METU)/Organization for Applied Research (OAR)
Monterrey Institute of Technology/Institute for Industrial Research (III)
Asian Institute of Technology (AIT)

Government Civil Service Institutes (State and Federal)

Federal Institute of Industrial Research (FIIR)
National Institute for Scientific and Industrial Research (NISIR)
National Institute of Technology (INT)
Institute for Technological Research (IPT)

Laboratory for Materials Testing and Technological Research (LEMIT)
Institute of Food Technology (ITAL)
Institute of Standards and Industrial Research of Iran (ISIRI)

Research Institute System

Council of Scientific Industrial Research (CSIR)
Pakistan Council of Scientific and Industrial Research (PCSIR)
National Institute of Industrial Technology (INTI)
National Institute of Science and Technology (NIST)
Indonesia Institute of Sciences (LIPI)
Institute for Industrial Research and Training (LPPI)

Perhaps it is also appropriate to conclude these introductory remarks with the observation that many changes in organizational hierarchy and operational practices are occurring with such rapidity that it is difficult to keep abreast of these changes. This is particularly true in Brazil, where the major research centers have been, or are, acquiring a nearly autonomous separate corporate status, with attendant increased management flexibility, instead of civil service status which largely stultifies incentive and opportunity for meaningful industrial interaction. It would seem that after more than ten years of struggling with overwhelming problems, several of the more aggressive institutes are beginning to demonstrate how it should be done.

CHAPTER 2

THE NATURE AND PURPOSE OF INDUSTRIAL RESEARCH INSTITUTES

Dr. Lawrence Bass* steadfastly maintains that industrial research institutes in developing countries are inappropriately named; they should be called institutes of industrial technology, which more appropriately defines the primary mission in which these institutes should be engaged. Indeed, nearly all of the research institutes in Latin America are so named.

It is not at all uncommon, for governments whose countries are in an initial stage of development, to establish research institutes with the hope that these will assist to hasten the development process. As a governmental entity, the institute is able to initiate programs of interest to its staff; what is usually missing is an effective mechanism for establishing direct contacts and interacting with industrial associations, private and public enterprise, etc. I am inclined to believe that the often disappointing contributions of the developing country research institutes may stem, in considerable part, from misconceived ideas--by government, by research institute, by industry--about what the role of the industrial research institute really should be. I also have the feeling that, in many instances, the government entities responsible for nurturing and encouraging their research institutes have not always understood the barriers and constraints, the limitations, the strong impact which governmental intervention policies can have on relevant research institute productivity.

IRI Role in Transferring Technology and Interaction with Industry

In many instances, as will be delineated later, the charter or policy guidance for the research institute may be much too general and leave unclearly defined the exact role which should occur between the research institute and the potential users of its services. Further, with the passage of time, and in the absence of vigilant and frequent assessment of goals and objectives, it is not unusual for an institute to learn that it has, in fact, drifted away from its original mandate. This can occur from a variety of causes: changing staff interests and abilities; availability or unavailability of equipment and facilities, etc. Those institutes largely dependent on contracted services support must of course be in a position to respond to client needs, even though this may stretch or violate the institute's charter. The alternative is lack of financial support of research staff.

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Research institutes are frequently criticized for lack of a long-range plan, but without full understanding by their detractors of all of the implications. These include short-term or changing governments, and the consequent impact on policies toward industry, as well as R&D. Additional constraints are the uncertainties of future direction if major support must be derived from industry. And there is also the problem, prevalent in so many instances, of a communications gap between the research center and its country's national planning process.

It is important to recognize fully the dangers which can result in pursuing the course of providing coverage for all scientific disciplines particularly where staff availability and facilities are subcritical. I believe the positive approach is to select those areas or disciplines which are clearly related now to national and industrial needs and priorities, and focus major attention to these--by providing applied research, but also by agreeing to provide testing, technical information services, techno-economic services, quality control, and trouble-shooting. I recognize that in many instances these activities are regarded as unprofessional, but they do meet the current requirements of industry. There is a widely accepted truism that when industry finds it cannot bring its small immediate technological needs to a research institute, it will seldom consider bringing major problems.

At the same time, and with careful planning and expert leadership the research institutes, as permanent institutions, can become valuable reservoirs of knowledge on the industrial problems specifically relating to the developing country's progress. They also become reservoirs of knowledge about technology from other countries, and with the appropriate mix of skilled and experienced staff members in many disciplines (scientific, technical, economic, administrative) can bring about effective exploitation and utilization of foreign technology.

A prime potential function of the developing country research institute, and one which is not often utilized, is that of scrutinizing technology which is to be imported into the country to determine whether or not it is really the appropriate technology or whether or not the purchaser is being cheated or misinformed in his negotiations with the seller from the developed country. As an adjunct to this, the function of the developing country research institute should, of course, be not only to evaluate such technology but be in a position to modify or adapt this technology to meet the indigenous conditions of the country.

The Government of Argentina, for example, has such a development policy designed to reduce dependence of local industry on imported technology and to stimulate development of indigenous technology. Under the law, all present and future licensing arrangements which involve importation of technology must be registered with the government (this could lead to undesirable controls or constraints). Such licensing agreements are required to meet certain criteria:

- The technology is appropriate and suitable for utilization in Argentina;
- The licensee is paying a fair price;
- There are acceptable or no restrictions on the licensees' market; and
- The licensing fee is based on profits instead of total sales.

The Instituto Nacional de Tecnología Industrial (INTI) is responsible for administration of this program; as an adjunct, INTI has opportunities for more frequent involvement with the industrial sector.

The Government of Mexico, in 1972, passed a law regulating the transfer of technology into that country. The main purpose of the law is to create a promotional mechanism for the importation of better technology and not a restrictive instrument to stop technological flow. The law requires registration of all licenses covering patents, technology and trademarks, and prohibits registration (and thus country acceptance) for a variety of situations which do not favor Mexico or Mexican industry, similarly to those constraints imposed by Argentina.

The Ministry of Science and Technology in Korea is currently contemplating the establishment of an "imported technology" tax for support of development, with, however, tax incentives to industry to compensate for the cost of importing technology, or alternatively, to stimulate development of indigenous technology. Other tax benefits will be provided for product improvement, etc., through the technology transfer process. KIST will be an active partner in such programs, either as an evaluator of the cost effectiveness, applicability to local conditions, need for additional adaptive R&D, or as originator of new technology to meet the needs of industry.

In Brazil, an organization, Institute of National Industrial Property (INPI), exists under the Ministry of Industry and Commerce to review and approve all technology acquired by foreign industry. INPI calls upon various technological institutes to provide assistance in evaluation of the acquisition, technical validity, etc.

The current development strategy of the Government of Colombia places heavy emphasis on exports of manufactured goods to stimulate Colombian growth. Colombia argues that abundant labor is its major resource and that embodiment of this labor in industrial product exports can provide a mechanism for full employment and rapid growth. This goal of an efficient and dynamic industrial sector has in the past tended to be frustrated by use of outmoded, inappropriate, overpriced or otherwise constrained technologies which have prevented Colombian industry from realizing its potential.

The biggest obstacle to the transfer of technology in Colombia is industrial unawareness of the cheapest and best technology available to solve production problems. Assistance is required to help the industrialist identify his technological needs and request aid either in the form of research, information, or credit in order to solve production problems. He also needs to know whether the technology he may wish to acquire is already available in the country, whether undesirable or limiting constraints exist (for example, licensee restriction on free product imports, limits on undertaking modifying research), etc.

Colombia currently has significant government supervision in the area of transfer of technology from abroad. A Royalties Committee within the Ministry of Economic Development must approve all contracts for the importation of foreign technology covered by royalties, commissions, trademarks and patents for which payment is to be made in foreign currency. Currently the committee operates largely to prevent excessive pricing of, and restrictions on the use of, foreign technology, but the committee

clearly has the potential to become more directly involved in the determination of appropriate technologies for Colombia.

A second agency, the Foreign Trade Institute (INCOMEX), is responsible for approving all requests for imports of capital equipment. To a significant degree, this process has involved a determination of whether the technology embodied in the equipment is appropriate for Colombian circumstances and rejection of requests where they appear to be excessively capital-intensive.

Both COLCIENCIAS (Fondo Colombiano de Investigaciones Científicas y Proyectos Especiales) and IIT (Instituto de Investigaciones Tecnológicas) should provide active participating inputs to the above process. To date, however, their contributions have been less than desired. A concerted effort is now underway to bring these several entities into more effective interaction.

Evaluation of IRI Contributions to the Development Process

There seems to be a serious lack of reliable statistics, comparative results and other indicators which might be used as yardsticks against which the research institutes can evaluate themselves. True, one can count patents, or publications, or processes on the shelf waiting to be reduced to commercial utilization. One indicator frequently used points, for example, to the percentage of the gross domestic or gross national product being devoted to in-country R&D which may somehow or other relate to industrial growth but does not really reveal the impact of the research center on industrialization. Research institutes in the United States are alleged to be effective contributors to U. S. industrial growth, on the basis of continued contract R&D support (even though in most instances the Federal Government provides contracted services support in the amount of 60 to 70 percent of the institute's budget). Even so, the U. S. National Science Foundation and the Department of Commerce are concerned about the barriers and constraints which impede more effective utilization of R&D in an innovative manner. These government agencies are supporting a long-term intensive effort to better understand the mechanisms which impede full industrial use of R&D.

The World Plan of Action, pointing out that in most developing countries adaptive industrial research is not yet attained or is of little significance in industrialization programs, estimates: ". . .less than one percent of Pakistan's industrial programme has been based on the technological research carried out under the auspices of the Council for Scientific and Industrial Research."[12] But the question must be raised: compared with what? How much Pakistan industrialization is indigenous? How much has resulted from multinational corporations? In contrast to the World Plan statement, Dr. M. Aslam, Director of the PCSIR Karachi Laboratories, has pointed out that: "It (PCSIR) has been able to lease out over 250 small- to medium-size processes, more than half of which have already gone into private commercial production. The total productivity of the processes actually in production is estimated at US$3.3 million per annum, compared with US$10 million in research expenditures,

[12]World Plan of Action, op. cit., p. 177.

with a recurring annual foreign exchange saving of about US$425,000. The annual revenues accruing to the government in the form of sales taxes, excise duties, etc., from these processes is somewhere in the range of $200,000 to $300,000. This figure could have probably been ten times as much had infrastructure for scaling up of these medium-sized industries been established in the country."[13] The Korea Institute of Science and Technology (KIST) estimates that its R&D programs have resulted in a savings to the Korean Government of about $20 million. Does this take into consideration some $22 million for institution building provided by the Governments of Korea and the United States?

According to Science magazine: "Latin America imports about 95% of its manufacturing technology. . . At the beginning of the 1970's, Argentina, Mexico, and Colombia each spent about twice as much on outside technology as they spent on their own R&D establishments. . . the figures for Brazil are about equal. By comparison, France, West Germany, and Japan each spent 6 to 10 times as much on their own R&D as on foreign know-how."[14]

There is a great deal of emphasis being placed on mechanisms for evaluation of industrial research institutes and much concern is expressed about the interaction of these institutes with the other sectors which relate to the total industrial development of a nation. At the same time, it is almost impossible to evaluate the research center alone without giving equal consideration to the effectiveness of interaction of the development banks, the industrial sector, the government agencies, and the government enterprises with the research institute. In other words, an evaluation must take place involving all facets of the total industrial complex.

When one undertakes to appraise the role or the contributions of an industrial research institute, the tendency is to evaluate the extent to which technology was transferred by the institute as well as to estimate the value of this transfer to the institute's contiguous society. But, as yet, no satisfactory criteria have evolved for evaluating the real economic effects of technological transfer activities. One inherent problem is that technological transfer cannot be considered complete until the new technology, or a modification of it, is put into practice, either by public or private enterprise, or as a socially viable contribution. This is a lengthy and involved process most often requiring ten to fifteen years from conception of an idea to adaptation to practical utilization.

Dr. Bass suggests that: ". . . the ability to attract client-supported projects is one of the most significant measures of direct service to industry and a guarantee that the results will be used in industry."[15] However, until this ability is transferred into an action-oriented program, the "measurement" must be adjudged to be qualitative a best.

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[13]M. Aslam, "Present Status of Industrialization and Science and Technology in Pakistan and Future Requirements for Effective Utilization of Advanced Technology," Proceedings of the International Seminar on Dissemination of Technology, KIST, November 1972.

[14]Science, Vol. 181, p. 42, 6 July 1973.

[15]Industrial Research Institutes, Guidelines for Evaluation, United Nations Publication No. E71.II B.22, New York, p. 2, 1971.

It has been suggested that: "...the extent to which technology has been transferred by an industrial research institute can be identified and measured via the changes in sales of goods and services and/or in costs of companies which have received services from the institute."[16] Hopefully, in some manner, by inclusion of estimates regarding the upgrading of products, services, labor, or working environment leading to increased sales or decreased cost, one could determine an institute "contribution factor" which, subjunctively at least, might represent judgment concerning the importance of the contribution of the research institute's services to the improvements attained by an industry in its operations. In my interviews to date, however, I have found these to be extremely difficult factors to estimate. Industry is reluctant to release cost data, particularly relating to increased profits. In most instances, the institutes themselves seldom know what the cost of their own involvement has been, particularly in those institutes totally or principally supported by government funding.

The utilization of "contribution factors" can be criticized also because of the often lengthy gestation period involved in application or utilization of new technology. It should be recognized that the current role of an industrial research institute may be significant even though no end results in terms of process or product development have as yet been achieved; consideration must be given to anticipated results, within the appropriate time frame. All too often, however, the end-result approach to evaluating an industrial research institute has contributed to the frequently expressed opinion that such institutes in emerging countries have had, thus far, little impact on industrialization.

There is usually insufficient use by research managers of input-output and cost-benefit analyses in the selection and management of research projects. Economic, marketing, political and other factors are often overlooked or set aside in favor of technological feasibility. In many instances, consideration as to the potential uses of the R&D (if indeed there is one) is neglected until considerable effort has been particularly important where internally sponsored projects are underway, not only from the standpoint of potential future accountability, but also to assure that such projects are relevant to real world national or regional needs and not merely an interesting research activity. These, which are exceedingly important internal evaluation techniques, do not depend, for the most part, on outside "contribution factors."

The barriers to transfer of technology are not just technical in nature. Factors such as politics, financial risk, societal or cultural considerations, legal restrictions, marketing problems, fear of change, and even sheer inertia may impede or block the transfer process and thus weaken or negate its economic effect.

This is not to say that institute appraisal or evaluation should be minimized, but rather that such appraisal must be conducted with recognition of the above factors, many of which are beyond the real control of the institute itself. Further, the evaluation, if properly directed, could lead to restructuring and reorientation of the institute,

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[16] "Technology: Processes of Assessment or Choice," Report of the U. S. National Academy of Sciences, July 1969, p. 29.

clarifying and emphasizing specific areas of work, with the overall objective of more closely aligning the activities and programs and services of the research institute to the needs of industry.

In a manual on evaluation of industrial research institutes,[17] Dr. Bass has suggested the following classification of major types of projects to be evaluated as a measure of assistance provided by the institute to industry and government agencies. These are:

(a) New industrial operations;
(b) National or regional development surveys;
(c) Managerial projects, including feasibility studies, economic analyses, market surveys, engineering evaluations and raw material surveys;
(d) Assistance to small- and medium-sized enterprises;
(e) Studies on industrial operations, including best-practice surveys and quality-control surveys;
(f) Product and process development projects;
(g) Technical service;
(h) Analysis and testing;
(i) Information services, including literature surveys.

Now, compare the above-suggested evaluative points to be examined by an institute and its peers in adjudging performance with the following comments excerpted from Graham Jones' book on The Role of Science and Technology in Developing Countries:

> The Central Asian Soviet Republics, in the 1920's, established a range of functions for research institutes to follow to help industrial development. These were:
> (a) to explore and examine the natural wealth and see how it can be developed;
> (b) to adapt processes to local conditions;
> (c) to develop new processes for working local materials;
> (d) to devise methods of obtaining new products and utilizing the output;
> (e) to raise the efficiency of the operating enterprises;
> (f) to improve quality and devise suitable methods of quality control;
> (g) to elaborate adequate siting and development patterns both for separate projects and entire economic areas;
> (h) to ensure standardization, provide relevant information, etc.[18]

The Director of the Indian Council of Scientific and Industrial Research, Dr. Nayudamma, even more succinctly states:

> The tasks of the research institutes comprise the proper identification and selection of problems in accordance with a ranking of priorities implicit in the choice of these projects relevant to economic growth. The main objectives of such institutions are:

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[17] Industrial Research Institutes, Guidelines for Evaluation, op. cit., p. 23.

[18] V. Duzhenkov, "Central Asian Soviet Republics: A Practical Experience," Science and Industrial Development, USSR Academy of Sciences, Moscow, 1967.

(a) to conduct fundamental and applied research;
(b) to develop know-how for better, newer products, processes and uses, better use of indigenous resources, etc.;
(c) to disseminate the know-how to industry;
(d) to furnish technical consultancy, techno-economic and routine services;
(e) to carry out operational studies; and, in some cases,
(f) to train technical personnel.[19]

The important issue in these several outlines of suggested research institute duties, obligations and responsibilities, as defined by three experts with widely diverse backgrounds, is that, with minor changes in phraseology, any of the above could be nearly a mirror image of the codes or charters or operating principles of most developing country industrial research institutes. In my meetings with research institute directors, the above categories are almost always elaborated, although frequently there is admission that some aspects, such as information services, techno-economic analysis, or promotion of technical assistance to the industrial sector, are lacking. Further, I have seen little evidence that such categories are being evaluated in a systematic, repetitive manner.

Perhaps it is timely at this point to briefly outline some of the problems of proliferation, diversification, and intersectoral competition, all of which can raise basic policy issues within the research institute as well as in various segments of the governments, planning agencies, etc. Certainly, these relate to the future of the institute and to possible redirection or re-emphasis if it is to survive.

Let us assume, for a moment, that an institute is in an initial stage of development. Perhaps it has been spawned from a university system or has been created as a special-purpose institute. Probably the institute has a charter with specific goals. Even if the charter is unlimited in scope, the constraints of equipment and facility limit staff operations to a small area on which the institute wants to bring science and technology to bear. Management requirements for the institute are relatively unsophisticated. Not yet faced are the problems of program development, internal project evaluation, cost effectiveness, government justification.

Usually this honeymoon lasts only a short time before the institute finds itself in an operational stage. Attempts are made to initiate programs with industry. The institute tries to establish joint agreements with the universities. The need is recognized for marketing and economic analysis sections to service the various institute research activities. The government has accepted the concept of a need for an industrial research institute. It is recognized that research institute management is just a little more sophisticated and complicated and difficult to predict. Relationships with industry may exist, but they are not good. Marketing functions are neither good nor bad. The government

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[19] Y. Nayudamma, "Promoting the Industrial Application of Research in an Underdeveloped Country," Minerva, V, No. 3, p. 324, Spring 1967.

does not really understand the need for a research institute but is still (so far) willing to accept the concept. The institute has established contacts for technical assistance and has a number of experts moving in and out of the institute. Several staff members are away in advanced training programs. Sometimes they return to the institute. More often they return to seek employment elsewhere.

Various kinds of other institutes begin to appear on the scene. Consulting engineering firms, who charge a fee, resent a research institute's providing similar services at near zero cost. Other institutes and testing laboratories, sometimes private, often a part of another government ministry, appear on the scene--agriculture, for example, with amission to undertake food-processing development or conversion of agricultural wastes to a useful product. Or perhaps the university decides it too must have a research institute and compete for industrial support in order to gain higher pay for its faculty and perhaps practical training for its students.

Management decisions under such circumstances become entirely different. There is the problem of conservation of human resources, of competition for limited contract support, of justification for existence as an industrial research institute, of possible erosion of the research institute budget as other governmental demands are met.

It is within such a context, then, that the institute director must begin to think of diversification, entry into new fields of endeavor which show promise for contract support or which have been defined as of interest to the national government. But how does one persuade a tenured, civil service employee who has researched into new uses for bagasse for the past ten years--who is comfortable with the extent of his knowledge about bagasse and who has no desire to learn about a new field--how does one persuade that person to shift his emphasis to, say, synthetic fibers? There are probably no salary incentives available--he cannot be fired--there is no money to hire a new person with an interest in synthetic fibers. Must the institute continue research in bagasse while passing up the potentially profitable synthetic fiber business?

The problem becomes even more acute where the institute depends on contracted services for a major portion of its financial support. New area development funds are severely limited or nonexistent. Sometimes aggressive staff members will develop new areas on their own time; occasionally grants are available from international assistance agencies. The ingenuity and promotional skills of the institute director thus become of paramount importance. Under such circumstances, it is appropriate to earmark a portion of the institute's recovered indirect costs to be used specifically for promotion, program development, entry into new areas, etc. The level of funding available depends, of course, on the institute's aggressiveness in selling its services and upon its ability to recover indirect costs. Several different approaches to program development will be outlined in Chapter 6.

No matter where he is in the scheme of institute development, the institute director must make decisions about retraining and upgrading his people. And these are usually difficult decisions because his best people are the ones he wants to upgrade and advance. These are also the people, of course, who are fully occupied, servicing clients. It becomes a very difficult management decision to take good people away from productive work in order to prepare them for productive work of the future.

There is not much that can be done about intersectoral competition (institutes created under the aegis of other ministries or governmental bodies and who enter into competitive or nearly competitive activities). About all a director can do is talk with these people, try to learn their interests, compare these with his own capabilities, and do the best job possible within the extent of his own resources.

But the director does have to worry about the problems of accountability. As representatives of the government become more knowledgeable about research or at least conversant with the phraseology, they begin to ask sometimes rather embarrassing questions about the money being spent and the results to date. The government begins to anticipate a pay-off on its investment in one form or another. The director can face difficulties in defending his request for continued support.

All of these are important management problems for which there are no easy ready answers. But they are problems which most institute directors are already facing or will face in the not-too-distant future. Such phases of development have been experienced by nearly all research institutes in advanced countries at one time or another. Perhaps the major contribution we can make is to tell institute directors in developing countries of our own errors--and we have made plenty--with the hope that they will profit by our mistakes.

Definition of Idealized IRI Goals and Objectives

The question to be raised is what pattern or mold should an industrial research institute in a developing country attempt to emulate? Also, once the pattern is established, is it reasonable, indeed possible, to reorganize, reorient, redirect emphasis of the institute in order to meet the changing needs of its industrial and public sector clients?

Should a developing country opt for a research institute which, staffed with empirically trained scientists, conducts sophisticated research more often relevant to the problems and interests of the advanced countries, with the hope that some day such research may prove to be a resource useful to that country? Is it not more important to deliberately structure research institutes so that these play an important and immediate role in national development, with a program of institute development deliberately designed to provide services and technical assistance in consonance with contiguous industrial needs?

The institute, in my view, should undertake analysis and simple testing initially; technical extension activities of a management as well as technical nature; troubleshooting and problem-solving. Finally, as industry needs become more sophisticated, and equally important as industry gains confidence in the research institute, then applied research and pilot plant development can be initiated. The important point is that the abilities and services of the research institute should be geared as much as possible to the changing requirements of those sectors it is intending to serve.

A monograph, prepared by Dr. H. A. Havemann, suggests that the varying nature of activities undertaken by research centers in developing countries should vary in accordance with the stage of country development or the stage of development of the industrial sector (see Figure 1).

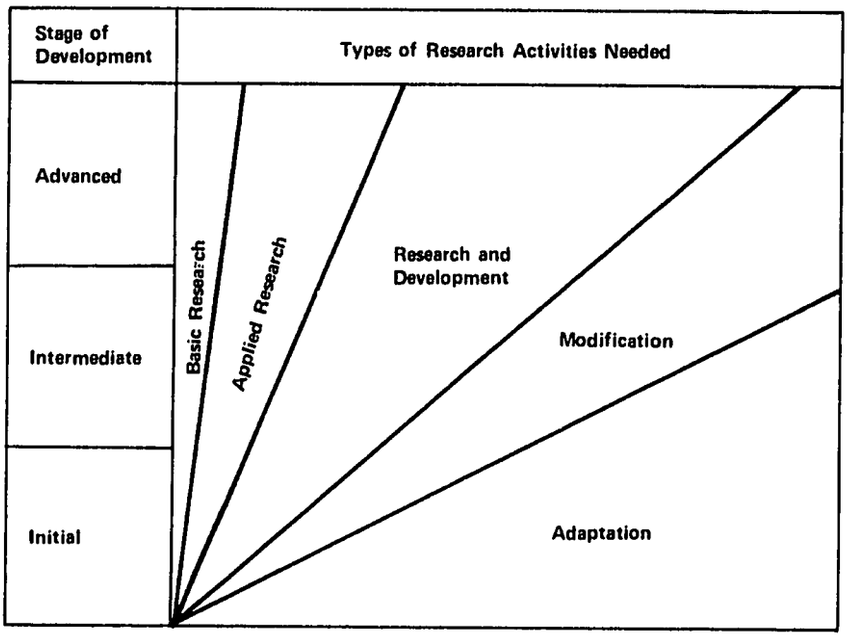

Figure 1. Relative importance of the types of research activities in accordance with the several stages of development in a hypothetical case.[20]

Dr. Havemann suggests that, while it is difficult to establish the exact level of country development, countries which have a GNP of less than US$75 per inhabitant are clearly in the initial stages of development; those countries which have a GNP of around US$1,000 per inhabitant are in an intermediate stage of development; those countries enjoying a GNP of more than US$1,000 per inhabitant are clearly in an advanced stage of development.

Again, I must comment that this approach is satisfactory as a generalization, and Dr. Havemann has so stated, but the actual ratio of basic to applied research, of testing to technical assistance, of technology adaptation to technology development will vary widely from one country to another. Only by keeping their fingers on the pulse of industrial development, through aggressive programs of promotion and contacts with potential clients, can the research institute director and his staff determine and be responsive to the needs of the industrial sector. The GNP ratios are really of little or no assistance to the research institute director in his planning process.

Dr. Luis Corrêa da Silva, former Secretary for Industrial Technology, Brazilian Ministry of Industry, comments as follows:[21]

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[20] "Industrialization of those Countries in Development: Problems and Perspectives," Industrial Research, p. 14, monograph 10, United Nations Publication ID/40/10, New York, 1969.

[21] Dr. Luis C. Corrêa da Silva, "Industrial Technology in Brazil: Ideology, Methodology, and Action," Proceedings of the IPT-DRI Management Development Workshop, São Paulo, October 1973.

Due to the high risk and low returns of technological 'production' in developing countries, government has to be a partner, frequently a major or even the single partner, in the establishment and operation of the technological institute. This does not preclude constant effort by the technological institute to maximize its own income, ideally attaining full economic self-sufficiency.

These institutes of technology could probably increase their relevance and effectiveness through increasing concern with:

a. Understanding of technology's nature and role in modern industry;
b. The realities of industry and commerce (closer working with industry);
c. Soft technology (analysis, planning, forecasting, etc.);
d. Economic aspects of technical problems.

The programs of the Singapore Institute of Standards and Industrial Research (SISIR) provide an outstanding example of the close communication and effective interaction which must occur, and which must result in changing objectives, operational modes, and close co-operation resulting in changing research institute direction as Singapore industrial needs change.

SISIR has not always been an effective institute, at least insofar as contributing to Singapore's industrial growth and development was concerned. The original objective in 1963 was to undertake in-house research projects which would create new industries for Singapore. This approach did not work. Entrepreneurs were not ready to exploit such SISIR research. Both SISIR staff and Singapore industry were frustrated; the government was discouraged by the results of such institute-industry interaction.

In 1968 a marked change occurred in the SISIR operational mode. A few country background comments are necessary. These do not, however, change the nature of the success that SISIR is now experiencing.

SISIR operates in an environment where industrial unemployment is exceedingly low, and industrial development of the immediate future is expected to become increasingly skills-intensive and highly sophisticated in nature. Areas of concentration include: shipbuilding, electronics, petroleum, petro-chemicals and plastics, metal fabrication and precision engineering, food processing. Foreign industry is being sought which will provide good employment opportunities for skilled workers and a good potential for technological advancement. Philips of Holland, Plessey of the United Kingdom, and Rollei of West Germany, for example, are newcomers to Singapore.

SISIR has an active interaction with all segments of industrial development--the ministries, the universities, the vocational training programs, and most importantly, constant, continuous and frequent liaison with Singapore industry. The SISIR staff spends a considerable

amount of effort in direct industry contacts. Routine services such as analysis and testing, quality control measurements, standards development and troubleshooting are regarded as door-openers for a potential follow-on phase of applied research. SISIR staff who visit segments of industry are required to review contact reports from prior industry contacts and to feed potential research ideas to the directorate. This aggressive attitude on the part of SISIR staff and management is leading to more sophisticated testing and the initiation of considerably more applied research as Singapore industry gains confidence in SISIR and demands additional assistance for its own development; currently about 55 percent of SISIR's annual income derives from contract services to industry.

SISIR encourages its staff to leave for industrial posts--sometimes to overcome research fatigue, other times because of the staff member's high degree of limiting speciality.

There are, of course, many who will argue against this approach, suggesting that qualified staff will not be content to long remain in an environment where their principal duties are to solve small problems. I argue that, in many instances such small problems can, with appropriate staff imagination and ingenuity, develop into mature research efforts which can lead to a new process or product of importance to the developing country. In my personal opinion, many researchers view in-house research as much more desirable, because they can proceed at a leisurely pace, they are usually only faced with problems of publication in a refereed journal and perhaps polite technical criticism from their peers. Whereas, when they undertake industrial problem-solving, the client wants a usable answer in a reasonable period of time and for a reasonable cost. He is frequently more interested in a "quick and dirty" answer presented in a report format which he can understand than in a long, involved empirical exposé which he may not understand at all or know how to apply to the solution of his particular problem. He also wants follow-up assistance in implementing the research. The reputation of the researcher may thus be put on the line.

At first glance, it would appear relatively easy to encourage or persuade--or coerce--otherwise reluctant civil service researchers to become more aggressive in responding to industrial problem-solving. But as Dr. Nayudamma points out: "Research and development. . .being done under the auspices of government, tends to be administered in the same way as any other government or office. In a traditional society, hierarchical attitudes, respect for age, and a belief that questioning is inappropriate, serve to reinforce similar tendencies which are codified in civil service rules and conventions. The usual governmental rules are not in any way conducive to the management of research. For example, in a government laboratory, a research worker can become a permanent government servant, and it is difficult to dislodge him, irrespective of the quality of achievement."[22] And perhaps it should be stated parenthetically that all too often a high cost is experienced for low productivity.

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[22] Y. Nayudamma, "Decentralized Management of R&D in a Developing Country," Minerva, XI, No. 4, p. 516, October 1973.

Now, add to this environment the fact that institutes suffer from an acute shortage of scientists and engineers suitably trained for problem-solving to meet the needs of the industrial sector. Experienced staff is difficult to recruit and hard to retain. University programs, locally as well as those in developed countries, are seldom directed toward preparation of graduates qualified for and interested in application of technology to industry's problems and to the creation of new commercial processes. Close collaboration should take place between the universities and the research institutes--mutually attractive because of shared facilities and staff and production of graduates attuned to the national need and as potential employees for the institutes. Such interaction seldom exists except on an ad hoc and usually unproductive basis.

Most young research institute staff members are interested in trying to solve the problems confronting their nation but they do not know how to go about it. Their advanced education has not prepared them to think in terms of practical problem-solving. They have not been trained to accept the philosophy that it is entirely professional to seek opportunities to solve industrial problems or to sell their institute's services. They are often further constrained by older staff members who recognize that they themselves are out of touch with the real world, but who are reluctant to lose face or position by letting young staff expose these weaknesses.

The IRI as Broker Between Technology and Industry

The industrial research institute can and should serve as a broker between local industry and available sources of technology from advanced countries. It is fairly easy to transfer technology into a technological institute. The problem occurs in transferring such technology to a potential user who may be interested in acquiring the technology but is not prepared or trained to understand both the technological and management decisions necessary to implement utilization of the technology in a productive manner.

There are three crucial issues to consider in any program designed to transfer technological information from advanced to developing countries. These are:

- Information transfer must occur by a pull process rather than a push process. This means that some entity or person in the developing country, a technological "gate keeper," if you will, is not only aware of the general nature of available technological information, but is also aware of the potential utilizers of the technical information. Thus, we really need to know the information needs of the LDCs, but we also need to encourage and stimulate mechanisms which will exert a demand for appropriate and needed information from advanced countries.
- The information infrastructure in many of the developing countries is weak and uncoordinated or non-existent. Such an infrastructure should consist of the following elements:
  1. A nucleus of physical information resources (libraries, documentation centers, etc.);

2. A supply of trained library and information personnel;
3. Linkages to significant economic, educational and R&D sectors, internal and external;
4. Two-way communications with users;
5. An organizational system that brings together and energizes these resources, personnel and linkages; and
6. National policies that promote the systematic development of the infrastructure.[23]

- Each of the above two issues relates to the third issue, namely the ultimate user of the information. Generally speaking, developing country national industry, particularly small- and medium-size industry, lacks personnel technically qualified to understand and apply technical information which might have a potential for exerting a major change in the company's process or product. What is required, then, is an "interpreter" who, similarly to the gate keeper above, is knowledgeable regarding the needs of industry and aware of appropriate sources from which to obtain the needed information. This suggests such a function should be performed either by the faculties of universities or by the technical staffs of the developing country research institute.

Information Management

Several attempts are underway to perform an "information broker" function. Notable examples are the National Technological Institute (INT) in Rio de Janeiro, the Korea Institute of Science and Technology (KIST) in Seoul, and the Indian National Science Information Center (INSDOC). I should emphasize that a considerable number of other information centers exist. These perhaps will serve as models to demonstrate a need and a service to be performed by an industrial research institute.

The Brazilian institute contacted 10,000 Brazilian industries during 1974 and maintains a mailing list of some 4,000 industries who receive annotated bibliographies, abstracts, other relevant technical information, etc. INT maintains several field service offices in other sections of Brazil. To date, requests for additional information have been running around 400 per year, although the number is increasing. Unfortunately, the INT service was suspended recently, thus depriving Brazilian industry of a valuable service. There appear to be plans to recreate the program separately from INT and on a national basis, but the start up date is uncertain.

KIST, with a key word file on 1,000 out of 12,000 Korean industries, mails on a quarterly basis technical abstracts to some 250 companies. During a three-year period ending in 1972, they had received only 47 inquiries for additional information, although at this point they are anticipating approximately 100 inquiries per year (on a small fee basis).

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[23] Scientific and Technical Information for Developing Countries, A Report of the Ad Hoc Advisory Panel of the Board of Science and Technology for International Development, U. S. National Academy of Sciences, April 1972.

INSDOC provides information service to science and industry both nationally and internationally. INSDOC compiles bibliographical inquiries, answers technical inquiries, provides translation. The information required must often be interpreted and evaluated in terms of user's viewpoint, constraints, technical know-how, etc., thus the need to "translate" information into a usable form and at different levels, that is, the manager level, the engineering level, the technician level, the worker level, etc. INSDOC charges a nominal fee to cover costs of materials, etc., but it is about 80 percent subsidized by the CSIR.

In these and other cases, the cost of disseminating information, and particularly the costs involved in serving as an "information broker and translator" create serious problems.

It seems to me, however, that most of the information systems in use tend to focus on dissemination of marginally useful information.

In the course of a recent study of some 18 international scientific and technical information services,[24] a typology of three different types of problems or issues and the information systems which correspond to them was developed. These are:

- Development-oriented Systems, which provide an aggregated information input on "big" technical-economic-social-political problems to government planners, international aid programs, etc.;
- Research-oriented Systems, which provide a disaggregated, purely scientific or technical information input on specific scientific and technical questions to research scientists and engineers;
- Implementation-oriented Systems, which provide practical answers to nuts-and-bolts questions in the form of semi-aggregated technical-economic-purchasing and other inputs to design engineers, managers, entrepreneurs, etc.

It is Mr. Freeman's conclusion, supported by experiences of myself and others in developing countries, that most information systems designed for and available to developing countries have been research-oriented, but that the greatest need exists at the implementation problem-solving level.

The problem is that whereas research-oriented systems can (1) plug into a readily usable, well-organized research literature, (2) serve relatively homogeneous client groups, and (3) be relatively well financed, the implementation-oriented systems typically (1) cannot obtain information in readily usable form, (2) must relate to heterogeneous client groups, and (3) are relatively under-financed. Therefore most industrial research institutes attempt to adapt to a research-oriented system rather than an implementation-oriented system of information management and dissemination which would more appropriately serve the needs of potential contiguous clients. Particularly in the case of national medium- and small-scale industry, information needs

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[24]James E. Freeman, "Improving Technological Information Exchange with Developing Countries: A Feasibility Study of the Progressive Establishment of an International Information System for Technology Transfer and Assessment," Phase I Report to UN/OST, Denver Research Institute, University of Denver, January 1975.

are more often directed towards "nuts-and-bolts" answers than empirical solutions to problems found in professional scientific journals.

DRI's experience to date in serving as a plug-in point to U. S. data banks of technology for its linked institutes points to the need for such information as machinery or equipment specifications, design data for pilot plant construction, availability of components that might be locally assembled in a local production operation, etc. There are also frequent requests for information about patents or processes, perhaps outmoded in the U. S. but still appropriate for application in a developing country. Finally the question is frequently asked regarding the possibility of process scale down through use of new equipment, design parameters, etc.

Interaction between a research institute and small-scale industry poses particularly acute problems. These industries seldom have the management know-how to recognize technical problems nor how to seek assistance for solutions to these. Often, their problems are more management-related than technology-related. Thus, a form of field service or technological outreach activity is required, where experienced industrial engineers regularly visit small-scale industries, solving their problems on the spot where possible, and referring more complicated problems to their institute's laboratories. But, research institutes seldom have capability for or, indeed, interest in providing this type of service.

A highly simplified system to portray research institute work flow and decision-making points is shown in Figure 2.[25] It may be seen that this system does not incorporate all of the elements which have been discussed above, particularly those elements which relate to analysis and testing, technical extension activities, etc. However, the diagram does demonstrate the iterative process confronting a research institute in establishing projects. More importantly, the diagram clearly portrays the need for continuous project evaluation and feedback, whether the project be in-house or externally supported.

Institute management practices will be discussed in Chapter 5. As a concluding comment here, it is perhaps appropriate to delineate the general goals to be sought by institute directors and their management staffs in achieving greater interaction with the public and private sectors, and thus increasing their institute's contribution to industrial growth and economic development. These are:

- Increased recognition by the institute of relevance of its research programs to national, public and private sector needs;
- Increased participation by the institute in early phases of public or industrial sector planning for development of new or improved processes or products;
- Increased transfer of institute research results into industrial utilization; and
- Increased industrial financial support of institute research projects and related activities.

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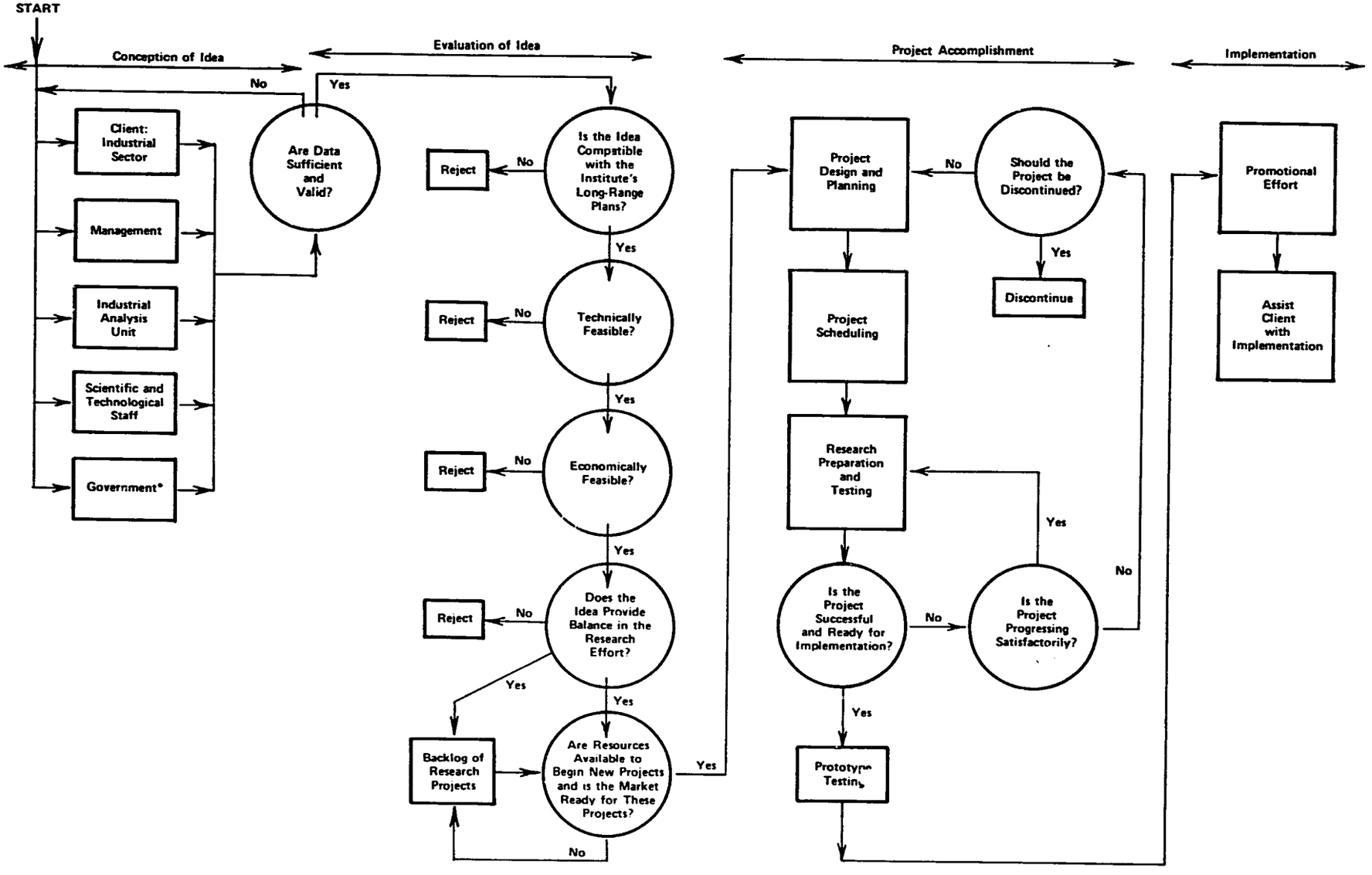
[25] Dr. Arie Beenhakker, private communication.

FIGURE 2
ENVISAGED SYSTEM OR WORK FLOW AND DECISION POINTS IN INDUSTRIAL RESEARCH INSTITUTES



* The government may operate a government owned enterprise and hence, could be a client for a specific problem, also the government may need assistance in policy and strategy formulation

If industrial research institutes in developing countries are to achieve these goals, it is probable that a redirection of international technical assistance programs will be required, so that the right type of training can be established and appropriately experienced consultants utilized. Most importantly, governments, the development banks, public and private enterprise must also recognize that a partnership is required; otherwise, the research institute may become a non-productive and expensive entity, making minimal contribution to industrial growth and economic development.

CHAPTER 3

THE ENVIRONMENT FOR INDUSTRIAL RESEARCH SERVICES

A UNESCO report states: "Statistical studies on research and development have shown that the lower the per capita gross national product in countries, the higher tends to be the ratio of fundamental research in the total national expenditure on research and experimental development."[26] The report proceeds with the argument that if the country is unable to mobilize and direct its scarce scientific and financial resources toward conduct of applied research, then it is natural to concentrate available resources on basic research needed to support higher education.

The question which must, of course, be raised is: how much of this basic research is taking place in the universities, and how much is being conducted within the industrial research institutes, thus diverting even more valuable scientific resources already in short supply? It is relatively easy to understand how such emphasis on basic research can come about. Nearly all of the scientists and engineers, until very recently, have received their graduate training in the universities of advanced countries, usually with equipment and on research topics of importance in the advanced countries, but frequently not yet relevant to the needs of the country where the graduate scientist returns.

I do not intend that my comments regarding basic research be critical, but rather objective and in balance with other technological needs of the developing countries. These vary, of course, depending on the level of national development. I do, however, believe that all too often basic research is overly emphasized, resulting from permissive management attitudes or funding sources for the support of research.

Science Versus Technology Policy Units

As an example, the Fundação A Ámpara E Pesquisas do Estado do São Paulo (FAPESP) has, for a number of years, supported research and development programs in Brazilian universities and research institutes which are intended to be beneficial to São Paulo industry. FAPESP receives, for such purposes, an annual budget amounting to one percent of the prior year's state budget. Recently, FAPESP conducted an analysis of its supported research and learned that only one out of 1,000 projects funded during the past several years really had practical direction or application.

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[26] National Aspects of Fundamental Research in Europe, Working Document of the UNESCO Conference of Ministers in Charge of Science and Policy in European Member States, UNESCO/MINESPOL/3, 1970.

The National Council for Scientific and Technological Investigations (CONICYT) in Argentina is responsible for the promotion of science and its relationship to technology, but unfortunately less than three percent of CONICYT's funds support applied research and technology projects. By contrast, the Scientific and Technical Research Council of Turkey (TUBITAK) has, since 1964, almost entirely emphasized and supported research programs related to Turkish industrial development.

The Korea Institute of Science and Technology (KIST) encourages its senior staff to engage in fundamental research for which there is no immediate foreseeable client support but which is directed into potential new areas of client support. Such basic research effort, however, is limited to a maximum of 20 percent. The balance of staff time must be devoted to client-supported R&D activities.

Perhaps a clue to governmental emphasis and institutional response to basic in preference to applied research can be drawn from consideration of Tables II, III, IV, extracted from the World Plan of Action,[27] which summarize the "Science and Technology Policy Making Bodies" of several regions of the world. Some changes and/or additions have taken place since this compilation. It is appropriate to reflect, for example, on the number of multisectoral science coordination entities and compare these with the paucity of coordination bodies for industrial research (a ratio of nearly four to one). It is also interesting to observe that, in the Asian and Latin American regions, there are more government policy-making bodies for atomic energy research than for agriculture, medicine, or industrial research.

There is a trend toward formulation of national science and technology bodies; however, it is probable, since their members will come mainly from academic institutions or are unfamiliar with industrial problems that their interests will continue to focus on scientific research rather than technological development as such.

An Ad Hoc Panel of the U. S. National Academy of Sciences has recently recommended to developing country governments "to recognize and pay special attention to aspects of technology policies that are distinct from those bearing on scientific and educational development but perhaps sensitive to domestic and international economic stimuli. A sound national technology policy must provide for aggressive development of indigenous technical management capability."[28]

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[27] World Plan of Action, op. cit., pp. 91-94.

[28] Research Management and Technical Entrepreneurship, op. cit., p. 32.

TABLE II[27]

Science and Technology Policy-Making Bodies
in Countries of the African Region

Country	Ministry for science,[a] or ministerial committee for science policy	Over-all science planning body	Multisectoral science research co-ordination body	Co-ordination body for medical research	Co-ordination body for agricultural research	Co-ordination body for atomic energy research	Co-ordination body for industrial research
Algeria							
Botswana							
Burundi							
Cameroon		Yes	Yes				
Central African Republic			Yes				
Chad							
Congo (Dem. Rep.)[c]	Yes	Yes[b]	Yes[b]		Yes	Yes	
Dahomey					Yes		
Equ. Guinea							
Ethiopia		Yes[b]	Yes[b]		Yes		
Gabon							
Gambia							
Ghana		Yes[b]	Yes[b]				
Guinea					Yes		
Ivory Coast					Yes		
Kenya							
Lesotho							
Liberia							
Libya							
Madagascar			Yes				
Malawi					Yes		
Mali					Yes		
Mauritania							
Mauritius							
Morocco							
Niger		Yes[b]	Yes[b]		Yes		
Nigeria		Yes	Yes[b]	Yes	Yes		Yes[b]
People's Rep. of Congo			Yes				
Rwanda							
Senegal		Yes[b]	Yes[b]				
Sierra Leone							
Somalia							
Sudan				Yes	Yes		Yes
Swaziland							
Togo							
Tunisia							
Uganda		Yes[b]	Yes[b]				
United Arab Republic	Yes		Yes				
United Rep. of Tanzania		Yes[b]	Yes[b]				
Upper Volta					Yes		
Zambia		Yes[b]	Yes[b]				

SOURCE: Table based on UNESCO World Director of National Science Policy-Making Bodies (Vol. IV, Oct. 1970).

[a]Having no other responsibilities.

[b]The same body performs both functions.

[c]Now Zaire.

TABLE III

Science and Technology Policy-Making Bodies
in Countries of the Asian Region

Country	Ministry for science,[a] or ministerial committee for science policy	Over-all science planning body	Multisectoral science research co-ordination body	Co-ordination body for medical research	Co-ordination body for agricultural research	Co-ordination body for atomic energy research	Co-ordination body for industrial research
Afghanistan							
Australia	Yes	Yes	Yes[b]	Yes	Yes	Yes	Yes[b]
Bahrain							
Burma		Yes[b]	Yes[b]	Yes			Yes
Cambodia							
Ceylon*				Yes	Yes		Yes
China (Taiwan)		Yes	Yes		Yes	Yes	Yes
Hong Kong							
India		Yes	Yes[b]	Yes	Yes	Yes	Yes[b]
Indonesia		Yes[b]	Yes[b]			Yes	
Iran	Yes	Yes[b]	Yes[b]	Yes		Yes	
Iraq		Yes[b]	Yes[b]				
Israel		Yes	Yes		Yes	Yes	
Japan	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Jordan			Yes		Yes		
Kuwait							
Laos							
Lebanon		Yes[b]	Yes[b]				
Malaysia				Yes	Yes		Yes[c]
Mongolia		Yes[b]	Yes[b]				
Nepal							
New Zealand	Yes	Yes	Yes	Yes		Yes	
Pakistan		Yes	Yes[b]	Yes	Yes	Yes	Yes[b]
Philippines	Yes[d]	Yes	Yes	Yes[e]		Yes	
Qatar							
Republic of Korea	Yes	Yes					Yes
Saudi Arabia							
Singapore	Yes	Yes[b]	Yes[b]				
Southern Yemen							
Syria		Yes	Yes		Yes		
Thailand		Yes	Yes			Yes	
Rep. of Viet-Nam			Yes		Yes	Yes	
West. Samoa							
Yemen							

SOURCE: Based on UNESCO World Directory of National Science Policy-Making Bodies (Paris, 1968), Vol. II and Vol. IV (in course of preparation).

[a]Having no other responsibilities.

[b]The same body performs both functions.

[c]Rubber industry only.

[d]The National Science Development Board is given the responsibility of co-ordinating all research activities in the country.

[e]Private organization.

*Now Sri Lanka.

TABLE IV[27]

Science and Technology Policy-Making Bodies
in Countries of the Latin American Region

Country	Ministry for science,[a] or ministerial committee for science policy	Over-all science planning body	Multisectoral science research co-ordination body	Co-ordination body for medical research	Co-ordination body for agricultural research	Co-ordination body for atomic energy research	Co-ordination body for industrial research
Argentina	Yes	Yes	Yes		Yes	Yes	Yes
Barbados							
Bolivia						Yes	
Brazil			Yes[b]		Yes	Yes	Yes
Chile		Yes	Yes		Yes	Yes	
Colombia		Yes[c]	Yes[c]	Yes		Yes	Yes
Costa Rica						Yes	
Cuba		Yes[c]	Yes[c]				Yes[d]
Dominican Republic							
Ecuador						Yes	
El Salvador					Yes		
Guatemala						Yes	
Guyana					Yes		
Haiti			Yes				
Honduras							
Jamaica			Yes				
Mexico			Yes		Yes	Yes	Yes
Nicaragua							
Panama			Yes[e]				
Paraguay			Yes[f]				
Peru		Yes	Yes	Yes	Yes	Yes	
Trinidad and Tobago			Yes				
Uruguay			Yes[b]			Yes	
Venezuela		Yes[c]	Yes[c]		Yes		

SOURCE: Based on UNESCO World Directory of National Science Policy-Making Bodies (Paris, 1968), Vol. III. The table includes Central and South America.

[a]Having no other responsibilities.

[b]This body also performs some functions related to over-all science planning at the national level.

[c]The same body performs both functions.

[d]Sugar cane by-products research.

[e]Private organization.

[f]Natural sciences.

Role of the Entrepreneur, the Development Bank, the Government Planning Ministry, the IRI

I ascribe to the philosophy that much more applied research, troubleshooting and technical assistance, and experimental development would take place in the developing countries if people only knew more about how to go about it. I am not certain that many people really know how and why a national develops, or why one nation develops at a faster rate than another. There are, however, some rather clear indicators which relate to the research services environment which encompass and influence the activities and course of direction of the industrial research institutes.

I wish to begin by making the assumption that the principal actors in the process of innovation* should be:

- The industrial entrepreneur;
- The development bank;
- The government planning agency or appropriate ministry;
- The industrial research institute.

Obviously, there are additional elements which influence or perturb such a system. These include political stability, the educational system, extent of natural and human resources, degree of sophistication of the industry-technological base, etc.

Many developing countries focus a large part of their governmental effort on the process of socio-economic development and industrialization. It is thus reasonable to assume that these have intervened in their innovation processes in novel and/or unique ways. But there are gaps in our knowledge about such unique ways and the extent of their success of failure.

Close effective working relationships should exist between the above-mentioned "actors" with the ultimate result of optimizing the innovation process. But, somewhere in the system, communication gaps frequently occur. What should be a team effort devoted to development becomes an uncoordinated, wasteful expenditure of scarce resources and limited funds. In many cases, conflicting priorities develop. The entrepreneur is uncertain whether to acquire foreign technology, seek alternative technologies, or give up the whole idea. The government planning agencies, the development banks, the research institutes who should encourage and assist the entrepreneur are often uncertain as to the extent of their individual or institutional roles in providing guidance and assistance.

It is, of course, dangerous to speak in generalities. But I have observed in the last several years, during the course of extensive travels and extended visits to many of the developing countries of the world, certain tendencies on the part of the above-mentioned elements:

- Research institutes aspire to conduct of long-term basic research instead of short-term problem-solving and technical assistance to industry and government.

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*Remembering that "process of innovation" includes the entire spectrum, from concept of an idea to its utilization for commercial or social purposes.

- Development banks tend to follow the conservative practices of the normal banking system instead of aggressively encouraging and nurturing entrepreneurs. Further, such banks only infrequently seek the advice and services of the research institutes to provide advice and counsel on technological aspects of loan requests by entrepreneurs; or, if they do so, it is usually after a crisis has developed in implementation of the project. They seldom anticipate the problem.
- The government planning agencies sometimes follow a similar trend, particularly if in their view the research institute staff lack development and planning experience or are unacquainted with and unaware of industrial needs. Thus, both long-term and short-term planning tends to become a somewhat isolated process, insofar as utilizing the technological capability of the institute is concerned.
- It should also be observed that the potential enterpreneur may have an idea but lacks the technical or managerial expertise to exploit his idea. He usually does not know where to go for guidance. He frequently thinks the most appropriate approach is to seek such guidance from external sources in the form of licensing agreements, purchase of technological assistance in connection with acquisitions of a process, etc. Frequently, he pays too much or acquires outmoded or inappropriate technology.

Now, some of the above tendencies develop because of inadequate or inappropriate experience and training of the people involved. Usually, research institute personnel have received good academic training, but on an empirical basis. Seldom are these people specifically trained in the process of applied industrial-oriented research. Equally importantly, they do not usually know how to sell their research ideas or technical assistance. It is not often that one sees experienced technologists on the staff of the development banks. Until recently, many of the people involved in the planning process similarly lacked industrial or technological experience, and even today, a shortage of such experienced people continues to exist.

But much of the above can be eliminated if the strengths and weaknesses, the capabilities and resources, the partial contribution which each sector can and should make to the total development process are recognized.

Some exciting innovations in interaction among government, banking, technology and industrialization are taking place in Minas Gerais State in Brazil. A similar program is beginning to take shape in São Paulo. These programs, if successful, can well serve as useful models for other states in Brazil and other countries in Latin America. More about these systems later.

The point is often overlooked that in most advanced countries, a strong industrial base already existed which, in turn,

created a demand for R&D. Initially, industry established its own testing facilities and research laboratories, recognized as essential in the manufacturing process to meet the demands of the marketplace. Further, the governments of these countries, particularly during World Wars I and II, found it necessary to initiate sizable programs of applied research directly related to defense needs, but research which obviously held secondary although equally important value to industrial development.

Within such an environment, creation of research institutes evolved naturally. An existing demand for problem-solving, applied research, technical assistance encouraged and nurtured these institutes. As these assumed their particular role in the industrialization process, collaboration was achieved with knowledgeable industry, with direct government encouragement and support, with realization that other forces--marketing potential, economic assessment, evaluation, innovation, usually outside of the research institute--were being brought to bear on the problems of utilization and application of R&D results.

It is clear that a kind of a "pull process" was taking place where interested partners helped to define the technology needed and the assistance required to utilize this technology, be it consulting, technical assistance, research, pilot plant development, management, or economic and marketing feasibility analysis. The government, the financial entities, in addition to industry, were essential partners in such a pull process.

It is recognized that research institutes in advanced countries should play an important role in adapting and developing technology appropriate to the needs of industry. But they cannot, of themselves, push technology on potential users. The need must be evident, the industrialist interested in pursuing the project, the barriers and constraints to utilization of the technology evaluated and understood.

Gabor Strasser[29] defines this process as a "Market Pull Versus Technology Push" and comments that successes or failures in transferring technology are in large part dependent on the path followed. He has observed that an institute demonstrating its products developed internally without regard to the potential users' needs, requirements, even interests, will usually be attempting to push inappropriate technology on inappropriate clients. The result is almost certain failure.

I concur completely with Dr. Strasser's compelling argument and definition of an alternative approach: "to contact potential recipients and become familiar with their problems (in their language and in their context) and then, after gaining sufficient familiarity with their problems on their terms, to figure out what kind of technological capability or combination of capabilities could be modified and offered in terms of the needs of these prospective users (again, in their

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[29] Gabor Strasser, Technology Transfer: Successes and Failures, San Francisco Press, 1974, p. xxi.

language and in the context in which they have to operate)."[30]

It is clear that this alternative approach is far more time consuming and requires that the research institute staff member must be broad-gauged in his interests and also innovative and imaginative in identifying the problem. According to Everett Rogers: "It really matters little, as far as human behavior is concerned, whether or not the idea is objectively new... It is the newness of the idea to the individual (user) that determines his reaction to it."[31] The research institute staff member cannot await confrontation in his laboratory by a potential user of ideas but must doff his white jacket and sally forth into the real industrial world, seeking problems to which he can apply his imagination, experience, and talents.

Now, somehow, the idea has persisted that in a developing country, a procedure reverse to the above can be effectively applied. Industrial research institutes have been created, in many instances, before a demonstrated awareness of and need for their services has become apparent. Particularly if the research institute is structured so as to dedicate its efforts to long-term research of limited immediate relevance, instead of analysis and testing, troubleshooting, technical extension services, the unsophisticated contiguous industrial sector will react unenthusiastically, to say the least, to utilization of the institute's services.

The industrial research institutes and applied research centers in developing countries are expected to be aggressive interpreters and adaptors of technology needed for industrial development. These centers are expected to establish and maintain an institutional capacity to undertake a wide variety of technical problem-solving which may or may not materialize and the costs for which may be, at best, only partially recovered. The staff of these institutes is expected to be adept at identifying and anticipating industrial technological needs, although they seldom have practical experience in such program development activities. Often, the institutes are unprepared to evaluate and assess those cultural, societal, economic and political factors which are part of the technology transfer process.

As mentioned above, the institutes are expected to provide broad-gauged services and expertise to be utilized on an "on-call" basis. Somehow the thought persists that, if the service is available, clients will clamor for help and assistance and pay the bill! But, the problem is that all of this advice and guidance seldom takes into account the particular conditions, constraints, staff limitations, etc., which confront the institutes. Consultation appears to focus on the level of contracted research services without regard to creation of appropriate promotion and program development activities. Some consultants argue that research institutes should not be involved in pilot or demonstration plant operations nor that these institutes

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[30] Ibid.

[31] Everett M. Rogers, Diffusion of Innovation, The Free Press of Glencoe, 1962, p. 13.

should engage in economic assessment and market feasibility activities, without regard for the needs of local industry who want to know what a product looks like, what it will cost, and who will buy it, before attempting to exploit the idea.

There is little incentive for most research institutes to actively seek contract research support. Money and fees from contract research, royalty and other income-generating activities, in many instances, legally revert to the government treasury and are not often under the control and management of the institute director for budget augmentation, institution building and growth. Such income may even cause a reduction of the government subsidy. The implications of such an operational constraint are obvious. The institutes tend to engage in programs which have no real relevance to industry needs or problems or to the national plan. The research staff, with no real motivation and incentive, lean toward replication of the research of their graduate school days, or seek the great breakthrough in single-cell protein, cancer chemotherapy, solar energy, or yet another use for bagasse. Interaction with industry and government enterprises is limited and infrequent. Instead of aggressive programs of frequent industry visitation and promotion of the institute's capabilities, the tendency is to wait for industry to contact the institute. Inasmuch as industry may not recognize that it has a problem that can be solved by the institute or is unaware of the institute's capabilities, nothing happens.

Thus, the research institutes operate within a microcosmic array that is frequently reluctant to sustain R&D and generally indifferent to, or unaware of, the contributions that appropriate adaptive research and experimental technology could make to industrial growth. The government planning agencies and public enterprises, the development banks, the industrial sector profess to recognize the importance of applied research and technological development, but unfortunately do not always include the research centers in their planning processes, nor do the governments always develop incentive programs for stimulation of industrial development which encourage partnership with the industrial research institute or research center.

The Multinational Corporations

It is said that multinational companies in a developing country seldom seek applied research or problem-solving assistance, preferring to send such problems to home-base laboratories. But, I believe that multinational company managers are vitally concerned with costs and efficiency, both in terms of time and money. In talking with many such managers I have received a clear indication that these companies use home-based laboratories, not by fiat, but because the services they need are not available locally at a competitive price and with a guarantee of meeting time schedules and producing quality results. Brazil is initiating a program, now in early stages of implementation, that will require certain MNCs to utilize to the extent possible local technological institutes. It is anticipated that with time

and as Brazil's technical assistance and R&D capabilities improve, nearly all MNCs will be required to abide by such an agreement.

It should also be observed that multinational companies do utilize a variety of local manufacturers and suppliers of materials, parts, etc., who may be potential buyers of technical assistance.

Reluctance of National Industry to Utilize Local IRIs

National large and medium industries represent a potential for exploitation; however, their attitude toward applied research and development assistance from indigenous research institutes can be generalized as follows:

- Industry lacks confidence in the ability of research institutes to provide meaningful solutions to their problems in a reasonable time and at a realistic cost;
- Industry (and government enterprise) believes that it should not pay for the services provided by a research institute when such institutes are largely subsidized by government funds derived from industrial taxes;
- Industry usually is wary of the research institute-government relationship which could result in disclosure of potential patent possibilities, technical secrets, or management information to government agencies or competitors;
- Industry does not often evidence a genuine interest in the research results of an institute until these have been carried through a pilot or demonstration plant phase and production, economic and marketing feasibility have been resolved.

Small- and Medium-Scale Industrial Development

Interaction with small-scale industry is a particularly severe problem. I have a feeling that, throughout the world, there is a need for providing technical assistance to this particular segment of industry, perhaps more than anywhere else in a developing country. Many of these small-scale industries are suppliers of the larger industries, and particularly of the multinational industries. They have a potential for growth. Their problems are generally more managerial than technological. In fact, in many instances these do not have the management capability to identify the technological problems with which they may be confronted.

Owens and Shaw[32] argue that: "the premise should be accepted that country development consists of a continuous succession of small advances, millions of individual actions by millions of individual people. Then, small industry, rather than large, better suits

[32] Edgar Owens and Robert Shaw, Development Reconsidered, D. C. Heath and Company, 1972.

the psychology of countries in transition from traditional methods of production." Dr. Alberto de Castro,[33] the Superintendent of the Instituto de Pesquisas Tecnológicas (IPT) in São Paulo, is convinced that the multinational companies, for economic reasons as well as to build a good public image, will utilize as its suppliers a large number of local enterprises. Indeed, in Brazil, companies such as Ford, General Electric, General Motors, etc., frequently provide technical assistance necessary for quality assurance programs, particularly where these assistance programs have not become available locally. In the opinion of Dr. de Castro, the local research institutes are, in general, prepared to assist small industry--with the technical assistance required to attain and maintain required quality standards and to achieve greater income through higher productivity and lower scrap losses. But, the institutes do not often do so.

Probably the only way that small industries can be helped is through creation of research institute technical extension of technological outreach activities. I liken this to the agricultural extension programs which have been conducted throughout the world for many years. Experts have gone out into the field, have talked directly with the producers, the growers, the farmers, and either helped them solve their problem on the spot or have referred the problem to an agricultural station which has the resources to solve the problem.

Similarly, research institute staff members could be utilized to make frequent and repetitive contacts with industry, solving small problems either managerial or technical at the time of the visit, or if more complex, beyond the capability of the technical extension man or requiring utilization of facilities or equipment not locally available (testing, etc.), referring the problems back to the institute for problem-solving. Not only is this an effective means of solving small industry problems, but the approach builds confidence on the part of the industrial sector and can indeed become an effective device for "selling" the institute's technical services. To date, however, I have found very few people who know how to provide this kind of technical extension expertise. Most of the institutes, staffed with people on a civil service tenured system, find it indeed difficult to develop skills necessary to provide technical extenstion assistance. Some of the institutes which do undertake at least limited technical extension activities are: EAIRO, FIIR, ICAITI, INTI, INT, ITAL, NIST, PCSIR, SISIR, and TUBITAK. This approach to promotion and program development will be further discussed in a subsequent chapter.

In all of the above, an urgent need for effective communications becomes clear. The industrial manager probably has a background in law or finance, with a limited knowledge of technical affairs. He will usually be quite willing to pay fees for legal accounting, advertising or similar services but objects to paying the cost of research services which might improve his product, particularly when such costs include indirect costs, usually termed overhead,

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[33] Alberto de Castro, "Utilization of Local Research Facilities by Foreign Concerns Operating in the Country," Expert Group Meeting on More Effective Utilization of Industrial Research in Developing Countries, Copenhagen, 23-27 August 1971, UNIDO Document ID/WG. 91/7.

which he regards as a profit. It is quite possible that the industry itself lacks requisite technical staff who can accept the technical assistance results proffered by a research institute and introduce these into his company's process. Similarly, the research staff must recognize the importance of follow-up to assure that a solved problem is properly understood and implemented, or to provide the necessary advice and counsel to make directional or other changes which can lead to proper utilization of the results.

All of the above are problems which daily confront the research institute director in a developing country. He is faced with counterbalances of extremely varied nature. And, if he is reluctant to delegate authority downward to lower echelons who can perform many promotional and program development functions, the institute may well find itself choked off from meaningful and productive relationships with those sectors it was established to serve.

Industrial Problem Identification

In my own experience, shared by that of many others, industry often either fails to recognize its problems or believes that these could be readily solved by purchase of new equipment, better market incentives, etc. As an example, I had occasion two years ago to visit a variety of metal-mechanical industries in the State of Rio Grande do Sul, Brazil. In each instance, I was advised that manufacturing problems were minimal or did not exist, yet the percentage of product rejects was, by admission of industry representation, inordinately high. Research staff in that area did not accompany me during these visits, since, in their view, researchable problems did not exist. However, in inspecting the facilities of approximately 15 small- and medium-sized plants, the following problems, most of which bear on efficiency of operations or product output, were identified:

1. Heat treatment--optimization for broaching operations, reduction of surface oxidation, differential cooling to control grain-size between thick and thin sections, secondary heat treatment to recover rejects, relationships between heat treatment and surface polishing, superficial hardening (less than one mm) of small areas by methods other than carbonitriding or carburizing, alternate methods of heat treatment of edges or small areas of very small parts, correlation of induction hardening with depth and metallographic characteristics of hardened area;
2. Forming--optimization of forging versus rolling dies, rolling and drawing of cole- and hot-short steels produced from steel scrap, decrease in thermal cracking in rolling mill rolls by Nb additions, cold forming of 430SS steel;
3. Electrodeposition and corrosion--effects of heat or mechanical treatment on adjesion of electrodeposited nickel and tin, galvanizing of malleable iron, influence of alloy content on color of oxidized surfaces, ultrasonic

cleaning, pitting corrosion, corrosion from sulfite liquors.

4. Foundry--stabilization and control of nodular iron to improve crack resistance, casting of ferritic nodular iron, control of pinholes by Mg and other additions to nodular iron, fluidity of cast steels, relation between gating and feeding, chemical composition, fluidity, etc., dimensional stability of molds and cores, relation between sand permeability and quality of casting, dimensional problems in micro-fusion, wax, refractory, steel casting-refractory--steel interaction in micro-fusion, corrosion resistant cast alloys.

None of the above would normally fall into the realm of long-term research (although obviously such lengthy programs could be devised). They do, however, represent real problems confronting a segment of industry, many of which could be solved by technical extension assistance, others by short-term, in-plant troubleshooting.

The research staff in ICAITI have experienced similar success in identifying a number of problems confronting the food processing industry in Central America. Through a cooperative venture with CODOT* members, and with the financial support of ROCAP,** ICAITI engineers and economists surveyed 150 small food-processing industries in the areas of milk, meat, fish, and fruits and vegetables. The CODOT-ICAITI team identified 120 technical problems, some of which could be solved immediately. ICAITI contracted with some of the industries to solve 15 problems. The remainder of the problems represent potential contract opportunities for providing technical assistance.

The Instituto de Pesquisas Tecnológicas (IPT) in São Paulo and the Denver Research Institute (DRI) have been conducting an experimental program designed to transfer explosive forming and cladding technology to Brazilian industry. IPT is the transfer agent with DRI providing backstopping support. After three months' intensive training of several IPT staff in Denver and construction of a demonstration facility in the São Paulo area, a team of engineers and economists, representing both IPT and DRI, conducted a promotional campaign to acquire contracts with interested users of the process (economic and marketing feasibility and technical interest had been established prior to initiation of the program). To date, seven medium-sized Brazilian industries have entered into contracts with IPT; others are expected to seek IPT's services in the near future.

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*Consortium on Development of Technology (Universities of Rhode Island, Michigan State, Wisconsin, California/Davis, Washington).

**Regional Office for Central America and Panama, U. S. Agency for International Development.

The Scientific and Technical Research Council of Turkey (TUBITAK) maintains an industrial relations group of several people who are in daily contact with industry throughout Turkey. This group uses a technical extension approach; if possible, problems are solved on the spot in one or a few days' time. If it appears that the problem is more complex, the industrial relations group will propose the problem to one or more qualified university professors or staff in a research institute and contract with these to do the study. Industry may or may not join in financing of the project, although this is encouraged. The important point is that the TUBITAK group is seeking problems that plague Turkish industry and then arranging for an appropriate solution to these problems. The response is rapid, since the researcher is not paid until the project is completed. Based on the experiences of this industrial relations unit in Turkey, it is clear that an excellent model is being demonstrated--a broker to translate problems and answers to these between the industrial sector and the researchers in universities or research centers.

A similar industrial liaison group is the link between the Indian Council of Scientific and Industrial Research (CSIR) and Indian industry. But contacts are most often with government agencies such as the Directorate General of Technical Development, the National Research Development Corporation, the Indian Council of Science and Technology, the chambers of industry, industrial associations, etc. Direct contact is seldom made with individual companies; these are handled by CSIR laboratory staff or liaison units, the efficacy of which vary with the interest and management abilities of the laboratory director.

The Role of the Development Bank

Earlier in this chapter I listed the national development bank as one of the necessary actors in the innovation process. The economic and political climate for investment in most developing countries is such that government-owned financial development banks can become of great importance in the encouragement of new enterprise and industrial growth. Industrial entrepreneurs, while demonstrating successful initiatives that result in new products or processes, must also have access to sources of financing which recognize and are willing to accommodate to certain risk factors, but which also are accustomed to undertaking financing of innovative new ideas, often without complete knowledge of the technical and economic factors involved.

The above relationship is well established and, indeed, frequently successful (unless one talks about small-scale industry). But, as our experience has shown, much of the world's industrial development has occurred without or despite the existence of industrial research institutes. The premise should be drawn that enlargement of the sphere of interaction (or even establishment of interaction) between the industrial research institute and the national development bank will augment their joint contribution to the pace as well as the

quality of industrial development. According to Dr. William Bredo: "The possibility of effective interaction between the research institute and the development bank hinges basically around whether it is possible for the institute to contribute technological and science-based information and analyses that will enable the development bank to make more intelligent decisions and conduct better programs in its role of financing new or expanding industrial enterprise."[34] But, representatives of both research institutes and development banks have informed me that, for the most part, the other has not really been knocking on their door. Again, it appears that what is lacking is the ability of the research institute people and the development bank people to understand each other's language.

In October of 1973, a management development workshop was conducted jointly be the Instituto de Pesquisas Tecnologicas (IPT) and the Denver Research Institute (DRI) in Sao Paulo. The principal thrust of the workshop was to emphasize ways of increasing the interaction and expanding the working relationships between the industrial research institutes and other nation-building institutions, such as the development banks. Participants included representatives of the development banks, but most of the program focused on what the research institutes could provide in the way of assistance to the banks; little time was available for the banks to indicate their technological needs.

Dr. Americo Oswaldo Campiglia commented in a paraphrased manner: "From a development bank point of view, we would state that there is a real interest in establishing interaction with the technological institutes... but (in the workshop) almost all subjects under discussion were of interest to institutes. Our suggestion is a development bank participation as co-host in order to help in establishing lines of communication and interaction between development bank and technological institute."[35]

In a similar vein, Dr. Alberto de Castro commented: "I think we have taken for granted that everybody thinks industrial research institutes and development banks should interact in the industrial development process, but I think economists in Brazil tend to see technology as something rather static, that is, like a sort of stock in a warehouse, where you can choose the part you want. Development banks in Brazil don't know much about the research institute... (but) I believe that we, the institutes, haven't really tried

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[34] William Bredo, "Integration of Technological Institutes with the Development Banks," Proceedings of the IPT-DRI Management Development Workshop, São Paulo, October 1973.

[35] Américo Oswaldo Campíglia, President, Banco de Desenvolvimento do Estado do São Paulo, private communication.

to know the development banks and to identify some of their problems where the help of the institutes might be welcome."[36]

These comments and similar ones all reflect the same consensus as so appropriately expressed by Dr. Bredo:[37]

> I have a feeling that the banks doubt that there is any advantage for them in promoting interaction with the technological institutes. Little work apparently is being sponsored by the banks and they may see little need to do so in the future. It is my impression that the banks expect the industrial client who approaches them for credit or equity capital to establish or expand an enterprise, to have gotten all the research assistance necessary for adequately formulating his proposal. The banks apparently see no need to do further studies of their own on the project. Nor do they seem to consider the wisdom of requiring the client to use a portion of the credit granted him for improving the feasibility (either technically or managerially) of his proposal.
>
> If one then adds on to this situation possible doubts on the part of the banks about the research capability of the (research) institutes, one can see little room for the banks to take the initiative with the institutes. In addition...the institutes do not seem ready at this point with a well-thought out promotional program to 'sell' the banks on the benefits they could derive from research assistance obtained from the technological institutes.

And yet, if a developing country is to achieve a significant impact on economic development, it appears obvious that the entrepreneur-development bank-research institute interaction should receive major emphasis. I conclude that the research institute should undertake a concerted program to hitch its efforts to the point in the system where the dynamics of industrial development are manifested. The impact may be direct--from the research institute or industry--or it may come about through the instrumentality of the development bank.

I commented earlier that until recently development banks have seldom included technically qualified people on their staffs. Thus, appraisals of entrepreneurial requests for financial support have most often been concluded on the basis of economic considerations, often with small regard for genuine technical merit, replication of a competing process, etc. There are several areas where an

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[36] Alberto de Castro, Superintendent, Instituto de Pesquisas Tecnológicas, São Paulo, private communication.

[37] William Bredo, private communication.

industrial research institute could perform an invaluable service to the development bank and also to the industrial entrepreneur. These may be summarized as follows (from William Bredo):[38]

1. Evaluation of pre-investment feasibilities;
2. Technology for environmental protection;
3. Opportunity gaps in the industrial structure;
4. Opportunities in newer sophisticated technology;
5. Adaptation and modification of technology;
6. Small- and medium-scale industry development.

The problem, of course is that most research institutes do not presently have the capacity to undertake many of the studies which would be important to the bank, techno-economic in character, including market feasibility, etc. Bredo[39] has suggested that government entities and development banks should work with the research institutes from both ends of the problem--by providing technical assistance for internal improvement and by giving them research grants and contracts which will build up their experience.

The development banks could provide material assistance to research institutes in assuring that institute research results are mated with industry interests. Perhaps the development banks should fund industrial loans which require liaison between industry and research institutes. Perhaps the development bank should develop liaison with an industrial research institute to keep abreast of what is happening in technological development and to jointly seek an entrepreneur with interests in a new project. Perhaps development banks such as the Inter-American Development Bank, the World Bank, etc., should take a leadership role in assisting national development banks to become knowledgeable about exploiting research results of industrial research institutes and getting these results into use. It would be entirely possible for the bank-institute team to provide technical as well as economic and marketing feasibility analyses, with the costs recovered by a forgivable or soft money portion of the loan.

Generally speaking, the development banks tend to ignore small-scale industry. The risks are greater, small-scale industry management is frequently weak, economies of financing favor big loans over small loans. It is also likely that development banks have not as yet recognized the potential which careful stimulation of small-scale industry could impart to the national economy in terms of increased employment, better products, community development, etc. Perhaps it might be possible for an industrial research institute to become a "technological partner with small industry and thus reduce the risk to the development bank loan." Perhaps a government guarantee could be provided to backstop such ventures.

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[38] William Bredo, Proceedings of the IPT-DRI Management Development Workshop, op. cit.

[39] William Bredo, private communication.

There are some examples of development bank-research institute inter-cooperation that will perhaps be useful as potential models. The examples are by no means exhaustive but merely illustrative of the various attempts underway to enhance and capitalize on a bank-institute interrelationship.

Sao Paulo State is heavily industrialized. Seventy percent of industry in Brazil is located in São Paulo; fifty percent of the GNP emanates from there. Sixty percent of the science and technology of Brazil is concentrated in São Paulo. Even so, there is a lack of articulation between the universities, the research institutes, and the productive sectors which deters effective utilization of science and technology in the development effort.

The State Secretariat of Economy and Planning is responsible for the development and implementation of programs designed to assist industry in increasing its output. The Secretariat, therefore, has devised a project that seeks to link science and technology to the economic development of the state, both as an important objective in its own right and as a model for the nation. Three years ago the Secretariat established a high-level Council of Science and Technology (CET),* and amongst other purposes, charged it with responsibility for the following São Paulo Project in Science and Technology:

- To promote the application of basic and applied scientific research and technology to the problems of Brazilian industry and agriculture;
- To develop the capabilities--in industry, government, universities, and research institutes--for providing an increased proportion of this research and technology from Brazilian sources; and
- To focus efforts for increasing capabilities in science and technology most closely on those industrial and agricultural sectors that hold promise for rapidly improving the capacities of commercial firms to compete successfully in world markets.

The CET and the Banco de Desenvolvimento de Estado do São Paulo (BADESP) are administering a financial incentives program of "soft" loans designed to:

- Encourage industrial firms to undertake specific research and development projects, either internally or by contract to Sao Paulo research centers;
- Aid and assist these research centers, both through the above industrial linkage and by direct financial assistance, in enhancing their capabilities to provide meaningful programs of technological research urgently needed for industrial development.

Approximately US$50 million in a revolving fund (US$15 million as a technical assistance loan has been obtained from USAID,

*CET now reports to the Secretary of Culture, Science and Technology.

and an equivalent amount from the State of Sao Paulo and Government of Brazil) undergirds the project.

In concept, this is an exciting and innovative approach which, although underway for less than three years, clearly requires close and careful scrutiny as it proceeds, both as a model for development in Brazil and, equally important, as a model for other developing countries.

The Secretary of Planning for the State of Bahia, Brazil, has recently created a Council for Science and Technology which coordinates three bodies having to do with application of science and technology to industrial development of that state. These are: FUNTEC, a foundation for support of basic research in the state's universities and research centers; CEPED (Centro de Pesquisas e Desenvolvimento), responsible for all applied science and engineering research; and CIETS, a center for information, statistics, data analysis, etc.

The Brazilian State of Minas Gerais Industrial Development Bank (BNDMG) has performed a rather remarkable entrepreneurial role in creating several new organizational entities designed to operate over a broad spectrum in the development field, giving to each other mutual support and forming a unique set of interacting agencies which function together for the industrial development of the region. A corollary and equally important partner has been the regional power utility, CEMIG, which has a role rather like that of the Tennesse Valley Authority, in expanding the use of electric power to make its operations profitable by supporting the promotion of the industrial development of the region.

In a sequence of events initiated in 1968, a BNDMG research department was spun off to form a new development agency--the Instituto de Desenvolvimento Industrial de Minas Gerais (INDI). INDI was established to promote the industrial development of the region by conducting research on investment opportunities to provide information to potential investors and to promote enterprises which would utilize the resources of the region.

The importance of INDI in this development process cannot be overstated. INDI was created to carry forward an action plan which included providing reliable information and other statistical data to industry and to advise entrepreneurs, either domestic or foreign, with regard to investment opportunities, financial and other assistance, governmental and private, which would be available to industry.

INDI has a staff of 31 engineers and nine economists, in addition to a variety of local and foreign consultants. INDI makes about 300 unsolicited contacts every month. It has established a data bank to provide information for the promotion of industrial development. Feasibility and other studies are conducted to identify promising investment opportunities.

In providing information to industry, INDI gives preference to the larger enterprises, who it is presumed would make a greater impact on the development of Minas Gerais. Small and medium entrepreneurs are given information only from the data bank, with little or no interpretation, analysis, etc. INDI management recognize

the short-sighted implications of such a philosophy but have insufficient staff to do more. INDI attempts to perform a "broker" role in bringing together potential domestic and foreign investors for the formation of new companies. INDI, however, provides only limited technical assistance to industrialists.

As a consequence of this, the Fundação João Pinheiro, a totally state-owned corporation, was created as a foundation to support development activities separately from the normal state civil service and other governmental constraints. More recently, an entity of the Fundação, the Centro Tecnológico de Minas Gerais (CETEC) has been spun-off as an autonomous non-profit corporation to provide scientific and technological support required for industrialization of the region.

CETEC works mainly with the Development Bank in assisting it to make sound investment decisions from the standpoint of the technology involved. In the past, the Bank has had some disappointing experiences as a result of not having access to adequate technical information related to the industry that they were financing. In some instances, there were complete failures of the business ventures because the technical aspects of their operations were not adequately investigated.

CETEC is just now initiating technical programs and is utilizing university and other space and facilities while awaiting completion of its own laboratories. CETEC areas of activity were selected mainly in accordance with recognition of regional resources and the development programs requested by the state government, and include R&D, testing, industrial design, information and documentation, and international marketing.

While INDI and CETEC work closely together, it has been considered administratively preferable to maintain them as separately operating entities. The wisdom of this decision may be in some doubt, inasmuch as CETEC is now beginning to develop its own industrial economics unit, some functions of which will obviously overlap with those of INDI.

Parenthetically, it should be noted that two other closely related organizations have been established outside of the state hierarchy. These are the Companhía Distrit Industriales (CDI) which handles the real estate and spatial aspects of industrial development. CDI assembles land for industrial estates, prepares the land, builds the infrastructure, and sells the land on a long-term basis to industrialists. The other agency, the Superintendencia for Fiscal Incentives (SIF) devotes its efforts to financial stimulation of industrial development.

It is too soon to tell whether this great diversion plan of the Minas Gerais Development Bank will indeed prove to be a uniquely different way to industrialize a region, or whether the several autonomous entities, somewhat in competition, will in actuality limit the effectiveness of the plan.

The U. S. Agency for International Development has recently extended to the Government of Colombia a long-term loan for small and medium industry development. The Corporación Financiera

Popular (CFP) will be the implementing entity and will assist Colombian small and medium industry development by (1) funding of innovative credit activities, and (2) providing funds, to be administered by the CFP, for technological transfer activities.

CFP has already established credibility as an aggressive, imaginative agency with a history of support for technical assistance. CFP will undertake the management role in developing credit activities of special impact on very small entrepreneurs. These will take the form of guarantee funds and confidence credits especially designed to reach the industrialist who does not have real guarantees, whose administrative systems are very poor, and who is located in small and medium cities or marginal areas of big cities. Loans will also be made, sometimes without guarantees, to cooperatives and other units, for acquisition of raw materials, manufacturing, mining, and agricultural activities.

The technical assistance aspects of the program are designed to provide technical assistance to the CFP and to small industry borrowers, either before the loan is made or at any time thereafter, if it appears that technical difficulties have occurred which are impeding the project. Participating organizations who will provide technical assistance as required are:

FICITEC-Fondo para Fomento de Ciéncia y Tecnología;
SENA-Servicio Nacional de Aprendizaje;
IIT-Instituto de Investigaciones Tecnológicas.

As a final example, I want to explain the unusual circumstances which have prevailed between the Instituto Centroamericano de Investigación y Tecnología Industrial (ICAITI) and the Central American development banking process. The ICAITI background will be presented in a subsequent chapter.

ICAITI is unique amongst research institutes in developing countries, for it is an institution serving five regional governments and their private sectors, and it is multinational and multipurpose in its functions. There is no regional policy nor a national one for each country on science and technology; indeed, there is no really cohesive regional policy on industrial development. These facts present problems that cannot be solved as easily as in the case of research institutes that serve a single nation. This means five, sometimes diverse, frequently nonparallel sets of constraints which influence ICAITI and its interactions with both the various public and private sectors.

In general, ICAITI has maintained good relationships with the various development banks in the Central American countries. On a contractual basis, these institutions have hired ICAITI's services in matters of technical assistance or the preparation of techno-economical studies. But formal and permanent linkages of cooperation have not been established between ICAITI and these institutions. The obvious question is, then, what are the barriers or constraints that have impeded a more effective interaction between ICAITI and the national development banks?

It is very difficult to pinpoint the heart of this matter. There are, in fact, many intangible factors which affect these relationships.

It is also evident that the nature of these banks plays an important role. All of them were established to stimulate economic development through loans and technical assistance. But the lack of funds and their rigid structures have, in some cases, curtailed their activities.

There are, however, two highly successful programs which have been undertaken by ICAITI for development banking interests in the Dominican Republic and Haiti. During a five-year period, ICAITI maintained a Technical Mission at the Central Bank of the Dominican Republic, by virtue of an assistance agreement signed with the bank in July 1968. The success of this mission is attested by the fact that the contract was renewed several times. ICAITI's Technical Mission in Santo Domingo, working in close cooperation with FIDE--the Investment Fund for Economic Development--was contracted to identify investment opportunities for small- and medium-size industries, to prepare appropriate feasibility studies, and to promote, jointly with the Bank, the identified projects among local entrepreneurs.

A total of 23 investment opportunities were identified which related to the manufacture of products being imported into the Dominican Republic. Of the 23 opportunities, nine were converted into viable industries within five years after initiation of the program; an additional eight identified opportunities are being further evaluated or are under serious consideration for implementation by local industrialists.

What has been the impact on the Dominican Republic by establishing the nine new industries? The industrial output of the country has increased by more than $3 million per year. The nine industries provide direct employment to 290 people. The investment in machinery and equipment, which was imported, amounted to almost $1 million. Savings in foreign exchange, from product substitution of exports, is estimated at more than $2 million per year.

Further, the nine new industires have generated important secondary economic benefits, by increasing the demand for local resources, materials, and services, all of which constitute non-quantifiable benefits.

When it is realized that the cost of the contracted services provided by ICAITI was in the order of $400,000, it is relatively easy to conclude that the benefits obtained to date, and anticipated, greatly exceed the cost of the contracted services. There is no question but that the Central Bank has recovered its investment through financing of the new industries.

These important contributions of ICAITI in research and development have demonstrated to the Central Bank the importance of a strong and continued industrial research institute-development bank interrelationship. As a matter of fact, encouraged by this successful relationship, the bank contracted with ICAITI to plan, establish, and develop INDOTEC, the Dominican Institute for Scientific and Technological Research. During the past two years, ICAITI has provided management, supervised construction of laboratories, searched for permanent staff, and initiated applied research and technical assistance services appropriate to the needs of Dominican Republic industry.

A similar agreement exists between ICAITI and Haiti's Institute for Agricultural and Industrial Development (IDAI). The contract calls for technical advice by ICAITI to improve, structure and strengthen the

technical and managerial capabilities of IDAI. Under this agreement, ICAITI is also to provide technical assistance to improve the productivity of the industrial concerns controlled by IDAI. It is still too early to ascribe a great success to this venture, but the results to date have been well received and the present contract is being renewed.

By contrast with the preceding two cases, the relationships between ICAITI and the Central American Bank for Economic Integration (Banco Centroamericano de Integración Económica, CABEI) and the Secretariat for Economic Integration (Secretaria Permanente del Tratado General de Integración Económica Centroamericano, SIECA) are not entirely effective. Inasmuch as the three organizations--ICAITI, CABEI, SIECA--are each a part of the Central American program for economic integration, close interrelationships should be expected as a matter of course and Central American Common Market (CACM) policy. There is obviously a mutual interest on the part of these organizations in optimizing contributions to regional economic development. CABEI, as a financial agency for economic integration, is interested in financing and promoting viable industrial projects. ICAITI's function within the integration scheme is to provide pre-investment industrial studies and technical services to industry. CABEI and SIECA have frequently requested the technical services of ICAITI in matters relevant to technological and industrial assistance. Some important industrial studies have been completed by ICAITI with CABEI financing, such as the "Study on the Food and Beverage Industry in Central America," and many others. There is no doubt that some of these studies have served to gauge the industrial potential of Central America and to detect some opportunities for investment. But the percentage of these pre-investment studies which have resulted in going industrial concerns is very low.

ICAITI has frequent and numerous contacts with high-level people in these organizations. But no scheme has evolved whereby ICAITI could provide technical assistance to these institutions on a programmed, permanent basis. I am referring here to contracts similar to the agreements which ICAITI has with the Central Bank of the Dominican Republic or with Haiti's Institute for Agricultural and Industrial Development (IDAI).

The obvious question is, then, why has such an effective interrelationship not developed between ICAITI and CABEI, or perhaps more importantly among ICAITI, CABEI, and SIECA?

Some answers are obvious and others are complex and intangible. For example:

- There is a lack of general coordination between the three institutions in matters of mutual interest and responsibility. ICAITI has an Industrial Advisory Committee in which CABEI is represented. But this has not been sufficient.
- There is no well defined industrial and economic policy at regional level to set the pattern for economic development. Thus, economic and industrial priorities set by CABEI, SIECA, and ICAITI are frequently different.

ICAITI management has initiated a concentrated effort to overcome this situation. Management and technical staff members make frequent visits to CABEI (and other Central American national banks)

to present potential ideas for consideration and to maintain an awareness of bank interests and needs. At ICAITI's request CABEI initiated a program of sending a CABEI staff member to ICAITI for one to two weeks at a time in order to learn more of ICAITI's capabilities to undertake feasibility studies, provide marketing and technical assistance, and developmental expertise, either on behalf of CABEI or for a Central American entrepreneur.

This effort has been only marginally successful to date. While ICAITI continues to send staff for discussions relative to potential technical assistance, CABEI interest in seconding its staff to ICAITI has largely disappeared.

In the course of extended discussions both with representatives of research institutes and the development banks, it has become apparent that the most effective strategy for increasing interaction between bank and institute will require the following elements:

- Two-way flow of staff members;
- Appropriate training of development bank people;
- Necessity for institute people to learn language of banks;
- Multiple-stage approach to problem-solving--where bank becomes involved in process after the conceptual idea is developed;
- Definition of the role of government planning organizations and their relationship with development banks and research institutes.

Government Intervention

Government intervention in the stimulation and application of R&D is an important issue in all developing countries and can be a potent factor in the technological innovation process, through application of mechanisms such as tax incentives for R&D, patents and licensing laws, investment opportunities, etc. Government intervention can, and frequently does, provide constraints on multinational companies, on licensing arrangements or on importation of products, processes, equipment, etc., with the objective of encouraging and stimulating national production of such items. Unfortunately, the extent and impact of such intervention is not often clearly understood. Different experts have different perceptions about what the important problems--barriers, blockages, screens--really are.

Some of these incentives and/or constraints have been mentioned earlier. It is appropriate here to briefly mention two examples of governmental incentive to stimulate use of indigenous R&D. Barriers and constraints will be discussed in greater detail in Chapter 4.

The State of Bahia in Brazil has imposed a "circulation of goods" tax, based on 15 percent of the wholesale value of materials produced or processed and used by another industry. Such taxes are collected by the state development bank, DESEMBANCO, which holds 60 percent of the taxes collected as a credit in the name of the taxed industry. But these credits are available for use only for development programs, such as research and development on new products, plant improvement and expansion, purchase of new equipment, etc.

Irrespective of the nature of the proposed development program, DESEMBANCO has stipulated automatic, mandatory review by CEPED, thus, in effect, making CEPED the coordinator for technological development in Bahia.

Review by CEPED may require technical evaluation, assessment of equipment or expansion desired, or may require research, economic analysis, etc., to verify the validity of the proposed development. Industry will contract directly with CEPED for such services and on completion of the evaluation will be reimbursed by DESEMBANCO from that industry's account. Certainly, it is clear that CEPED becomes an important partner in the development process, providing that the institute can produce. The program is too new for a meaningful analysis but is interesting as a concept for forcing interaction between industry and the research center.

The Peruvian Government, in 1970, established the Institute of Industrial Technological Research and Technical Standards (ITINTEC) as a public organization, decentralized from the industrial and commercial sectors and with administrative and economic autonomy to undertake the following:

- Promote, coordinate, orient, and execute industrial technological research according to the policy of development and promotion from the Ministry of Commerce and Industry;
- Promote and develop greater use of technical standards in the country;
- Approve national technical standards.

In order to support a national program of R&D, the government has imposed a tax of two percent of the net income of industrial corporations to be utilized either by the corporations or by ITINTEC to undertake research studies designed to decrease Peruvian dependence on foreign technology and accelerate development through the creation of indigenous appropriate technologies. The essential elements of the law are:

- The projects undertaken may be individual or collective. The law provides that a group of companies may join together to invest two percent of their joint net income in financing a project of common interest;
- The projects may be undertaken by industry, either individually or collectively, through use of their own research facilities or by contracting with other public or private research organizations, the universities, or ITINTEC;
- If the cost of the proposed research project exceeds the amount equivalent to two percent of net income for one year, project costs can be carried forward as debits against anticipated tax recovery, up to a maximum of five years;
- All research projects undertaken with funds under this law require prior evaluation and assessment by ITINTEC as to appropriateness, applicability, capability of the proposed research organization to complete the project, reasonableness of funding, etc.;

- ITINTEC is responsible for monitoring and periodic reviewing of research projects and has full access to data produced by such research;
- If industry does not initiate research projects, or does not utilize all of its tax credits, the funds revert to ITINTEC, who may use such funds for support of other R&D as deemed appropriate to the national need.

This program has been underway in Peru for a relatively short time. Needless to say, however, Peruvian industrialists, since they are being forced to support R&D in a real and measurable way, are becoming extremely interested in the process of R&D and are beginning to seriously consider the impact which such a program can have on their own products or processes.

Korean industrialists are encouraged to make investments in R&D, either internally in their own laboratories or externally by contracted services with universities or institutes such as KIST. Tax exemptions up to 100 percent of the R&D expenditure are possible, so that Korean industry is acutely aware of the potential for utilization of R&D results. By contrast, the Government of Brazil, which has been innovative in providing tax exemptions and similar incentives for nearly every form of commercial enterprise, has thus far refused to allow tax exemptions to industries who would spend such funds on the support of R&D, on the grounds that such an incentive plan is unmanageable and unaccountable.

CHAPTER 4

BARRIERS AND CONSTRAINTS TO INSTITUTE EFFECTIVENESS

Major problems confront the process of converting or adapting new or existing technology to another use; additional research and development must be carried out, production planned, capital allocated, and marketing studies conducted. So-called "barriers to innovation" exist in all stages of the development of a new product. Faced with the substantial investment required, large industries have been slow to exploit much of the new advanced technology, and small companies have found it most difficult to participate except in those cases where the barriers and conversion costs are minimal. Much of the more sophisticated technology with far-reaching economic and social implications remains unexploited because of the substantial investments required for its conversion. New approaches should and must be used to assure effective utilization of this most valuable and potentially productive resource.

One of the chief problems lies in the conversion process--that innovative process which must take place to adapt the original technology to a new use. The barriers which stand in the way of the successful adaptation of an idea are many and formidable and involve several complex social, economic and human factors. Each potential user has its own set of barriers, some of which are peculiar to its own environment and which can discourage the adoption of new ideas.

Non-Technical Barriers

To illustrate the complexity of the conversion process and the factors which influence it, several of the chief barriers should be mentioned. The importance of each of these will, of course, vary widely depending upon the country, the industry, the nature of its product and its resources. They include:

- The high cost and risk involved in additional research and development to adapt the new technology for another application;
- Difficulty in deciding among which of many potential innovations to commit resources;
- The level at which innovative ideas enter the industrial system;
- The substantial investment in capital, equipment and trained personnel required for the manufacture of a new item;
- The investment required for new material procurement;
- Lack of quantitative cost data as to production and development costs;
- Lack of reliability and performance data on the new item;
- Risk and cost in marketing and distributing a new product;
- Resistance to making changes in existing and proven products or systems;
- Lack of capital for investment in new ventures;

- Reluctance on the part of individuals to take responsibility for the failure of a new venture.

Barriers such as the above are difficult to overcome in technologically sophisticated countries such as the United States. These become almost insuperable barriers in the developing nations.

It is fair to state that the less adaptation or conversion required, the easier it will be to find a user. The real impact of this, however, is that the more sophisticated and advanced concepts, which require substantial investments to convert, are the ones which are less frequently adopted. Further, only those few companies with considerable venture capital can afford to risk exploiting the most advanced concepts, and small business has little opportunity to introduce new ideas. Yet these advanced concepts may be the ones most needed for application to many of the major problems confronting society.

The major problem in approaching the design and development of programs to either increase the rate of innovation or to increase the rate of technology transfer is to make sure that programs are addressed to real problems; that is, many programs are addressed to perceived problems or barriers in the transfer and diffusion and innovation process, but in reality these problems or barriers are usually based upon conventional wisdom and may be either trivial or nonexistent.

The barriers which confront new ideas are as many and varied as the innovations themselves, but it seems certain that key hindrances to innovation can be identified. Pinpointing the most common and acute obstacles should suggest critical points at which programs could be applied to foster innovation and overcome blockages. These programs could be aimed at promoting the adoption of selected innovations which otherwise might be ignored by industry; specifically, innovation incentives could be applied to ideas representing potentially great benefits to the developing nation.

I commented in Chapter 1 that one of the objectives of this study was to attempt to:

- Differentiate between those types of constraints to development which are country-specific and those common problems which have limited the value of research institutes regardless of their geographical locations.

In my view, there are three key issues which directly influence the above. These are:

- R&D of the bench level is seldom of interest to industry until production, marketing, training and other parameters are defined;
- There is an inordinately long delay between conception of an idea and reduction to commercialization; and
- Technological knowledge has been shown to be less important in the innovation process than a sizable number of non-technical constraints.

An analysis of barriers to institute effectiveness quickly becomes subjunctive in nature. Perhaps most importantly, it is difficult to assign real values to such an analysis. The spectrum of problems is extremely broad. A few examples to be considered are:

1. Civil service rigidity and limitations;
2. Budgetary constraints and lack of discretionary control;
3. Lack of coordination between national plan and institute programs;
4. Inappropriateness of institute programs;
5. Unawareness of industrial problems and needs;
6. Lack of client-oriented promotional and program development activities;
7. Problems of professional staff recruitment, development and incentives;
8. Management limitations on development, delegation of authority, and encouragement of staff;
9. Failure of universities to train potential institute staff members appropriately;
10. Government interventions which may enhance or impede institute-industry interaction.

I feel that one must differentiate between barriers and constraints on the basis, particularly, that the research institute or its management staff may be almost completely unable to influence the barrier (e. g., civil service rigidity and limitations) to effective interaction with public or private sectors, while there is some hope that constraints (unawareness of industrial needs) might be altered or modified, with appropriate skill, consultative assistance, etc., to encourage and, in fact, achieve increased industrial interaction.

For example, I described earlier the supposition frequently held that an industrial research institute was expected to be a major contributor to the industrial innovation process. It has been rather clearly demonstrated that it is possible for a research institute to become a contributor, but, for the most part, such contributions occur only in the first stages described by Charpie as a "continuous innovative chain linking scientific research, marketing research, invention, development design, tooling, first production and marketing of the new product."[40] Charpie has estimated typical costs in successful product innovations as shown in Figure 3.

Now it may be seen that the industrial research institute, in the majority of instances, must be regarded as a minor, although admittedly important, factor in the following defined distribution of process innovation costs. In fact, unless the research institute is willing, indeed encouraged, to establish demonstration plants, initiate limited production, conduct market feasibility studies, and train the employees of potential entrepreneurs, it is unlikely that much of the potential for institute contribution to innovation will achieve reality.

Specific Obstacles Constraining Innovation

As an example of the inadequacy or inability of a developing country research institute to cope with the innovation process in its

[40] R. A. Charpie, Technological Innovation--Its Environment and Management, U. S. Department of Commerce, p. 8, 1967

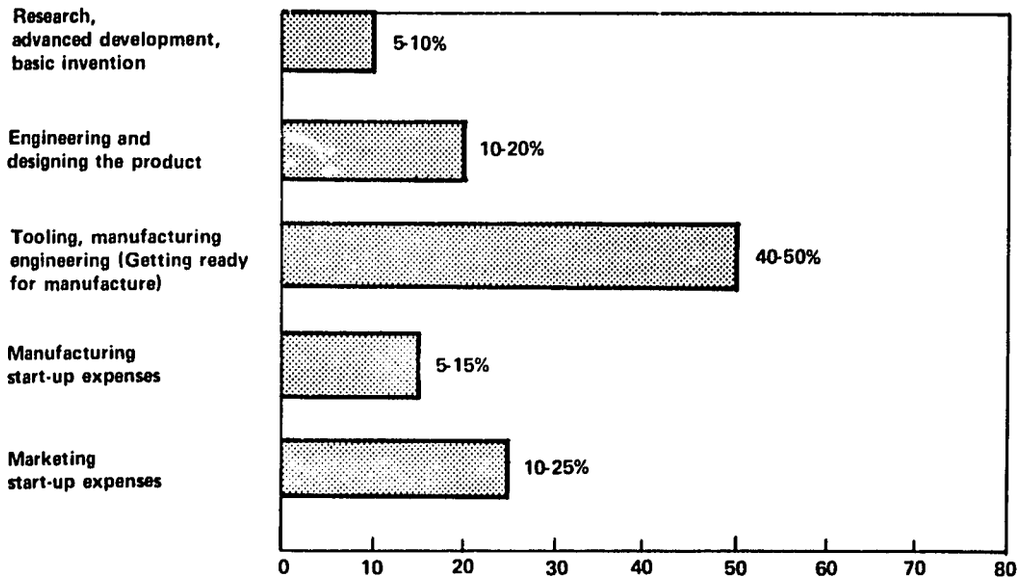

Figure 3. Typical distribution of costs in successful product innovations.

totality, it may be appropriate to cite the findings of a study[41] of a selected number of U. S. industries. The general approach was to develop case data on technological innovations that were either stopped, delayed or shelved, then determine what the causes were, and then attempt to assess what, if anything, could be done to overcome these blockages.

Analysis of these case data was first based upon separating those innovations that respondents believed should have stopped for legitimate reasons from those that respondents believed should have continued through to market development and full-scale production. Myers and Sweezy found that respondents reported a wide variety of different obstacles affecting the innovations. These obstacles were then catalogued and categorized. Prior experience has identified in the United States a total of 87 different kinds of obstacles spread over nine different categories. The nine general categories of obstacles that stop, delay, or shelve innovations are as follows: management-related; organization and staffing-related; capital, budget, and finance-related; marketing-related; regulations and laws-related; patent-related; anti-trust-related; technological-related; and a category of others including such problems as labor unions.

It is interesting to examine these categories of obstacles and, particularly, sub-categories within these which have constrained the innovation process (see Table V).

[41]Sumner Myers and Eldon E. Sweezy, "Why Innovations Falter or Fail--A Study of 200 Cases," A Report to the Denver Research Institute for the National Science Foundation under Contract NSF-C860 (to be published).

TABLE V[42]

Specific Obstacles Contraining Innovation

Category and Obstacle

1. MANAGEMENT (internal)

Poor market analysis
Company policy not aggressive
Poor marketing planning or strategy execution
Inadequate performance requirements definition
Inadequate cost analysis

2. ORGANIZATION AND STAFFING

Exceeded staff capabilities
Inadequate marketing expertise or distribution organization
Inadequate internal responsibility assignments

3. MARKET (external)

Producer's cost/price ratio unacceptable for market competition
Limited sales potential
Customer's cost/benefit/risk analysis unfavorable
No perceivable market for public interest innovation
Inability to aggregate market
Too many competitors

4. CAPITAL

Insufficient resources for needed research
Opportunity cost too high
Insufficient capital to start new product lines
High cost of pilot production and test program
Installation or changeover costs too high

5. LAW AND REGULATIONS (excluding patent and anti-trust)

Federal requirements uncertain
Federal standards too stringent
Excessive length/cost of federal tests
Interstate variability

6. PATENT

Government patent rights policy too restrictive
Inconsistency of court protection
Competition has cross-licensed patents

7. ANTI-TRUST

Anti-trust law bars industry joint effort

8. TECHNOLOGICAL BARRIERS

Design problems
Superior competing technical approach
Difficulty in controlling process quality

9. OTHERS

Potential labor union opposition (in customer's company)
Inadequate government response to proposals

[42] Ibid.

While it is highly likely that a survey of barriers to the innovation process in any one country would uncover all or most of the same 87 barriers mentioned above, the relative importance or priority ranking of the barriers would differ depending on indigenous conditions, the stage of economic development, and the climate for innovation in a particular country, as would the solutions or policy recommendations that could be used to overcome the barriers. Most likely, each country has a unique profile of significant barriers to which policy solutions should be addressed.

Characteristics of IRIs Tending to Inhibit Interaction with Industry

In conjunction with management development workshops being conducted by the Denver Research Institute, * Donald D. Evans has utilized a group discussion approach to develop relative rankings, in the opinions of participating research institute directors, of the external and internal constraints which tend to inhibit or impede interaction with industry. His results, stemming from workshops conducted in Latin America and Southeast Asia, are summarized below.

TABLE VI[43, 44]

Internal Constraints of Research Institutes
Tending to Inhibit Interaction with Industry
(based on a ranking of 1 = high, 7 = low)

	7 Latin American Institutes	10 SE Asia Institutes
Lack of physical facilities	7	5
Low pay for professional technical staff	4	1
Inexperience	5	2
Disinterest in practical problems	3	7
Inadequate knowledge of industry	1	3
Poor marketing skills	1	3
Inadequate information resources	6	6

*In cooperation with Instituto de Pesquisas Tecnológicas, São Paulo, Brazil. Participants from Brazil, Colombia, Guatemala, Venezuela.
*In cooperation with Applied Scientific Research Corporation of Thailand, Bangkok. Participants from Thailand, Taiwan, Korea, Philippines, Pakistan, Singapore, Malaysia, Indonesia.

[43]Donald D. Evans, "The Role of Industrial Research Institutes in a Rapidly Developing Region," Proceedings of the IPT-DRI Management Development Workshop, São Paulo, October 22 through 27, 1973.

[44]Donald D. Evans, "The Role of Industrial Research Institutes in a Rapidly Developing Region," Proceedings of the ASRCT-DRI Management Development Workshop, Bangkok, Thailand, July 8 through 19, 1974 (to be published).

TABLE VII[45, 46]

External Reasons for Inability of Research Institutions to Serve Industry
(based on a ranking of 1 = high, 10 = low)

	7 Latin American Institutes	10 SE Asia Institutes
Lack of mutual interest and understanding	1	1
Inadequate technological payoffs	3	3
Lack of confidence in a technological institution's capabilities	4	2
Industry bias toward government institutions	8	7
"Tied aid"	7	10
"Tied" technical assistance from foreign companies	6	4
Protected markets	10	9
To buy or to develop?	5	6
"Leap frog" tendency	9	4
Power, control and politics	2	8

So far the data are too sparse to achieve other than a simple, qualitative rationale for the relative rankings of 17 research institute representatives. It is clear again, however, that the research institutes involved in these workshops recognize their weaknesses with respect to marketing skills and knowledge of industrial problems. There is also recognition that institute and industry do not understand each other and that industry lacks confidence in the ability of the institute to find solutions to industrial problems. Perhaps the great disparity in the relative rankings for power, control and politics can be traced to the predominantly military governments in Latin America as contrasted with nonmilitary governments in Southeast Asia. It is also true that, insofar as salary schedules are concerned, Latin American institutes, because they are already nearly autonomous or are approaching autonomy, enjoy more competitive salaries and are currently experiencing less difficulties in attracting and retaining staff than are research institutes in Southeast Asia.

Problems of Commercializing R&D

The Traces study has demonstrated clearly the long-time interval between conception of an idea, solution of the technological problems, and ultimate conversion into a commercially viable process (see Table VIII).

[45] Ibid.

[46] Donald D. Evans, Proceedings of the IPT-DRI Management Development Workshop, op. cit.

It must be recognized that variation in the time span between concept-laboratory research-demonstration plant-commercial utilization can be profoundly influenced not only by technological capability or funding availability but also by political, cultural, socio-economic, and other factors over which a research institute can exert virtually no influence. While the green revolution rice program, for example, can be adjudged to be successful technically, the fact remains that seed costs are higher, more fertilizer is required, many people have not yet accepted the different taste of the new rice strains, etc., so that both economic and cultural considerations remain to be solved. Similarly, protein-enriched food products such as Gari, Incaparina, a variety of bread flours, soft drink mixes, pasta, etc., while technologically feasible, most frequently are more expensive and thus out of reach for the food requirements of the very poor who need such products most desperately.

A few examples of industrial research institute attempts to develop and commercialize R&D results are worthy of note. In each of these cases, technical know-how and feasibility have been demonstrated, but the barrier has evolved around the unwillingness of industry to attempt to implement the process.

TABLE VIII[47]

Duration of the Innovative Process for Ten Innovations

Innovation	Year of First Conception	Year of First Realization	Duration (years)
Heart Pacemaker	1928	1960	32
Hybrid Corn	1908	1933	25
Hybrid Small Grains	1937	1956	19
Green Revolution Wheat	1950	1966	16
Electrophotography	1937	1959	22
Input-Output Economic Analysis	1936	1964	28
Organophosphorus Insecticides	1934	1947	13
Oral Contraceptives	1951	1960	9
Magnetic Ferrites	1933	1955	22
Video Tape Recorder	1950	1956	6
Average Time Span			19.2

The problem relates to the difficulty in "selling" research results to a potential user. Observations to date have revealed a surprising amount of uniformity in the similarity of the problem, influenced perhaps by the level of country technological sophistication, but nonetheless a recurring problem to nearly all research institutes.

[47] Science, Technology and Innovation, Battelle Memorial Institute, prepared for the National Science Foundation under Contract NSF-C-667, February 1973.

The PCSIR laboratories in Karachi, for example, initiated a project in 1959 to develop a chlorinated petroleum-base insecticide. The process was patented in 1963 and 1964. Toxicity tests on the product, Petkolin, were completed between 1964 and 1967; a one-ton-per-day pilot plant was built in 1967. Total investment was approximately US$300,000 for research and US$150,000 for construction of the pilot plant, or US$450,000 total investment.

Pakistan currently imports approximately US$60 million pesticides per year, which is meeting only about 20 percent of need; the country cannot afford to import more. It is estimated that this new PCSIR process can replace 20 percent of the above imports. The PCSIR is willing to lease its pilot plant to an industry on a rental basis and produce the product until a larger plant is completed. The PCSIR would expect a primary fee and royalty payments for use of the process.

On the surface, this appears to be a good investment and a process which should be put to work. But there was no economic analysis and market feasibility of the potential for the process, which should have been conducted early in the developmental program. What was subsequently learned was that the Pakistan Government provides a substantial subsidy to importers of pesticides so that imported pesticides are, in effect, cheaper than the PCSIR-developed Pektolin. Recently, Pektolin was placed on the government-approved list on the basis of being a locally developed process. A more accurate economic assessment of the process, however, reveals that Pektolin production will cost approximately 15 percent more than similar imported pesticides. Thus, commercial exploitation of the process may not take place without further government intervention, such as import quotas or other constraints on imported pesticides.

The National Institute for Electrotechniques in Indonesia has developed some very interesting electronic communications devices (mobile dial telephones and multiplexing communication links) which they feel to be important to Indonesia's communications needs of the future. But the government agencies have not recognized such a need, and industrial manufacturing concerns who have reviewed the prototypes will become interested only after production, economic and marketing considerations are resolved. There is no economic and marketing assistance available to the NIE laboratories. The director recognizes the need for help in selling his developments but is stymied in his efforts to go further.

The experience of KIST and the development of a capability to produce tantalum solid electrolytic capacitors should be mentioned. During the course of a program to identify, adapt and transfer hard aerospace technology to Korea,[48] KIST ascertained that three Korean electronics firms are interested in producing or using tantalum capacitors for use in electronic calculators and various military communications equipment. The present domestic market for these is estimated at US$1 million and can be expected to expand rapidly in the future. External markets are expected to be good.

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[48] In cooperation with Illinois Institute of Technology Research Institute under Contract NASW-2083.

On the basis of this expressed interest, KIST initiated a development project to establish procedures for fabricating, quality control, and reliability engineering. This capability has been achieved. KIST is in a position to assist in the establishment of production lines, training of industry personnel, and continued consulting to assure success of the project. A thorough study of economic feasibility of a tantalum capacitor industry has been proposed to be supported jointly by the interested industries. But these have indicated they are unwilling to proceed further until there are stronger assurances of an actual domestic market.

One potential producer of the capacitors, Sam-Wha Condenser Industry Company, currently produces aluminum capacitors and has received considerable assistance from KIST in product development and evaluation. The company is expected to contract with KIST in the near future for pilot plant operations for substitute raw materials for ceramic capacitors and sintering of ferrite cores.

It appears that there is no lack of confidence in KIST; however, the economic and management incentives seem to be lacking for early production of tantalum capacitors which would enable Korea to become more aggressive in export sales of electronics components. Thus, KIST has undergone a process development program which may well be delayed in implementation for two to five years and may even be by-passed by other advances in electronics.

Interestingly, other KIST electronics projects in miniature transceivers and high-sensitivity transceivers, initiated under the technology transfer program with IITRI, have resulted in prototype production and field tests are being conducted.

In Chapter 2, I mentioned the success of the PCSIR in finding industrial concerns who were willing to pay part of the cost of PCSIR processes and to put these into commercial use. It is interesting to examine an analysis of the processes which have been sold or leased. These may be categorized as follows:[49]

PCSIR process know-how and technology	74
PCSIR process know-how and imported technology	10
Small-scale processes with no technological problems	50
Total Processes in Production	134

This breakdown does not include 100 processes which have been leased out but not in production, processes of a classified nature for the Defense Ministry, and miscellaneous projects undertaken for industrial clients to improve processing, formulation, purification/preservation or yield. Again, less than one-third of the incurred R&D costs have been recovered by PCSIR through sales or leases, although, in my view, this nonetheless represents a rather remarkable achievement in the face of the frequent reluctance of industry to utilize R&D.

[49] M. Aslam, PCSIR, Its Economic Impact, Cost-Benefit Analysis of Some Typical Projects, Pakistan Council of Scientific and Industrial Research Laboratories, Karachi, November 1974.

There are a few other examples of institute experiences in attempting to sell the results of internally generated R&D which will assist in delineating the problem of transferring R&D results into utilization by industry.

The Federal Institute of Industrial Research in Nigeria has spent several years perfecting a commercial process for Gari, a low-starch staple food from Cassava roots and currently produced on a limited basis in almost all Nigerian villages. The local product lacks controls, and taste and starch content vary drastically. The FIIR process produces a good quality Gari but at higher unit cost than the village product. Two problems are unresolved. These are mechanical peeling of Cassava roots and assured production of the root.

FIIR, in cooperation with a foreign firm, is trying to sell the process and has tried to obtain financial assistance from the Nigerian Development Bank. NIDB, uncertain of economic feasibility of the process, is unwilling to finance the project.

In the meantime, in a separate deal with another agency of the government, a Brazilian company is entering into Nigeria to produce Gari, using its own equipment and process and ignoring the FIIR process.

The Instituto de Investigaciones Tecnológicas (IIT) in Colombia has achieved considerable experience in food technology pilot plant operations and has been quite successful in developing processes for preserving and canning bananas, mushrooms, various fruits and vegetables, which processes have been passed onto industry.

One of IIT's main interests is preparation of protein enrichment of common foodstuffs such as bread, pastries, pasta, etc. During the past two to three years IIT has developed suitable formulations, has established a pilot plant, which is in actuality a small-sized industrial operation, in order to demonstrate the quality, taste, processing methodologies, economics, etc. IIT staff have aggressively interacted with potential multinational as well as local industrial clients with a variety of on-site demonstrations, sample product runs, market analyses, etc. The increased cost for protein enrichment is reasonable and probably would not result in decreased product sales. The process modifications required for enrichment are not unduly complicated and do not require extensive plant equipment modifications. So far, the bakery and pasta industries have been reluctant to utilize the new product.

IIT has, however, been successful in contracting with a local milk processor who will distribute, on a trial basis, an IIT-developed protein-enriched drink that could serve as a substitute for milk (Colombia has a shortage of milk). If the trial is successful, the milk processor will go into full-scale production, utilizing the IIT process.

ICAITI in Central America several years ago was successful in developing a protein-enriched corn flour, called "TORTIYA." Since corn flour for tortillas is commonly accepted as a basic component of the Guatemalan diet, TORTIYA has been widely accepted with beneficial results. The cost of development of the process has been estimated to be around US$100,000--both direct and indirect costs. ICAITI sold the process outright several years ago to General Mills for US$20,000. General Mills' income from this process has been estimated to be around US$4 million to date. By ICAITI management's own admission,

the project was successful from a technical point of view but not from a financial management point of view.

The point at issue relates to the difficulty in "selling" R& D, which, in turn, evolves around having staff experienced in identifying a potential client and sufficiently knowledgeable about the client's needs as well as potential for utilization of the available research results. Probably one of the greatest weaknesses confronting research institutes is their lack of experience in selling R& D.

It is important to repeat the barriers which industrial research institutes face in selling their services to industrial clients. These were generalized in Chapter 3 as follows:

- Industry lacks confidence in the ability of research institutes to provide meaningful solutions to their problems in a reasonable time and at a realistic cost;
- Industry (and government enterprise) believes that it should not pay for the services provided by a research institute, when such institutes are largely subsidized by government funds derived from industrial taxes;
- Industry usually is wary of the research institute-government relationship which could result in disclosure of potential patent possibilities, technical secrets, or management information to government agencies or competitors;
- Industry does not often evidence a genuine interest in the research results of an institute until these have been carried through a pilot or demonstration plant phase, and production, economic and marketing feasibility have been resolved.

WAITRO Rating of IRI Priority Needs

The WAITRO survey of research institute needs, referred to earlier, and my own discussions with institute directors, show clearly the preoccupation of these managers with gaining experience required to sell their services to the industrial sector. In a way, the survey can also help to define the internal and internecine barriers which confront an institute. It may be seen that, by and large, staff development programs have a higher priority than do building and facility requirements, or administration of research. These priorities are summarized in Table IX.

Parenthetically, it should also be observed that the survey evolved from the first Biannual Conference of WAITRO in October 1972, which had as its principal theme the management of industrial research. Undoubtedly, most experts anticipated that research institute management would be a high priority item; after all, every research institute conference since 1964 has sounded this theme. But in actuality, as will be seen from Table IX, management requirements were perceived to be much lower in priority than those needs having to do with identification and understanding of industrial problems and the promotion and selling of technical services. This may have resulted in part from the questionnaire format, which fragmented the overall problem of institute management into several subsections, thus inviting a variable mix, particularly when such a small sample was involved.

TABLE IX[50]

Priority Ratings on Industrial Research Institute Designated Needs

	Priority Rating	
	Relative Position	Relative Weighting, %
Industrial training of technical personnel Training in industrial application of R&D	1	100%
Industrial exploitation of R&D results	3	91
Financing of equipment Financing of training of personnel	4	89
Managerial training of personnel	6	86
Financing research projects Dissemination of technical "know-how"	7	84
Promoting research programs Sources of technical information Needs related to trouble-shooting	9	82
Training in promotion of technical services and research Financing travel to seminars, meetings, to other IRIs	12	79
Needs for library services, operation of library	14	77
Academic training of technical personnel Information on IRIs with particular capabilities	15	75
Evaluating research programs Information on industrial equipment	17	72
Needs related to physical testing	19	70
Planning research programs Needs related to chemical/biological testing	20	68
Assistance in administration of IRI Financing technical services Assistance in selecting research programs	22	65
Assisting in planning, organizing and operation of IRI Assistance related to chemical/biological analysis Needs associated with standards or approval testing	25	63
Financing buildings	28	58
Assistance in planning buildings, other physical facilities	29	51
Justification of establishing institute	30	35

[50] WAITRO Publication No. 3, op. cit.

IRI Management--A Controllable Problem?

I tend to believe that the phrase "industrial research institute management" has become a cliche to fall back on in the course of institute evaluation and its success or failure when conducted by an outside expert. It is, or should be, perfectly clear that management practices must vary depending on whether the institute is totally or partially government-subsidized, under civil service or similar constraints, or is a private entity. Even where policies of themselves offer no constraint, institute management usually is successful or unsuccessful depending on the capability of the individual director. All too frequently institute directors receive such appointments because they have had distinguished careers or are competent scientists, talents which do not always connote competence or ability in the art of research institute management. To quote Nayudamma:

> The conduct of research and development in a country like India is affected also by the fact that the directors and managers of research institutions are generally drawn from the universities and bring with them the outlook which is conventional there. They may have little or no experience of collaborative or team research; they are jealous of departmental boundaries, distrustful of equals, and imperious toward subordinates. Each research worker is allowed to continue in his own way working in a watertight compartment with no interaction with other disciplines, and working on problems which have no clear relationship to practice or application. There are no concerted efforts involving whole teams whose efforts are focused on problems, the solutions to which could be incorporated into industrial production or practical activities.
>
> In principle, these arrangements might well be adequate or even indispensable for fundamental research, especially where the necessary cultural conditions exist. Applied scientific and technological research, particularly in underdeveloped countries, can only be made effective through the use of modern methods of management.[51]

I see clear indications that such categorization is diminishing with experience, acquisition of highly qualified, younger staff members who are insisting on downward delegation of responsibilities as a condition of continued employment, and recognition by research directors themselves that change is mandatory in order to integrate their institutes more effectively into the process of industrial development. Further, the increasing focus by governments on accountability for institute programs, anticipated results and accomplishment of these certainly

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[51] Y. Nayudamma, "Decentralized Management of R&D in a Developing Country," Minerva, Vol. II, 4, p. 516, October 1973.

exerts positive pressure on the institute director to review his operating policies and procedures and to incorporate needed change.

Research institutes which are required to operate under government civil service regulations are confronted with unusually severe problems, which, in many instances, effectively preclude meaningful interaction with industry. Some of these problems were elaborated in Chapter 2. The motivation and management of civil service employees becomes particularly acute. Often the institute directors are not really aware of their government's plans. Indeed, these are only infrequently included in the planning process. Until recently, the tendency has been to permit the institute to exist, often at a marginal level, but to provide neither the funds nor the operational flexibility necessary for the institute to cope with changing requirements.

The problem was discussed in detail during the UNIDO-sponsored Beirut Workshop, where the following conclusions were reached:

> In most of the developing countries it is a problem to convince government officials that the government should give money to a national research institute without having the privilege of controlling its activities, that is, controlling the appointment of personnel, the expenditures and the programs of research and evaluating the results of the research work.
>
> The national industrial research institute should be an independent organization with its own board of directors representing the government, educational institutes, industry, commerce and agricultural organizations. Its budget should come directly from the congress or parliament rather than from any one ministry budget. It should be independent from the control of a particular government department. Its administration should have freedom in establishing the salary scale of research personnel and in purchasing equipment and machinery without the hindrance of bureaucratic red tape.[52]

A variety of changes are beginning to take place in several countries which aid in overcoming or circumventing such problems. Institute directors are devising means of establishing separate "revolving fund" accounts, not always legally permissible but tacitly approved in most instances by governments, into which additional income collected from analyses and tests, various services, contracts, sale of products, etc., are deposited and from which monies are withdrawn to expand facilities, make incentive payments to staff, etc. In other words, such revolving funds become discretionary in nature and, being controlled by the director, provide considerably more latitude in decision-making regarding the operation of the institutes. This will be discussed in greater detail in Chapter 5 on research institute management practices.

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[52] Proceedings of the Interregional Seminar on Industrial Research and Development Institutes in Developing Countries, United Nations Publication, Vol. II, Part 4, Beirut, 30 November to 11 December 1974 (ST/TAO/SER. C/77/Vol. II).

The Impact of Limitations on Government Funding of IRIs

There are several research institutes who are experiencing a reduced level of government support, either due to steady state government inputs in the face of double-digit inflation, spiraling costs, and required growth to retain a competitive position, or because the government is deliberately decreasing its subsidy in order to force increased interaction with public and private enterprise. These institutes are seriously concerned about the necessity for promotion and program development activities and training or acquiring staff members who will aggressively seek clients willing to support projects within the institute.

The PCSIR in Pakistan is experiencing a deliberate curtailment of its operating budget each year. The government withholds a certain amount from each laboratory budget with expectation that the amount withheld will be obtained by the laboratory from contracted services. In the case of the Karachi laboratory, for example, the government withheld 200,000 Rps (US$20,000) in 1973 from a budget of 4.5 million Rps; 300,000 Rps in 1974 from a budget of 5 million Rps; and is withholding 500,000 Rps in 1975 from a budget of 6.5 million Rps. This, in my view, is an excellent way to exert a positive push on the research institute to more aggressively seek interaction with industry. Further, such an approach clearly demonstrates recognition by the government that increased interaction with industry is necessary.

The case of level governmental subsidy or financial support can also be cited for ICAITI in Central America and IIT in Colombia. The government subsidy which the five Central American governments provide annually for partial support has remained unchanged since ICAITI's creation some twenty years ago. With the passage of time and inflationary cost of operation increases, the net effect has been an actual reduction in government support, thus forcing ICAITI to assume a much more aggressive attitude in promoting and obtaining contract services.

ICAITI has been highly successful in this regard. For example, during the period 1970 to 1974, ICAITI's operating budget has increased from US$885,000 to US$1,446,000. Government subsidies,* as a percentage of the total budget, have declined from 36.6 percent in 1970 to 19.7 percent in 1974. Contracted services with industry, government entities, regional organizations, and international entities (UNEP, OAS, USAID, IDB, etc.) have increased from 59.8 percent in 1970 to 73.5 percent in 1974. (Interest on investments, donations, sale of documents, etc., make up the balance.)

The subsidy provided IIT by its sponsors** has remained constant for the past eight years, although it is expected to increase slightly during 1975. The 1973 IIT operating budget was US$750,000, of which US$490,000 was earned from contracted services with public and private enterprise. The projected 1975 operating budget is US$780,000, of which contracted services in the amount of approximately US$520,000

*As distinguished from government contracts for specific services.
**Banco de la Republica, Federación Nacional de Cafeteros, Empresa Colombiana de Petróleos, Caja de Crédito Agrario, Instituto de Fomento Industrial.

must be procured if IIT is to avoid staff retrenchment, reduction in services, etc. The pressures on IIT management are severe to say the least. Further, much of the increase in costs is due to inflation and does not really represent a growth situation. The IIT director and his senior staff are seriously focusing on this problem and are receiving technical and management assistance through their linkage with DRI.

The industrial contract support of KIST has also increased dramatically, from 31 percent (of an operating budget of US$1,140,000) in 1970 to 57 percent (of an operating budget of US$6,200,000) in 1974. While 1975 figures are not available, a continuing trend toward increased industrial utilization of KIST's services is anticipated by KIST management. From a pragmatic viewpoint, I would expect this ratio to level off somewhere around 70 percent industrial support and 30 percent government support, and the KIST staff will be required to work very hard to attain and maintain such a ratio.

SISIR, which is an autonomous government corporation, has experienced steady growth. SISIR income doubled from 1972 to 1973, and the SISIR director projects an additional expansion in growth of 50 percent by 1976. These goals will undoubtedly be met; the Singapore Government grant is fixed at US$715,000; the 1973 operating budget was US$1,098,000 and will be US$2,137,000 in 1975. Contracted services amounted to 58 percent of the 1973 operating budget, and a similar or slightly higher recovery rate (65 percent) is anticipated for 1975.

Two Brazilian research institutes, currently constrained by civil service regulations, have nonetheless been quite successful in increasing the level of contracted services with industry and government and more importantly, perhaps, in devising strategies to use these revenues for a variety of purposes under the discretionary control of the institute director.

The Instituto de Tecnologia de Alimentos (ITAL) in Campinas, Brazil, recovered 21 percent of its 1974 operating budget of US$3,026,400 from contracted services to industry and sale of pilot plant products. I believe this percentage figure would be higher had contracts with government for specific services been included under the present ITAL accounting system; however, no differentiation is made between government subsidy and government contract.

IPT, the Instituto de Pesquisas Tecnológicas in São Paulo, is a state-owned research organization which receives funds both from the state and federal governments, similarly to ITAL. IPT's operating budget has increased from US$4,620,000 in 1971 to US$14,700,000 in 1974 (1,400 employees), and the percentage of income from contracted services has remained relatively constant at 35 to 37 percent of the total budget. The amount of contracted services is expected to increase markedly beginning in 1975 as IPT achieves long sought after autonomy.

The state research institutes in Brazil have long been hamstrung by civil service regulations. Because of Brazil's almost incredible industrial growth, a severe shortage of technical personnel exists; research institute, civil service-controlled salary schedules have just been too low to attract qualified new staff members to say nothing of retaining the existing staff who are capable of industrial problem-solving but who leave to accept more attractive offers in industry. To counter

this devastating deterioration of the state research institutes, regarded as essential partners in Brazil's economic growth and industrial development, the state governments have established laws which permit the restructuring of the research institute as a nearly autonomous, government-owned corporation. Thus, salary schedules, operating philosophy, goals and objectives, and undertaking of contract R&D services are outside of civil service regulations; obviously much greater operational flexibility and efficiency are possible. The state research institutes in Rio Grande do Sul (CIENTEC), in Minas Gerais (CETEC), and in Pernambuco (ITEP) have already been restructured. IPT and ITAL in São Paulo State are in the process of converting over with target dates of July 1975.

One of the problems which was recognized early in the deliberations about organizational change was the question of what to do with the tenured civil servant who was not yet ready for retirement but who was adjudged to be unacceptable in the new organization where staff productivity becomes of paramount importance. What has happened is that the states simply agreed to continue such employees on their regular civil service status until retirement, either assigning them elsewhere or, in effect, placing them in limbo. The institute director is thus able to seek and/or promote aggressive younger staff members without being confronted with the constraint of having all upper echelon positions filled by marginally productive employees who have seniority rights.

There seems also to be increasing recognition on the part of governments that industrial development must be a partnership process, based on full cooperation between the government planning and implementation entities, the development banks, the industrial research institutes, and the public and private sectors. It is to be hoped that this trend will proliferate and become stronger. As noted in Chapter 3, the process of growth and development must be an integrated process. Otherwise, scarce and valuable human resources are inefficiently used, progress towards country goals becomes diluted or diffused; what should be an optimized approach to development becomes subverted.

Training Programs and Expert Consultants

Many institute directors have commented about the tremendous lack of <u>appropriate</u> short-term training for their staffs. It is relatively easy to obtain post-graduate training opportunities, leading to the M.S. or Ph.D. degree. All too often, the programs of this nature prepare the staff member to solve highly sophisticated problems of importance to the host country, but not of immediate relevance to the staff member's own country development. Universities are not structured, as a general rule, to accommodate training of non-degree candidates in a specialized topic. Industrial research institutes in the advanced countries seldom have funds or personnel available to accommodate such specialized programs. Industries are frequently reluctant to accept outsiders into their plants due to fear of exposing operational practices and trade secrets, or else they just do not want to be bothered.

I feel that appropriate short-term training programs must be devised. International agency or national government assistance must be provided to enable, indeed encourage, institute directors to obtain the practical training so essential to staff development and so that the efficiency of interaction between their institute and industry will increase.

I mentioned in Chapter 3 the training program in explosive forming conducted at DRI for several months of the technical staff of IPT. This has been a particularly significant training activity. A new and appropriate technology was transferred to Brazil, the IPT staff are gaining experience in "selling" utilization of the technology, and seven industrial firms are beginning to utilize the technology.

To date, however, such training opportunities appear to be limited, and there is no clear evidence that the trend is changing to any appreciable degree. The research institute is nearly always in a position to pay salaries of its staff undertaking short-term training. What is required are travel and living allowances, institutional fees for training, and a willingness on the part of industrial research institutes in advanced (or even other developing) countries to accept trainees. In my view, long-term linkages or contracts are essential if the training is to be effective. First of all, continuity of relationships, frequent follow-up, and creation of strong viable institutional friendships are needed. Then too, time is required for the "trainer" institute to become really knowledgeable about the needs, the problems, and the peculiar operational characteristics which confront the developing country institute. There needs to be a two-way flow of people between the linked institutes. If the training is to be conducted totally or in part in industry or governmental laboratories or in yet another institute, the "trainer" institute will be much better prepared to make necessary contacts, local arrangements, etc., if it is thoroughly acquainted with its linked institute.

The problem of lack of continuity is particularly acute with respect to consultants and experts provided to the industrial research institutes in developing countries. New advisors must be educated regarding the institute they are supposed to serve. Often, they do not stay long enough to really complete this educational process, thus the tendency, in many instances, appears to be one of imparting a few gems of wisdom based on the expert's experience elsewhere, often without regard to the actual existing situation, and then depart for another assignment elsewhere, leaving the institute or the government science and technology entity confused as to what to really do. It appears that consultants seldom have an opportunity to follow-up the results of their advice and counsel by means of a return visit. I feel that this is unfair both to the expert and to the institute seeking assistance.

During the course of several visits to Indonesia and discussions with government officials and institute personnel, I have gained the distinct impression that Indonesian science and technology has, in effect, suffered from an expert advisor "overkill." There have been so many well-intentioned workshops, advisory panels, experts from various countries, etc., that in my opinion at least, people responsible for science and technology decision-making are still trying to sort out the variety of options which have been proposed.

I have been advised that, all too often, experts are provided at the director or equivalent level, whereas many institute directors feel that experts at the section leader are more useful. The problem, of course, is that such experts are younger and still intent on establishing their careers. It is thus difficult to persuade these people to leave or uproot their families and turn their back on professional advancement for a year or so in order to provide the type of technical assistance which is needed by developing country research institutes.

CHAPTER 5

RESEARCH INSTITUTE MANAGEMENT PRACTICES

Downward Delegation of Authority and Responsibility

The most promising environment within which a research institute can function is meaningless unless that institute is organized and operated under a system of modern management practice. This, in turn, implies an absolute necessity for delegation of authority and responsibility to the lowest professional levels. Only in this way will institute staff understand the responsibility that they must assume in accordance with their level of experience and capability, as well as the opportunities for demonstrating initiative and the consequent rewards that will accrue. But, all too often, one observes limited or greatly constrained downward delegation of authority and accompanying clearly defined responsibility. This encourages in such institutes, to say the least, lack of initiative and aggressive desire to undertake productive projects. Also, it is likely that the new research staff member, upon joining the institute, may not perceive clearly what it is that he is supposed to do.

Research institutes in advanced countries practice decentralization of responsibility and participative management with the objective of creating coherent and coordinated team networks. Delegation of authority downward is not regarded as dilution of authority but rather as maximizing the effective talents to be gained by initiating professional staff development at the earliest possible stage in a staff member's career. Then, too, it has been clearly demonstrated that where authority has been delegated downward, the staff members devote considerable energies to scoping and trying to sell innovative ideas and to make suggestions appropriate to growth and progress of their institute in which they are keenly aware that they have a significant role.

The impact on morale when staff is given an opportunity to participate in management decisions at the appropriate level is easy to observe and, generally speaking, results in much higher productivity. For example, Dr. M. Aslam, while Director of the PCSIR Laboratories in Lahore, developed to a high degree a methodology for downward delegation of authority and responsibility. His staff was responsive to industry needs, aggressive in seeking solutions to industrial problems, and eager to interact with and provide services to industrial clients. They understood clearly their role in the process of exploiting technical know-how. They exhibited pride in their ability to function with minimum supervision and yet recognized their individual responsibilities to get the job done.

At the same time, the Karachi Laboratories of the PCSIR had no such system of delegation of staff responsibility. In 1972, staff morale was low. At that time, Dr. Aslam was appointed Director of the Karachi Laboratories and instituted the management practices which he had exploited in Lahore. The change in the level

of staff morale in 1975 is striking. There is an excitement running throughout the laboratories.

The management team is innovative in seeking new ways to provide technical services to industry. The staff are fully involved in an incentive program which rewards them financially for incentive and entrepreneurship. By utilizing and exploiting such management tactics, the Karachi PCSIR Laboratory is confident in being able to markedly increase contributions from industry as well as services to them. Because he has delegated many of his responsibilities downward, the Karachi Laboratory Director devotes his major energies to longer term planning, more aggressive contact with government and industry needs and programs, entry into new areas of R&D, etc.

Similarly, Dr. Lee Kum Tatt, Director of the Singapore Institute of Standards and Industrial Research (SISIR), encourages his younger staff members to assume responsibility to the extent of their capability. He recognizes that, in some instances, staff members will not want to accept responsibility and thus will soon depart from SISIR. Others, for a variety of reasons, may be content to assume minimal responsibility and thus want to work under other leadership. Such people, of course, have an appropriate place in any organization. But, when a young SISIR staff member demonstrates a burning desire to aggressively develop new ideas or be innovative in his dealing with industrial or government clients, the SISIR management system provides him with ample opportunity and financial support to try out his ideas.

The innovative ideas of Nayudamma with regard to delegation of authority and optimum utilization of staff managerial as well as research capability are well stated in two papers which have been referenced earlier in this report. He has commented that gerontocracy and the discouragement of initiative among the younger researchers are some of the factors which militate against effective research, and he argues for drastic change to overcome such factors.[53] He has pointed out that each person, no matter what his status, should know what he is responsible for, to whom he is responsible, and with whom he is to cooperate. He should be evaluated by a well-defined set of criteria, and he should be aware of the shape of the career which awaits him in accordance with his accomplishments, as well as the opportunities for initiative, development, and reward which will be available to him.[54] Nayudamma also makes the convincing statement that staff members who have been given authority and responsibility in trust by their director are more often capable of proceeding directly to undertake their tasks without awaiting instructions from upstairs. The advantages of this approach should be obvious.

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[53] Y. Nayudamma, Promoting the Industrial Applications of Research in an Underdeveloped Country, op. cit.

[54] Y. Nayudamma, Decentralized Management of R&D in a Developing Country, op. cit.

Both the Instituto de Pesquisas Tecnológicas (IPT) in São Paulo, Brazil, and the Instituto de Investigaciones Tecnológicas (IIT) in Bogotá, Colombia, have initiated specific management training programs at the sub-director as well as at the project supervisor level, in order to prepare their staff for assumption of additional authority and responsibility and to encourage these people to seek an active role in institute management. These programs will be further described in a subsequent section of this chapter on experimental management development programs.

The management staff of the Instituto Centroamericano de Investigación y Tecnología Industrial (ICAITI) in Central America have been experimenting with a program of downward delegation of authority to division heads and project leaders. These meet with the senior management of ICAITI at frequent intervals to review programs, both from a technical as well as a fiscal aspect, for the future, to discuss differences of opinion occasioned by priorities, etc., and to air their views on ICAITI operational procedure. While, as might be expected, such an open-handed approach to management can lead to problems and differences in opinion, at least the ICAITI senior management is being exposed to the views and opinions of the younger staff members. Improvement in overall ICAITI management is very apparent.

The PCSIR Karachi Laboratories also have established an Executive Committee comprised of division heads who meet monthly to discuss operational needs, problems, accomplishments, etc. Each division has a steering committee composed of younger staff who help the division head in developing projects which can be elaborated as a total laboratory program for the following year. The steering committees become involved in problems of support, cross-divisional cooperation, etc., in addition to technical considerations in their area.

When this procedure is not utilized and the director holds tightly the decision-making process, as I have observed in several institutes around the world, the demands on his time for staff consultation, refereeing disputes and priorities, and involvement in trivia become overwhelming and divert the director from performing more important functions. Perhaps a good example of this, and one that I cannot understand, is the requirement for two-way flow of correspondence across the director's desk. The argument that the director needs to know what is happening within his institute is, in my view, not valid. Important letters or documents may require review; certainly there is no need to examine casual exchanges of technical information between scientists, requests for equipment bulletins and related data, etc.

Analysis of Functional Responsibilities

Lawrence Bass has devised an "Analysis of Functional Responsibilities," shown in Table X, which delineates the broad range of primary responsibilities which confront the institute director, but which also reveals the responsibilities that he should delegate in order to devote his energies to those areas which require his personal attention.

TABLE X[55]

Analysis of Functional Responsibilities

Functions	Board of directors	Institute director	Deputy directors	Section heads	Echelons project leaders	Technical staff	Administrative executives	Administrative staff
Institutional policies	3	1	4	5	5	5	5	5
Technical objectives	3	1	4	5	5	5	5	5
Organizational structure	3	1	4	4	5	5	5	5
Planning	3	1	4	4	1	-	4	-
Project formulation	-	3	2	2	1	5	5	-
Project execution	-	3	3	3	1	4	5	-
Client contact policy	3	1	4	4	4	5	5	-
Client contacts, executive level	5	1	2	2	4	5	5	-
Client contacts, working level	-	3	-	-	1	4	5	-
Personnel policies	3	1	4	4	5	5	4	5
Personnel procedures	-	3	4	4	5	5	1	-
Personnel policy execution	-	1	2	2	5	5	2	5
Public relations policies	3	1	4	4	5	5	2	5
Public relations execution	-	3	4	4	5	5	1	4
Financial policies	1	2	4	4	5	5	4	5
Financial procedures	-	3	5	5	5	5	1	4
Financial control	3	1	2	4	4	5	2	5

Key:
- Primary responsibility 1
- Delegated responsibility 2
- Responsibility for approval 3
- Direct participation 4
- Need for information 5
- Nil -

Dr. Bass suggests that: "Institutional policies are formulated by the director, the chief executive, with the assistance of his deputies, who constitute the executive staff, and are submitted to the board of directors for its approval as operating principles for carrying out the objectives of the organization. They are communicated to the rest of the staff in a form appropriate for the guidance of the various echelons in carrying out their respective responsibilities. Tactics for such communication, will, of course, vary, depending on the size and nature of the organization, but generally include annual all-staff meetings, periodic (perhaps monthly) meetings of division or section leaders, and frequent intra-divisional meetings between the division head and his project leaders and staff."[55]

Based on my own institute management experience, as well as on conversations with several international experts in the field, I must comment that it is really impossible for an institute director to assume primary responsibility for all of the categories indicated in Table X, unless he delegates considerable downward authority and responsibility to subordinates.

I also hold the opinion that the Bass analysis reflects considerably less involvement by the technical staff in promotion and program development that is desirable or necessary, particularly in an institute which needs external support.

Finally, I tend to disagree with the ranking of responsibility that Dr. Bass has accorded to the administrative executives (unless this post is held by a deputy director). I believe that the senior administrative officer should be directly involved in many more aspects of decision-making than only fiscal responsibility. While it is recognized that administration should be a service to the R&D activities of the institute, nonetheless, the chief administrative officer should be in a position to react to and control project overruns, as an example, and his knowledge of cash-flow and income/expense projections is invaluable in determining whether to undertake a project, particularly on a cost-sharing basis. Also, the costs involved in laboratory modifications, etc., have to be evaluated in terms of ultimate recovery of costs or long-range benefit to the institute.

Conclusions on Research Management

All of the above comments clearly define the critical importance of modern management practice. More importantly, these observations define the nature, experience, capability and personality which a research institute director must possess. He must be innovative in keeping his finger on the pulse of the industrial and public enterprises as well as of the government entities which administer, control or fund research. He must be imaginative in development of programs which serve both current as well as anticipated needs of potential clients. He must be ingenious in creating an environment, often with considerable barriers and constraints, in which his institute can function appropriately, frequently with inadequate facilities, insufficient funds or inability to retain discretionary control of contract service funds. He must be skillful in dealing with

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[55] Industrial Research Institutes, Guidelines for Evaluation, op. cit.

professional scientists and engineers, admittedly a sometimes difficult task. He must demonstrate almost clairvoyant acuity in creating effective professional staff development programs, particularly when constraints interposed by civil service or other government regulations impede this important element of effective institute operations. I suppose the elemental question should be asked: How many institute directors can pass the test?

I commented earlier (Chapter 4) on the general tendency to appoint directors who may be eminent scientists but not necessarily good managers. This view is generally held by technical people in the developing countries. Thus, effective management and means to achieve this have been focal points of preoccupation by research directors for a number of years, beginning with a UNIDO interregional seminar in Beirut in 1964 which concluded:

> Of the many problems faced by such institutes in developing countries, that of management is of paramount importance. The problem stems from the difficulty of finding persons for appointment as institute managers or directors who have the training and experience pertinent to the requirements.[56]

In a similar vein:

> ...one of the serious gaps in effectively optimizing and utilizing the research in India comes from the managerial and organizational aspect of this effort... in the absence of such managerial and organizational experience, the research effort in the country tends to become academic.[57]

In 1971, a workshop in Indonesia reached a similar conclusion:

> There already exists a substantial nucleus of dedicated and trained personnel in several government research institutes and universities. The problem of increasing their effectiveness and productivity is at the heart of more efficient management of research.[58]

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[56] "Proceedings of the Interregional Seminar on Industrial Research and Development Institutes in Developing Countries" (ST/TAO/SER.6/77), Beirut, Lebanon, November 30 and December 11, 1964, Vols. 1 and 2, United Nations, 1966.

[57] National Institute of Sciences of India and National Academy of Sciences, USA, "Report of the Indo-U.S. Workshop on the Management and Organization of Industrial Research," Baroda, India, 2 to 6 March 1970, p. 45.

[58] Lembaga Ilmu Pengetahuan Indonesia and National Academy of Sciences, USA, "Workshop on Industrial and Technological Research," Jakarta, Indonesia, January 1971, Vol. 1, Overall Findings and Recommendations, p. 23

The findings of a WAITRO survey in 1972 relevant to perceived needs has already been commented on (see Table IX, Chapter 4).

An ad hoc panel of experts on research institute management was convened by the U. S. National Academy of Sciences in 1972 to consider the role of the United States Government and U. S. research organizations in improving management skills in developing countries.[59]

The conclusions and recommendations derived from the panel's deliberations are germane to this topic of management development and are indeed being implemented in several instances with specific programs. A few of the most appropriate conclusions are abstracted here:

> Given the still rudimentary experience in organizing comprehensive technical-management training programs for developing countries, the approach to be followed in program development should be gradual and selective, giving first emphasis to pilot experimentation. This approach should reveal which of the many elements in technical management are most transferrable, by which method, and within what cost boundaries with the goal of building up a U. S. aid capacity that is tested, flexible and responsive to the needs of the developing countries. The single most important goal of technical-management training should be to institute technological entrepreneurial qualities in the participants, be they from the research institute or from industry. It is essential that these two communities working at the two ends of the innovation continuum--one generating and the other using research results--be motivated by common objectives and outlook.
>
> A major objective should be to implant within selected developing countries a cadre of personnel, institutional resources, and other means adequate to sustain an ongoing, indigenous action for the improvement of technical management.
>
> Several developing countries that have achieved an intermediate level of development and have acquired institutions or established practices of recognized quality should also be encouraged to participate. Their experience and their proximity to other developing countries in the region may help facilitate the organization of training programs on a larger scale and at a lower cost than possible in the United States or other advanced countries (ICAITI-INDOTEC linkage, for example).

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[59] Research Management and Technical Entrepreneurship: A U. S. Role in Improving the Skills in Developing Countries, National Academy of Sciences, September 1973.

All of the above and other reports reference as a universal need a general improvement in management. The question becomes one of what exactly should be the design of programs to achieve this improvement. Based on extensive discussions with a number of research institute directors, it appears that the need can be best met by:

- On-the-job training in other institutes;
- Short- or long-term training, either in the home institute or elsewhere;
- Specific in-house programs designed to put newly acquired knowledge into immediate use;
- Recognition by the institute director that his staff members have managerial talents also;
- A reward system for staff members who assume managerial responsibilities.

Programs to improve management capability should include such factors as:

1. Basic organization;
2. Management of research, technical and administrative;
3. Improvement in internal project review process (problems stem from constraints of budget, time, lack of personnel, etc., and also from experience in "how to do it");
4. Staff development with emphasis on managing large numbers of professional scientists (often prima donas) and developing incentive and reward programs to encourage and motivate such people;
5. Financial management, to include contracts, trusts, contributions, indirect costs, project fiscal control, budget control (of utmost importance to business management staff; project personnel should have understanding of these, although not a thorough command of subject; top management similarly);
6. Particular attention should be directed to lack of knowledge on how to deal with transfer and exploitation of technology, patents, royalties, licensing, turnkey operations, operation of demonstration plants, etc.;
7. Of utmost importance is a periodic and realistic review and assessment of the institute's resources, capabilities and needs, and its compatibility with the needs of its potential clients.

It is usually difficult to establish appropriate management development programs for institute directors and sometimes equally so for sub-directors. Generally speaking, the constraints imposed by current operational problems, shortage of staff, funds, facilities, clients, etc., and sometimes discouragement or denial by government of extended absences, limit the senior management staff to short-term participation in conferences, workshops, consultation with other colleagues facing similar problems, etc. And yet, this aspect of research institute management development is of crucial importance.

The question which must be raised, then, is: have such colloquia for institute directors properly addressed the "how-to-do-it" aspects of management; have the evolved methodologies related realistic management needs to realistic internal and external management problems; have such colloquia been founded upon lectures and tutorial sessions, or are these designed to be participatory in nature, so that institute directors have an opportunity to share their experiences, and examine and critique the experiences of other colleagues?

It is my view that management development workshops, if they are to produce meaningful results, should:

- Focus on those internal and external forces which impact on the effective functioning of the institute and its interaction with its contiguous private and public sectors (examples are: internal--staff motivation, project control and evaluation, promotion and program development; external--interaction with development banks, government planning and operational entities, public and private enterprises);
- Be so constituted as to encourage mechanisms for pre- and post-workshop assignments, along with follow-on contacts with each workshop participant to observe and evaluate effectiveness of the workshop and its impact on the individual and his institute, and to suggest corrective measures, where appropriate, which may assist the participant in more fully achieving his management goals;
- Serve a potentially useful purpose in the development of a model, flexible to regional or country needs, and adaptable to varying levels of developing country research institute sophistication and/or experience.

DRI is conducting a series of experimental management development workshops, with the support of USAID, in order to verify the validity of the above assumptions. The principal focus of the workshops is on increasing interaction with the industrial sector. The workshops are participatory in nature, require agreement to undertake post-workshop assignments,* include follow-up six months after the workshop to discuss the "homework" assignments, suggest alternative strategies, and evaluate results emanating from these post-workshop activities.

During the first phase of the program, workshops, two weeks in duration, have been conducted jointly with IPT in Brazil, ASRCT in Thailand, and TUBITAK in Turkey. Attendance has been limited to directors or sub-directors from institutes in neighboring countries. DRI assumed the leadership role for the first phase workshops. However, during the second phase of the program, the host institutes will assume the leadership role, and DRI will act as an observer. The findings from the phase one post-workshop assignments are being used to structure the program format for the phase two workshops.

*Generally, the assignments have focused on undertaking or strengthening the following: industrial seminars; IRI-industry staff interchange, industrial liaison; in-house management seminars for lower-echelon staff; industry subscribers; internal evaluation of IRI successes and failures in industry interaction.

"Sabbatical leave" arrangements of four to twelve months would be ideal for improving the management capabilities of institute directors, and there are ample opportunities for "director-in-residence" programs designed specifically to assist the institute director in correcting perceived areas of weakness, expose him to broad-gauge management philosophies of modern institute operations, etc. A decidedly important co-advantage would be the opportunity for his deputy to gain practical how-to-do-it experience in operation of the institute during the absence of the director. Unfortunately, it appears that, for the present time at least, few directors from developing country institutes believe such an approach is feasible.

In contrast, management upgrading is relatively easy in the United States. A comprehensive spectrum of workshops, seminars, study programs, etc., are available during almost any month of the year, ranging from three to thirty days in duration. Contiguous universities offer a variety of enrichment programs. Communications between institute directors are frequent and continuous; short distances and air transport networks make inter-institute visitations easy. Since nearly all institutes are dealing with sponsors having similar experience in research utilization, support, policies, philosophies, etc., the institute directors are in a position to share views, experiences, problems and suggest solutions to these. Through an iterative process such as the above, U. S. institute directors can rapidly accommodate to changing needs or conditions.

These U. S. programs have the advantage that, with few exceptions, they are privately organized and thus can be provided within a short time frame, and include timely, current issues. Programs for managers of developing country institutes sponsored by international assistance organizations frequently take so much time in getting underway that one questions their real contribution to management development. A UNIDO management program, for example, has been in the planning stages since 1972, was finally funded in 1974, and probably will commence in 1975.

Staff Development

I would now like to touch on the importance of management emphasis on professional staff development. This has been alluded to earlier, of course, within the context of appropriate delegation of authority and responsibility and the need to bring younger staff members into a management training mode as quickly as possible. I mentioned earlier (Chapter 4) the preoccupation of institute directors with obtaining practical industrial training and experience for their staff members, particularly important since the university training of these people, whether in advanced or developing countries, seldom prepares them to appreciate real world problems.

Perhaps the most effective mode is short-term training in industry, government, or technological institute laboratories. Seldom will training of this nature result in a graduate degree but should be

regarded as "on-the-job" training directed toward providing:

- Practical experience in putting R&D results into industrial practice;
- Management skills to motivate and orient R&D staff to seek solutions to actual industrial problems;
- Guidance in developing capability for "selling" R&D as a mutually profitable service;
- Training of young staff in industrial R&D.

Several institutes, such as EAIRO, IPT, LPPI, PCSIR, and SISIR have a practice of seconding members of their staff to industry for varying periods of time from a few weeks to one year. IPT has seconded a staff member, who will head up IPT's industrial liaison group, to the Brazilian National Bank of Development for one year. LPPI institutes have sent their staff members to institutes in the Philippines and India for appropriate training in technical extension, for example, from the LPPI Leather Research Institute in Yogyakarta to the CSIR Leather Research Institute in Madras.

A variety of staff management programs is being used to train second echelon staff. The TNO in the Netherlands, in cooperation with UNIDO, conducted a 15-week practical workshop in September of 1973 for representatives of industrial research institutes in a number of countries. DRI has conducted, in Denver, several topical workshops on subjects such as project management and information dissemination and management. More recently DRI has initiated a series of one-week workshops at IIT, ICAITI and PCSIR which cover specific topics such as program budgeting and project cost controls, proposal preparation, report writing. These workshops are developed around actual in-house problems of the particular institute concerned (for example, a proposal in preparation, or a report needed to complete a project). It appears that these workshops, in which 25 to 35 staff members participate, have produced very tangible results in terms of better understanding of the need for cost controls, methodologies for writing good proposals, and preparation of reports that the recipient client will be able to understand.

Through use of these training techniques, institute staff members can be returned to their home base relatively quickly and, if properly utilized, can begin contributing to their institutes operations and management, as well as train other colleagues through seminars, consultation, demonstration, etc. There is some evidence of a beneficial multiplying effect, although this is based more on subjunctive opinion than on clear facts.

Post-graduate training or training in new specializations frequently poses serious management problems as a consequence of programs to encourage professional staff development. All too often, institute directors send staff members abroad for such training only to lose these people to industry upon their return. Most institutes attempt to utilize staff agreements or contracts which stipulate a guarantee of service to the years devoted to training. But, such contracts are difficult in actuality to enforce rigidly, or else the staff member will remain the minimum time required, and then depart.

From a country point of view, it is probable that such employee "spin-offs" are beneficial, but from the institute director's point of view, the loss can mean collapse of a promising and long-awaited entry into a new area of endeavor, or inability to meet agreed-to contractual commitments or program goals.

Incentives for Staff Motivation

The often vastly different salary scales between research institutes and their contiguous industry pose extremely difficult barriers to retention of professional staff. In the absence of competitive salary schedules, therefore, the institute director who is able to retain and attract competent staff must exercise considerable ingenuity in devising programs, incentives, and reward systems. Particularly where constraints are imposed by state or national civil service salary limitations, most schemes center around incentives for staff participation in contract research.

These take the form of increased salaries for the most part and must usually derive from royalties, licensing fees, or income from contracts with sponsors. Most institute directors in developed countries would cringe at the thought of implementing such practices as these. Certainly, there is a clear imbalance in treatment of a staff member who is assigned in-house research, troubleshooting or consulting to a government enterprise or industry who will not pay for services.

Such practices undoubtedly will return to haunt the institute directors in the future, however, there is some evidence that these tactics are retaining staff and encouraging them to become more aggressive in their search for contracts with the public and private sectors. In some instances, such practices are clearly in violation of government policy, yet most government agencies are aware of these practices and have accpted the establishment of revolving funds required to administer the incentive program.

One or two examples will illustrate tactics which have been devised for optimizing staff initiative.

Both the Pakistan Council of Scientific and Industrial Research (PCSIR) and the Indian Council of Scientific and Industrial Research (CSIR) pay an incentive increment to staff who develop exploitable processes or patents or undertake contracts for services to industry. The payment usually amounts to approximately 40 percent of the royalties, licensing fees, face value of contract, etc., distributed in accordance with staff participation and technical contribution. Thirty percent of the income is earmarked for payment of fringe benefits, and thirty percent is used to augment a revolving fund for laboratory modification, equipment needs, pilot plant construction, honoraria, etc. The PCSIR also makes bonus or honorarium payments to staff for developing good processes even when no royalties or contract funds are paid, for example, programs for the Defense Ministry. PCSIR senior officers receive no additional pay if they become involved in routine testing, although junior officers who supervise technicians, and the technicians, do receive incentive pay for such services.

PCSIR management is pushing each staff member to become involved in such activities, and monitors staff effort closely to maximize this involvement. Senior staff members are currently allowed to devote approximately twenty percent of their time to undirected basic research, although even this must fit within the general framework of the PCSIR's interests and objectives.

The Korea Institute of Science and Technology (KIST) operates under a philosophy that 80 percent of professional staff time must be devoted to contracted or government-supported applied research; 20 percent of professional staff time may be devoted to basic research which is related to KIST's overall programs. The Singapore Institute of Standards and Industrial Research (SISIR) requires its junior staff members to expend 90 percent of their effort on contracted services; senior staff are expected to expend 70 percent of their effort similarly.

The faculty members of Middle East Technical University (METU) in Ankara, Turkey, who undertake applied research for industry through METU's Applied Research Center, receive a one-third increase in base salary with no reduction in teaching load; a higher increment is possible with reduced teaching, but is not often permitted. A similar approach is being contemplated by the Universidad Simon Bolivar in Venezuela and the Applied Development Center of the Bandung Institute of Technology in Indonesia.

Base salaries for researchers in the various research institutes of the Indonesian Ministry of Industry are severely depressed, although these are partially offset by allowances for wife and children and regional differences. Most research staff receive housing; senior staff and directors receive both housing and a vehicle and driver for their use.

Even though there is little actual contracted service activity in Indonesian institutes, a bonus payment scheme has been devised for staff members who work on development projects. Such development projects are planned in cooperation with industry and are perceived as a pragmatic realization of industry need. Thus, the government regards development projects, even though they are government funded, to be the same as contracts with industry. Research staff who work on development projects (or industrial contracts) receive a fixed amount based on their rank and extent of participation. People not working on projects of this nature receive no bonus. When the project ends, participants lose the bonus until assigned to another project or the project is renewed.

Since the institute directors try to make assignments so that as many staff as possible receive some bonus, the productivity is not always in consonance with the bonus designed to encourage incentive. There appears to be no clear evidence as yet that the system stimulates innovative ideas for development projects.

In Brazil, many of the state technological institutes either have achieved separation from civil service constraints as government-owned corporations (CETEC, CEPED, CIENTEC, ITEP) or are in the final phases of such organization (IPT, ITAL). The Federal Instituto Nacional de Tecnologia (INT) is also seeking such

organizational change although it is unclear at this moment whether such action is possible in the foreseeable future. Those institutes which have been incorporated are able to pay considerably higher than civil service salaries, although in many instances these are still less than industrial salaries. But, the very mechanism and potential for advancement appears to encourage staff to remain with the institute. Institutes such as Instituto de Pesquisas Tecnológicas (IPT), in the interim, have developed a system whereby staff receive additional salary payments for obtaining and continuing contract research.

The INT career staff receive no incentive for outside contract research, although INT can hire scientists and engineers under contract for specific projects at competitive salaries. This is true for many of the institutes with which I am familiar. For example, Instituto Nacional de Tecnología Industrial (INTI) central laboratories in Argentina have salary schedules tied to civil service salaries. However, in their research centers (joint ventures between INTI and various industrial associations) salaries to contract employees are competitive. A similar situation exists in the National Institute of Science and Technology (NIST) in the Philippines, and the National Institute of Science and Industrial Research (NISIR) in Malaysia. Unfortunately, even when institutes have an ability to pay higher salaries through contracts, these positions are not often sought by scientists and engineers, as such positions lack tenure and fringe benefits (and sometimes prestige) of civil service employment.

Separately incorporated institutes have discretionary control over salary schedules, constrained however by availability of contracted service and other income.

Internal Project Evaluation

The internal review of projects, particularly those supported by institute funds, is probably the most difficult management aspect to control. Often decisions are largely subjective in nature; it is difficult to ascertain in many instances, just when a breakthrough might occur. A few points are absolutely clear, however, and should evoke serious questions, to wit:

- Has the work already been done elsewhere;
- Can economic and marketing justification be demonstrated;
- Has the research proceeded for an extended time without demonstrable results;
- If being performed under contract, has the project exceeded the projected cost estimates;
- Is the project in consonance with the institute's goals and objectives; the national need; the requirements of potential clients.

A much longer list could be devised, depending upon various institute situations. Some of these questions are particularly difficult under conditions where a tenured civil service researcher has nothing else to do.

Perhaps the experience of the PCSIR in Pakistan can be helpful in this regard. For the past three years, the PCSIR

laboratory managers have asked each scientist to define his individual goals within the context of the PCSIR goals as well as the national goals. Each laboratory conducts a comprehensive annual review to evaluate all projects. The primary objective is to cut off unproductive projects and/or to initiate promising new ones. No one in the PCSIR can initiate an in-house project without management committee review and approval.

Since the various Pakistan Government agencies frequently want to utilize the PCSIR staff talents to solve their problems, but are unwilling to pay the labor costs involved, the Karachi laboratories have developed a philosophy that such government requests will be accepted only if people are available who are not already engaged in applied R&D being paid for by industry.

Part of the PCSIR's problems in project evaluation stem from the fact that people with economic and marketing backgrounds have not heretofore been included as members of the laboratory staffs. Thus, evaluations have tended to consider technical feasibility rather than marketing feasibility and economic analysis of the project's potential. Lack of such expertise, as an integral component of the research team, can lead to undertaking projects and expending funds which may not be economically attractive or for which there is no foreseeable market.

Recently, through its linkage with the Denver Research Institute, the PCSIR Karachi laboratories have been undertaking a series of joint economic and market feasibility analyses of potential projects which have received preliminary technical evaluation, and from a technological point of view, hold promise for industrial exploitation. In the near future, such an approach of economic justification and market viability is visualized for all projects prior to initiation of laboratory research and development.

This techno-economic assistance to PCSIR resulted in an unanticipated learning experience. A team of six PCSIR chemists and chemical engineers was formed to work with a DRI economist to evaluate the technology under consideration. When interrogated at the end of the analysis phase about the most significant accomplishment, the PCSIR was unanimous in its opinion that a heretofore unused tactic for team problem-solving had been demonstrated.

KIST, since its inception in 1965 has followed a procedure of evaluation of all internally funded projects by the KIST technology assessment group to assure that these projects were in consonance with national need and KIST objectives. The evaluation has been advisory to the KIST president and can be overruled for reasons of political expediency, future KIST interest or other valid management reasons. About three years ago, in consortium with the Illinois Institute of Technology Research Institute (IITRI), KIST attempted to transfer selected NASA technology to Korean industry. While the technology was appropriate and carefully screened, it became obvious that potential industrial users were not involved in the transfer process soon enough. KIST lacked understanding of the real interest of industry as well as the economic justification and potential which would assist in selling the technology to industry. As a consequence of this

experience, KIST has initiated a technology assessment process for all projects, either internally or externally funded.

Regularly scheduled internal review can provide a platform--a first step in planning for the future. Admittedly, long-range planning is difficult, particularly where government long-range goals are not articulated clearly, and also when the institute must depend in part on opportunism and the changing demands of clients.

Appraisal of Institute Effectiveness

Bass has categorized the major resources of an institute with the suggestion that institute directors and their staff (perhaps with the assistance of outside groups or experts) regularly, thoroughly and objectively appraise the following as these apply to their own institute and its contiguous resources and potential:[60]

(a) Management--capability at various levels for additional responsibilities; depth and extent of utilization of managerial talents; organizational problems restricting optimum functioning;
(b) Marketing--characteristics of present marketing area; capability of staff to handle new fields; special advantages or handicaps;
(c) Technology--strength and breadth of technical expertise; managerial skill in the use of new and improved technology;
(d) Raw materials--degree of direct control or dependence on outside sources; possibility of improving raw material position;
(e) Manufacturing--condition and flexibility of facilities; potential for extension of processes and know-how to new applications;
(f) Potential for growth--economic outlook for present types of products or services, other directly or indirectly related areas for consideration; competitive position in the particular sector of industry;
(g) Financial position--resources for maintaining present position, ability to finance new undertakings.

Needless to say, even the discipline involved in arriving at rational interpretations or answers to the above would be of extreme value as an element of effective institute management practice. Not only will such an appraisal identify internal weaknesses and strengths, needs, and underutilized potential, but it will also require that institute staff members become much more aggressive in learning about the needs and requirements of their governments, their national industries, and the resources available or required to meet these needs.

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[60] Industrial Research Institutes, Guidelines for Evaluation, p. 50, op. cit.

Similarly, and again quoting from Dr. Bass, the research institute, in seeking diversification and opportunities for entry into new areas of research or technical assistance should consider the following rational method of analyzing the potential of new areas to be entered:[61]

(a) Objective appraisal of the existing strengths and weaknesses of the organization;
(b) Analysis of the industrial sectors which offer possibilities for diversification;
(c) Analysis of the degree of correlation between the industrial sectors and the skills and resources of the enterprise;
(d) Cross-coordination between (b) and (c) to select the most promising sectors of industry from the point of view of using the skills and resources of the enterprise.

Implicit in both of the above evaluative guidelines is the almost mandatory requirement for some form of promotion and program development and industrial liaison and technical extension activities. These essential elements of an effective research institute are deemed so important that they will be covered in a separate chapter.

Bass suggests also that an institute's director can be evaluated on the following points:[62]

(a) Leadership;
(b) Policies and procedures he has established;
(c) Public image;
(d) Character of relations with the board of directors and the founders;
(e) Character of relations with industrial, government and financial executives.

Perhaps even more important from the institute's point of view are the following additional criteria of performance:[63]

(a) Ability to plan activities systematically, including effective planning of his own time;
(b) Ability to attract personnel of high competence;
(c) Ability to maintain good morale through establishment of organizational relationships that create respect for the individual;
(d) Willingness to accept other points of view and to effect compensatory changes;
(e) Ability to create opportunities for development of staff capabilities.

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[61] Ibid.

[62] Ibid.

[63] Ibid.

The comments above raise questions, then, as to programs which are being devised to ameliorate these management problems, both by the institutes themselves and by the external sources of assistance. As mentioned earlier, recognition of the problems has been documented by a variety of publications, workshops, training programs, etc., dating back to 1964. It appears that the subject continues to be a subject of preoccupation at every gathering of research institute directors from developing countries.

CHAPTER 6

PROMOTION AND PROGRAM DEVELOPMENT

Undoubtedly, the most important element of promotion and program development is communications. To communicate is the beginning of understanding (according to AT&T). If the research institute is to become actively involved in its country's industrialization and development process, the institute management, and also the technical staff, must become acutely familiar with:

- Government development plans and needs;
- Industrial requirements for growth and increased productivity;
- Industrial problems which constrain growth;
- Nature and availability of resources--natural, recyclable, human--required to meet development needs;
- Understanding of mechanisms for creating realistic programs of interaction with those sectors involved in the industrialization and development process--government planning entities, development banks, industry, and public enterprise.

The activities of KIST, SISIR, TUBITAK, PCSIR, and CSIR in establishing effective communications were mentioned earlier. The National Institute of Science and Technology (NIST) in the Philippines has initiated (as a result of the ASRCT-DRI Workshop in Bangkok in 1974) industrial advisory meetings to encourage industry to work with NIST. Originally, these were general in nature, however NIST how is beginning to focus on specific sectoral or program areas. Industry is beginning to respond with requests for cooperative programs (NIST pays most of the costs, but at least industry is beginning to recognize the contributions which NIST can make to industrial problem-solving).

The Malaysian Prime Minister periodically briefs all government department heads, including the Director of the National Institute of Scientific and Industrial Research (NISIR) on current government planning, needs, problems, etc. From NISIR's point of view, such meetings are most important to keep abreast of government planning. NISIR still must, however, make industrial contacts to learn the needs of that sector. Inasmuch as NISIR is located in the midst of a large and rapidly developing industrial park, such contacts are easily made.

It is also important to mention a rather unique situation in Iran which relates to communications and interaction with industry. When the Institute of Standards and Industrial Research of Iran (ISIRI) was chartered, it was expected to perform the dual role of establishing and enforcing quality standards for products manufactured in Iran as well as to perform the research required to assist the industries in achieving the necessary quality. While the idea was perhaps acceptable in theory, it soon became evident that industrialists were extremely critical of this dual role, the principal premise being that the standards

side of ISIRI could force industry to support R&D on the research side for a fee, without any real opportunity for the industrialist to question the decision or seek expert advise elsewhere.

As a result of this, the R&D activities of ISIRI have virtually diminished. ISIRI now functions solely as a standards institute, and refers non-compliant industries to the Tehran University Center for Applied Research and Consultancy (CARCS) for help in finding solutions to the industry's problem. If CARCS cannot solve the problem then the industry may have a valid complaint that the ISIRI is incorrect or too rigid.

Emphasis on Selling Services

In Chapter 4 I mentioned several constraints which impede the process of communication and interaction. These are summarized as follows:

- Usually there is no history of the valuable contributions that R&D and transfer of technology can make to the development process;
- Development banks tend to think like banks instead of development entities;
- Government planning entities often ignore or fail to recognize the research institute talents potentially available to the country's development plans;
- Industry is suspicious of the close government-institute interrelationship, and is reluctant to pay for technical services;
- Research institute staff lack experience in identification and finding solutions to developmental and industrial problems.

Unfortunately, it appears that, if these constraints are to be overcome, the industrial research institute will have to assume principal responsibility for devising tactics and mechanisms to improve interaction. Some governments take an aggressive role in this regard, and a few industries are beginning to utilize institute technical services, although usually at a troubleshooting, rather than at an R&D level. But, the principal emphasis of the research institute, its management and its staff must be on the active promotion and selling of services.

Responsibility of Technical Staff

Here, some definition is required. In my opinion, research institute staff should be talking about, and trying to sell, utilization and exploitation of technology, rather than technology transfer, which implies licensing, royalties, turnkey operations, and often transfer of plant management along with technical know-how. Frequently, in the process of selling research services, the research institute staff member will be attempting to communicate with a non-technically trained industrialist, who may not even recognize that he has a technical problem. Thus, appropriate interpretation of suitable

technology or solution to the problem--a technological broker function, if you will--is exceedingly important, along with knowledge of the industrialist's needs, if he is to adequately understand the institute's proposed approach to problem-solving.

Before a project becomes a reality, it has to pass through various stages of development which needs many inputs, such as technical information and reference library services; survey of industrial possibilities, technological, socio-economic and market feasibility studies, examination of the soundness of the proposed industrial investment projects, and their redesign where necessary, applied scientific research and pilot plant development, cost reduction, adjustment of processes to special local conditions, project planning, increased productivity, development of industrial safety standards, testing and quality control, technical troubleshooting and many allied problems.

Nearly always, potential clients consist of small- or medium-sized industry, so that the problems are as likely to involve management and economic considerations as well as technology. As a consequence of increasing awareness of the nature of the needs of such clients, research institutes are beginning to create information services, economic analysis and industrial liaison units and technical extension or technological outreach activities. All of these are key components in the process of research promotion and program development.

One additional element needs definition--the push-pull process of exploiting or utilizing technology. All too often, research institutes in developing countries tend to devote considerable effort to development of processes, based on their own interest or limited perception of need or interest on the part of industry. Attempts to sell such laboratory developments may be likened to attempting to push an object (the research results) with a limp string. Progress in selling the idea is uncertain at best, and exceedingly slow. If, on the other hand, a potential client has a need for a particular product, process, or solution to a problem, he can, if properly motivated, exert a pull force on the system, so that the institute is involved in technical activities which relate to the client's needs and problems. Again, all of the elements of promotion enter into the institute's role in this process of effective interaction with the client, and most importantly, to motivate the potential client to initiate the pull process.

The role of information services and government intervention in promotion and program development has been discussed in Chapters 2 and 3. Obviously, these have a great impact on effective programs of selling research services. It should be noted, however, that government intervention, in the form of tax incentives, for example, can encourage but not guarantee that industry will take their development problems to the technological institute, so that with awareness of the potential of the system, research institute staff must aggressively seek and maintain contacts with industry who may have tax credits, etc. Similarly, a mechanism must exist for continuous follow-up with clients who indicate an interest in information; internal

institute communications between information management people and research staff becomes of crucial importance in such instances.

Several institutes have attempted to use formally structured promotion and public relations units to sell research services. It appears that the public relations aspect of such units is beneficial, inasmuch as it is seldom that research institutes are well known in their community or country. It is clear that continuous dialogue must be maintained between the institute, the news media, industrial associations, government entities, etc. Propaganda concerning successful institute developments, completed projects, endorsements by satisfied clients, etc., can do a great deal to invoke interest and confidence in the institute. Also, members of public relations units, if diligent, can obtain valuable information to transmit to appropriate colleagues in the institute laboratories.

From the standpoint of actually selling research services, however, such units have met with varying, usually unsatisfactory degrees of success. It is exceedingly difficult for people who are not actively engaged in research to sell research ideas to someone else. In my view, selling of research services must be the prime responsibility of the research staff member, who is competent in the technological area of interest, and who is capable of devising possible problem solutions for consideration by the potential client. The promotion and public relations units, as mentioned before, can perform a useful service in relaying intelligence about possible projects; it is up to the researcher to write the proposal and convince the client of his capability to undertake the project.

Industrial Relations Units

There is however an exception to the above. This is the TUBITAK Industrial Relations Unit which was established in 1969 and currently has a staff of five engineers, one agronomist, one economist, and one veterinarian. The head of the unit, Dr. Turgut Uzer, has described the functions and purposes of the Industrial Relations Unit as follows:[64]

The activities of the Industrial Relations Unit are:

- To investigate and to point out the problems that need further studies, in the sectors concerned;
- To more clearly formulate the problems, with persons or firms concerned;
- To find or help find solutions to problems;
- To communicate the results to persons or firms involved in a way that can be understood and applied by the latter;
- To follow-up and evaluate the effectiveness of services given and determine the extent to which the results have been useful.

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[64] Turgut Uzer, "The Industrial Relations Unit," Presented before the TUBITAK-DRI Workshop on Effective Linkages Between Industry and Research Organizations, Ankara, April 1975.

The Industrial Relations Unit does not make any distinction mong small-, medium-, or large-size firms or between public and rivate enterprise. Usually a fee is not charged, although probably ees will be charged later after industry gains confidence in the unit nd the services that it renders.

Problems that are identified by the unit, or which come rom industry, are dealt with in the following manner:

- By giving advice, by looking up in the literature and by making experiments in order to give an immediate solution on site;
- By passing the problem to TURDOK in order to find a solution by documentation services;
- By communicating the problem to the research institutes or units in TUBITAK;
- By communicating the problem to the research units supported by TUBITAK; and
- By putting it into a supported project form by means of the research groups in TUBITAK.

n some cases written reports or documents will not be sufficient for ne industrialists to solve their problems. A "show-how" is in many ases needed after giving the necessary know-how.

Some of the problems, because of their importance from the ational economic point of view, are given to researchers in the niversities or in other public or private research institutions and re solved within the framework of a contract. Thus the unit forms sort of bridge between the sectors having problems that need research nd the research organizations.

It is interesting to compare the growth in the activities of ne unit. For example, in 1969 to 1970, 40 problems were tackled y the unit; in 1973 to 1974, 455 problems were tackled by the unit; nd in 1974 to 1975, 503 problems were tackled by the unit.

The problems undertaken in 1973 to 1974 came from 284 firms, f which 104 were from the public sector, 170 from the private sector, nd ten were from cooperatives.

The problems for the period 1 March 1974 to 28 February 1975 vere solved by the following Turkish R&D entities:

Where the problems are solved:	Number of problems:
ndustrial Relations Unit	432
TURDOK	25
Universities	16
Marmara Scientific and Industrial Research Institute	4
Research Groups of TUBITAK	16
Other	10
TOTAL	503

The Marmara Scientific and Industrial Research Institute, stablished by TUBITAK in 1963, has slowly achieved operational tatus as facilities have been completed, and appropriate staff selected o man the several research divisions. MSIRI now has a staff (1975) f 408 professional, administrative and support people. Its 1974

operating budget was US$7,850,000 of which five percent was obtained from contracted services. The 1975 operating budget is expected to be US$10,000,000 with a corresponding increase in contracted services. As Marmara becomes fully staffed, the Institute anticipates establishing its own industrial relations unit. The question as to whether this may change the status of TUBITAK's unit is unresolved.

One important function of a promotion and public relations unit, and infrequently undertaken, is to conduct a continuous follow-up on projects which have been completed, in order to ascertain client utilization and application of the project results, satisfaction with institute performance, and possibility of additional projects that may develop in the future. Obviously, the researcher who conducts the project should maintain liaison with the client, both during the life of the project and after completion to assure that his suggestions and results were both understood and properly implemented.

I feel that this very important aspect of creating a professional institute image is all too frequently overlooked, so that the institute does not learn whether it has satisfied clients or that the project has been successfully completed. If the institute has an effective follow-up program, institute management will learn quickly whether the client is unhappy, or whether the project results have been beneficial and take immediate steps to rectify the situation.

In my opinion, research staff, particularly at more junior levels, do not devote enough energies to becoming thoroughly acquainted with industries and government enterprises in their community and who may have problems in the researcher's field of technical competence. I also do not believe it is possible to visit an industry and receive a positive response to a general question about problems confronting the industry. Usually, technical problems are not recognized or revealed; the response will be to the effect that better equipment or facilities are needed, etc. The researcher must learn, by observation, inquiry and familiarization with the process, to himself identify potential problems and discuss these with the potential client. Unfortunately, most staff members from research institutes in developing countries lack experience in the "how-to-do-it" of such a procedure. I mentioned earlier a WAITRO study which showed that industrial exploitation of R&D results and training in industrial applications shared the priority one and two spots along with industrial training of technical personnel as the most important and urgent needs of the institutes surveyed.[65]

The above comments have emphasized promotional relationships with potential clients but are no less valid in learning about government planning and industrial needs in order to appropriately select internal projects to be supported by institute funds. The same public relations efforts prevail, the same requirements exist for aggressive research staff activity in cultivating people at appropriate government and industry levels to learn as much as possible about planning for the future, and problems which will be encountered.

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[65] Priority of Needs of Industrial Research Institutes in Developing Countries, op. cit., p. 2-3.

Proposal Preparation, Reporting and Follow-Up

It is important to comment briefly about proposal preparation and report writing, the first of utmost importance in convincing the client that the research institute has a reasonable expectation of solving his problem, and the second to properly conclude the project and assist the client in implementing research results for which he has paid.

If a researcher cannot clearly and concisely define the problem he is addressing as well as the general methodology he intends to use in solving the problem, it is unlikely that he clearly understands the nature and ramifications of the problem. Further, the potential client will be unlikely to pay for the costs of a project that is not clearly defined, particularly if it appears that the institute may not have a clear picture of the problem.

Equally important is the necessity for elaborating a budget and a time schedule for performance which are realistic and which can be adhered to. Finally, it is important to follow-up with the client, after the proposal is submitted, to assure that he understands the proposal and to answer questions about certain aspects of the proposal that may be troubling him.

DRI was asked, in 1973, by USAID to initiate and manage a grants program whereby selected industrial research institutes in several developing countries would have an opportunity to bid competitively for grant support of laboratory research results which were deemed of interest to entrepreneurs but which required further elaboration through the pilot plant stage.

Thirteen institutes submitted 34 proposals with a face value of US$950,000 (US$200,000 was available for grant support). Nearly all of the proposals received were well prepared and appeared to address the problem of potential industrial utilization although actual apparent interaction by industry was disappointingly low. Staff members of Battelle Memorial Institute, Arthur D. Little, Inc., and Southwest Research Institute evaluated the proposals. Of the total, 15 were adjudged to be worthy of funding. Due to funding limitations, however, it was possible to fund only five institutions. These were:

ASRCT, Thailand	Rubber Seed Oil
FIIR, Nigeria	Malt Substitution
ICAITI, Guatemala	Gossypol Reduction
IIT, Colombia	Refinery Effluent Recovery
KIST, Korea	Wheat Flour Substitution.

While these grants are still in process, it appears that the project has successfully demonstrated the importance of proper proposal preparation, and that those institutes who competed have benefited from the experience. A second round of such grants is expected to be initiated in calendar year 1976.

In most instances, the report is the sole product that emanates from the project, and thus, the absolute necessity for careful attention to preparation of the report cannot be overemphasized. Clarity and simplicity of expression are of paramount importance. Complex technical explanations, instead of impressing the client with the

researcher's brilliance, are rather more inclined to "turn off" the client and discourage him from using the results.

Similarly, pages of charts, tables of data, etc., without appropriate, accompanying explanation can be troublesome to the client. In many reports that I have seen, the client is left to draw his own conclusions from the data presented, and often is expected to elaborate his own procedures for implementing the data.

The researcher must devote the time necessary to thorough explanation of these matters, indicate a willingness to discuss personally with the client, and be available to assist in implementation or modification in accordance with the project results. Needless to say, this latter action, in effect, becomes a viable opportunity for the researcher to gain an insight into the application of R&D to industrial problems.

Stimulating Program Development

A variety of promotional devices and aids are being used by some institutes in developing countries to sell research services. These run the gamut from topical seminars for segments of industry to formal affiliation with industrial associations. A few examples will indicate the nature of these aids.

Perhaps the simplest tactic is to second members of the research institute's research staff to industry, government entities or public enterprise for varying periods of time. The advantages are two-fold: industry gains valuable technical assistance, and the institute staff member gains valuable practical experience and an understanding of real problems and needs. The industrial research institutes of the Indonesian Ministry of Industry, the National Institute of Science and Technology in the Philippines (NIST), the PCSIR in Pakistan, the East African Industrial Research Organization (EAIRO) in Kenya, the Singapore Institute of Standards and Industrial Research (SISIR), ITAL, INT, and IPT in Brazil are a few of the several institutes who engage in such activities, with assignments ranging from a few weeks to a year or more. In nearly every instance the salary of the individual is paid by the industry or government entity.

Obviously, this practice sometimes results in the loss of the staff member. On the balance, however, the institutes benefit by such an arrangement. A seconding of industry and government people to research institutes is an equally important approach, in my view, to achieve greater interaction, but I have not seen many examples of this.

ITAL has used the industrial seminar approach effectively for several years to acquaint potential clients with ITAL's capabilities. Some eight to twelve short courses are conducted each year for specific segments of industry, e.g., freezing, drying, processing of fish, processing of meat products and by-products, processing of vegetables, juice, etc.

Seminar topics are selected after a rather thorough review of potential areas of interest. Fees are charged for seminar attendance. The advice of industry is sought relative to their needs which match with ITAL's interests and capabilities. The government interest is integrated into such discussions, so that industry becomes aware of the

potential for financing and ITAL is able to identify specific projects to be funded by industry, or in some cases, through cooperative arrangements between government, ITAL and industry.

SISIR, PCSIR, CSIR, KIST and other institutes have similar programs. As a result of the ASRCT-DRI Management Development Workshop in Bangkok in July 1974, several other participating institutes have initiated industry seminars. The results of these seminars are now in the process of evaluation and assessment.

A few institutes have developed interaction with industrial groups or associations, with varying degrees of success. A few examples which will describe the programs follow.

The PCSIR Lahore laboratory is located in the midst of a major concentration of industry, small- and medium-size, approximately 50 percent of which are multinational firms. Production is geared to textiles, metal-mechanical, chemicals, sugar, petroleum products. Recently, as the result of aggressive promotion by the senior staff, a strong bilateral interaction has started to develop.

The industries approach the Lahore laboratory for help. The laboratory sends its staff as liaison representatives to industry. These may be engineers, scientists, or economists--but they provide on-the-spot technical assistance and identify problems which require laboratory assistance. They have been particularly successful in technical extension efforts in glass and ceramics.

As an extension of this successful venture, an Industrial Advisory Service Group has been formed. Members pay annual subscription fees to the Lahore laboratory, according to size, nature of problems, frequency of contact, etc. In exchange, the members receive free advice and on-the-spot technical assistance, but agree to an additional charge if the laboratory does any further work or details a staff member to that industry for in-plant service.

The laboratory and industry jointly establish committees to evaluate excess or wasted industrial production, identify the problems, and recommend solutions. The laboratory then conducts research to solve the problem and/or develop the process which is passed on to industry for utilization.

Industry is beginning to pay for part of such costs of development but at a slow rate. The mechanism in use at the present time specifies that interested industry pay a fixed amount for the research to be conducted and on a no-guarantee basis. If the research is unsuccessful, either for technical or economic reasons, the industry loses its investment; if successful, the laboratory and the industry negotiate a settlement for the total costs. This has been a successful approach to date, except for the low cost-share usually accepted by industry. In return, industry receives a three- to five-year protective license on the process. If the industry does not put the process into application within a stipulated time, PCSIR has the option of selling the process to another user.

One unexpected problem relates to the fact that while industry pays a small fee, these nevertheless expect that such participation entitles them to autocratic treatment of PCSIR staff, and to demand priority and immediate attention to solution of their problem.

KIST has established a small industry assistance plan also. Korean small industries deposit US$250 at KIST. These industries can then draw against the deposit for technical services or consultation, without the requirement for individual contracts or other red tape. KIST also allows such clients to pay for R&D services on an installment basis--30 percent down and the balance in monthly payments without interest.

KIST often undertakes cost-sharing projects with industry, whereby KIST will cost-share up to 50 percent, with industry agreeing to royalty payments to KIST from successful processes. In the case of small industry a package agreement is available. The Korean Government provides funds for development costs; the small industry agrees to partially repay these costs through royalty payments to KIST.

Recently, the Korean Technology Advancement Corporation (K-TAC) has been formed to facilitate promotion of KIST R&D, sale of by-product R&D, sale of patents and know-how, etc. K-TAC is particularly active in helping small entrepreneurs with all aspects of forming a new industry, evaluation, market assessment, etc., in exchange for a royalty or an equity position in the new company.

The Marmara Research Institute in Turkey uses an industrial advisory board for each technical unit, such as materials, composed of two university professors, three to five people from specific interested industries, and a representative of the state planning organization. These boards meet frequently to scope the extent and nature of the problems of the particular industries concerned and recommend action to be taken by the Marmara Institute and industry. The composition of the board can be varied with the nature of problems to be resolved. In theory, at least, such advice and counsel provide an invaluable assist to the Marmara unit director and his staff in undertaking research of practical relevance to Turkish industry.

Two systems of interaction between research institutes and industrial associations have been observed which are so interesting that they deserve more than normal elaboration. These are the CSIR, India system, and the INTI, Argentina system.

Before describing the systems, the basic differences between CSIR and INTI should be outlined. Thirty-four separate research units--national laboratories, institutes, regional laboratories--along with 65 field stations, operate under the CSIR umbrella and are located at various sites throughout India. In addition, 14 research association laboratories have been established; these will be discussed later. The national laboratories are engaged in research which is basic to industrial development. The regional laboratories are multi-purpose in character and are concerned with problems of industrial development in their respective geographic areas. Some of these laboratories are concerned with general needs of the nation, such as food, fueld, buildings, highways. Others devote their efforts to research in engineering, public health, geophysics, oceanography, experimental medicine and toxicology. Laboratories have been established to deal with problems of interest to specific segments of industry--electronics, ceramics and glass,

leather, minerals and metals, marine chemicals, drugs, scientific instruments. These research units are largely subsidized by the Indian Government. Approximately 6,000 scientists and engineers and an equivalent number of support personnel are involved in the CSIR system.

INTI, on the other hand, operates a group of central laboratories, located near Buenos Aires, and a network of 20 research centers throughout Argentina. The central laboratories include departments of chemistry, physics, metallurgy, nondestructive testing, building materials, structures, rubber, ore dressing and metrology. These laboratories conduct research, testing and analysis, technical assistance, etc., for government enterprises and industry and also provide a backstopping function for the research centers. Approximately 20 percent of the INTI operating budget derives from services and contract research. About 150 professional staff man the central laboratories along with an additional 500 support and administrative staff.

The key element to the CSIR-INTI system is the tactic which has been devised to create special-purpose research units outside of the normal organizational hierarchy of either CSIR or INTI and to dissolve these units when these have fulfilled their purpose or are no longer required. These research units are created on the basis of requests for assistance by particular segments of industry, by industrial associations, etc., and who, as a condition, pay 50 to 75 percent of the operating costs of the unit. Since the units are designed to meet specific needs, staff assignments can be made on a multidisciplinary basis and altered easily to meet changing needs. In each instance the CSIR or INTI permanent laboratories and staff provide backstopping, management advice and direction, use of specialized facilities, etc. In each case, executive committees review problem areas, recommend action to be taken and review the results.

The CSIR and INTI schemes are modelled on variations of similar schemes which have been successfully utilized in Europe.

The CSIR approach encourages the creation of "research associations" made up, in theory, of small, medium and large industries which have a need for technical assistance and which pool resources to share such assistance and pay 50 percent of the cost of operating the research association laboratory. The Government of India exempts funds spent for such research support from the computation of profits for income tax and excess profits tax. CSIR provides the balance of costs for capital and operational expenditures and assumes the management of the laboratory. The stated objectives of the research association laboratory are to undertake, on behalf of the member companies, basic and applied research germane to the needs of those companies and also carry out testing, quality control, operations research, market surveys and consumer trials. Currently, CSIR research association laboratories are concerned with the textile, cement, plywood and tea industries, as well as paint, electronics and automotive industries.

The INTI approach is somewhat different. If INTI attempts to contract directly with industry or industrial associations, the funds

would revert to the government. However, INTI can establish, by law, research centers that can conduct research problems and services with the participation of industrial enterprises, universities and government enterprises. Contract funds made available through such arrangements can be used to pay higher salaries to research center employees and for other developmental and institution-building activities.

When an industrial group or association recognizes a need for technical assistance to a specific category of problems, arrangements can be made with INTI to establish a research center to investigate those problems. Generally, the industrial association agrees to provide 75 percent of the cost of such a center, while INTI will provide up to 25 percent of the cost in terms of capital, use of facilities, equipment or people. In several instances, the industry contribution approximates 90 percent of the total costs involved.

Unlike CSIR, which has six research association laboratories devoted to textile research, INTI research centers have little overlapping of research interests. INTI classifies its research centers as follows:

- Technology of construction and the human habitat. Research centers in building technology, building and housing (Bowcentrum Argentina), acoustical and illumination engineering, ambient engineering;
- Productivity, work methodology and training, management and industrial design. Research centers for techniques and methods in small- and medium-sized industry, industrial design, mathematical techniques applied to management;
- Natural products and food. Research centers in fats and oils, fruits and vegetables, leather technology, marine biology, cellulose and paper;
- Mining industries and metallurgy. Research centers in minerals, mineral industries, metallurgy;
- Research center in technology of elastomers and plastics;
- Research center in combustion technology;
- Research center in textiles;
- Research center in documentation.

How successful have these research centers and research association laboratories been? The evidence suggests that the benefits are, in many instances, marginal. Several persons of the CSIR directorate have commented that not much has been accomplished in the way of developing new processes and that virtually no increased industrial development has occurred as a result of programs of their research association laboratories. The principal activities of the laboratories have been to provide testing, quality control and development of standards.

It turns out that, in India at least, the idea that industries have common interests has been misleading. Large industries solve their own problems or go outside of India for assistance--these infrequently become or remain part of a research association. Medium and small industries do participate (the small industries largely for

prestige reasons), but their needs are largely limited to services.

It must be recognized, of course, that the role of these laboratories in providing testing and other services is of utmost importance, but they should be so structured and not include a policy and staffing for conduct of research.

The INTI research centers have faired somewhat better. These have been formed at the request of existing associations or government enterprises which are already working together and have identified common problems. It should be understood that a large amount of effort of these centers is directed towards analysis and tests, quality control, and other services. But, increasingly, the amount of adaptive research is increasing as industry gains confidence in the ability of these centers to solve their development problems.

From its inception in 1963, SISIR has had an active interaction with all segments of industrial development--the ministries, the universities, the vocational training programs, and most importantly, constant, continuous and frequent liaison with Singapore industry. The SISIR staff spends a considerable amount of effort in direct industry contacts. Routine services such as analysis and testing, quality control measurements, standards development and troubleshooting are regarded as door-openers for a potential follow-on phase of applied research. SISIR staff who visit segments of industry are required to review contact reports from prior industry contacts and to feed potential research information to the directorate. This aggressive attitude on the part of SISIR staff and management is leading to more sophisticated testing and the initiation of considerably more applied research as Singapore industry gains confidence in SISIR and demands additional assistance for its own development. Currently about 55 percent of SISIR's annual income derives from contract services to industry.

SISIR utilizes a three-year revolving fund approach as a stimulus for new areas of research involvement and thus industrial development. By agreement, up to $200,000 per year is available for such purposes from the government. SISIR staff members, singly or in consortium with industrial representatives, make proposals to SISIR management for utilization of these funds--the amounts requested may vary from $1,000 to $200,000 over a three-year period--to support ideas which will pay off in new research programs of interest to industry. The requests for support may include prototype development, purchase of items of equipment, or employment of new staff with specialized qualifications. Irrespective of the nature of the request, the guidelines call for 25 percent return of the investment during the first year; perhaps 50 percent by the end of the second year; and full recovery by the end of the third year, except for extenuating circumstances. "Return on the investment" includes the face value of contracts or services emanating from this "seed money," use charges on equipment, royalties from patents or licenses, etc. It is expected that the success of such a venture will lead to the creation of a SISIR Development Corporation in the near future.

The important point, of course, in this tactic for promotion and program development is that all of the SISIR staff have an opportunity to express and receive financial support for their innovative ideas. They

must stand the test of rigorous evaluation by their colleagues, who also have new ideas, and their innovations must stand the final professional test of resulting in returned income, in one form or another, to the much sought after revolving fund for SISIR development. Staff incentive for such involvement includes possibility for promotions, salary increases, etc.

SISIR is willing to take the first risk in service costs in order to generate such confidence, working up to cost-sharing and eventually full support for follow-on projects, although the SISIR management attempts to negotiate a variable first project support and tries to obtain a pledge from the industry if the project is successful. Usually SISIR subsidizes quality control and standardization services and recovers direct costs on other technical service contracts.

Technical Extension Services

I mentioned earlier the problems of achieving meaningful interaction between the technological institute and small-scale industry. This segment of industry can become an important source of potential clients to many institutes, perhaps not in terms of income to the institute but in terms of contributions by the institute to country development. Such industries suffer not only from lack of technical assistance but also lack of management and financial assistance. Usually, these industries are neither able to recognize their problems nor are they able to pay very much for assistance.

The question, then, is how can technological institutes assist such industries, either to survive or perhaps more importantly to become more effective, to grow, to hire more employees, to contribute to the country's economic growth and development? Some institutes have devised an approach similar to that of an agriculture extension agent. Institute "technical extension" experts, usually engineers with industrial experience, call regularly on small industry, solving their management-technical problems on the spot, if possible, referring more complicated problems to the institute laboratories and advising development banks or similar entities of fiscal problems. Usually, services of this nature are not reimbursed unless the institute has funds for such purposes, or a government organization such as TUBITAK will reimburse the institution for at least a portion of the expenses incurred.

As a consequence of this, institutes who must rely on contracted services for a major portion of their support are reluctant to perform such services to any appreciable extent. It seems to me that international assistance organizations, development banks, etc., must, through appropriate funding and encouragement, stimulate small industry expansion and growth through technological institute assistance of this nature.

I believe that research institutes have only recently recognized the necessity for such service, and particularly that small-scale industry, in terms of numbers, represents a large clientele for technical assistance. Programs of the U. S. Agency for International Development, either technical assistance loans or grants, are beginning

to stimulate technical extension activities of institutes in Guatemala (ICAITI), Colombia (IIT), and Brazil (ITAL and IPT). The Canadian International Research and Development Corporation is supporting similar programs in Southeast Asia. The activities of the PCSIR laboratories in Lahore and Karachi have been mentioned earlier. INT in Brazil and KIST in Korea perform such services, in part, as part of their programs of providing information services. SISIR maintains a continuing program of providing technical extension assistance as part of their promotional program.

Perhaps it is desirable at this point to describe a technical extension activity or technological outreach services program. It may be seen that such a system has, in reality, two purposes: (1) to provide effective assistance to small-scale industry and (2) to serve as an effective vehicle for promotion and program development.

The extent to which technology is transferred by a research institute depends on the manner in which the utilization process is envisaged to occur. The process of adopting a new idea and, hence, the transfer of technology can be accelerated if one realizes that utilization should not be simply a one-way flow of research findings from researchers to practitioners; a more potentially successful route begins with a flow of client needs to researchers.

Client needs are often difficult to assess. Some needs are salient and patent. These may be ascertained by surveys or via regular contacts with a large number of (potential) clients. Other needs are of a more profound nature and may be assessed only through delicate probing and a thorough understanding of economic conditions.

In order to both further strengthen contacts with potential clients and to ascertain their research needs, a technical extension or technological outreach services system (TOSS) is highly desirable. For the sake of simplicity I will use the acronym TOSS, with understanding that technical extension is synonymous.

A technological outreach services system should have two major objectives. The first is to provide needed technological services to industry and government; the second is to feed back information about the needs of industry and government to the institute and other related institutions or to government entities which are concerned with the generation or adaptation of new technology. That is, research agendas in the institute and research planning in the government ministries should be strongly influenced by the kind of information that is fed back from the clients of the technological outreach services system.

A technological outreach services system should include at least four major services. The first of these is referral services--i.e., the system should be able to provide referrals to sources of information, sources of technology, sources of raw material or equipment, sources of consulting or research assistance, etc. Sources of raw materials and equipment are probably among the most important of the referrals that TOSS could provide. The second service is a technological and business information service, through which information required by business and industry could be obtained rapidly and at lowest possible cost. Since many elaborate information systems already exist, the prime function of this system would be to act as a broker to coordinate

and link together existing services to meet the needs of client individuals or business firms. It should be emphasized that this service should focus on technical and know-how information rather than theoretical or academic. The third service provided by an outreach services system should consist of problem definition, consulting, alternative solution identification, and, to a very limited extent, applied research activities for industry and government. This service should focus primarily on problem identification and definition, with a provision for consulting, problem-solving, or research services to follow. The fourth service of the technological outreach services system should be education and training. Such education and training should not be of the type already available from colleges and universities, but rather aimed toward the application of specific new technology. It should include well-focused, short courses and training sessions to enable those in industry and government to apply the latest technology.

The development and implementation of a technological outreach services system to provide assistance to local industry, particularly small-scale industry, should be tailored to fit the specific circumstances of the country and might provide services of the following kinds:

- Identification of industry needs which have a technological component;
- Development of technical and/or performance specifications required for technological acquisitions;
- Identification of alternative sources of technologies;
- Performance of technical validation and evaluation of technologies;
- Performance of technological adaptations;
- Assistance in technological installation, start-up, and repair and maintenance;
- Assistance in negotiations with technological suppliers, financing sources, government regulating agencies, etc.; and
- Performance of socio-economic feasibility and marketing studies, etc.

Once a technological outreach services system is established, this system can acquire a wealth of information regarding the application of, and need for, industrial research. This information can be categorized by (but is not necessarily restricted to) the following components:

1. The collation of technological information including patents. In order to be able to select and adapt the most appropriate technologies to be utilized under certain local conditions, entrepreneurs must first know what alternative technologies are available. They must also have this information in a format which facilitates the making of decisions and choosing among them--e.g., costs, properties, terms of payment, guarantees, etc. These data should be readily comparable.
2. A cognition of the size distribution of production units and of the utilization of capacity for these units. It is noted here that large-scale production tends to favor transfer

of technology via importation and adoption of foreign technology, whereas small-scale production tends to require the development of indigenous technology. Also, knowledge of capacity utilization rates, together with an appraisal of missing links in the industrial sector, often indicate possible problem areas and, hence, a need for industrial research.

3. Information regarding existing internal trade routes, external trade relationships and the geographical identification of major markets. This information facilitates the identification of the level of economic activity, the actual or potential shortages of particular goods and services, and, hence, the long-term needs for industrial research.

4. Cognition and impact of the country's industrial policy as well as industrial practices. Governmental industrial policy can have a significant influence upon the potential success of industrial research, because it may favor labor-intensive production techniques, import substitution, or other desirable objectives which create the need for research. The significance of government industrial policy may be exemplified by established long-term arrangements with overseas markets for the supply of raw materials and semi-finished products.

5. Information concerning international and national sources of finance as potential support for entrepreneurs who may be interested in implementing technology which is identified as appropriate and available to the country. These sources of finance will include, but are not necessarily restricted to, the Inter-American Development Bank, the IBRD, the Asian Development Bank, as well as the national development and commercial banks.

It is recognized that the development and implementation of a technological outreach services system is of the utmost importance if appropriate technologies are to be introduced on a larger scale than has been the case thus far. In its most useful interpretation, appropriate technologies mean that the more scarce resources must be conserved and utilized only in key technologies or where no other alternative is available, while the relatively abundant resources must be utilized as intensively as possible. The selection of appropriate technologies can be significantly strengthened via the introduction of a technological outreach services system, which will minimize both the direct and social costs of the further development of the country's industrial progress.

Demonstration Plants

Nearly every research center has a sizable collection of completed research projects waiting exploitation by an entrepreneur. These include processes for producing chip board (or some other product) from bagasse or bamboo or other fibers, anti-cancer or anti-fertility compounds from indigenous shrubs (usually with a history

of folklore efficacy), or an enriched protein foodstuff, derivable from local raw materials and which can substitute for that expensive imported variety. Programs of research emphasize production of single-cell protein from petroleum, solar energy processes for desalination of water, refrigeration, etc. There are many other completed projects--in electronics, food products, pesticides, etc.--which should be important to industrial growth, but which are also sitting on the shelf. So far, contribution of much of this research has to be considered as a form of education for indigenous research staffs with very little input to industrial growth and development.

Thus, two major questions must be asked: Why such extensive replication? And, why haven't the entrepreneurs appeared on the scene? The first question relates to the lack of global information dissemination and communication of research results. The library holdings and annual acquisitions of many of the research centers are woefully inadequate. Generally, research institute staffs are concerned with difficulties in obtaining technical information quickly. If they are not acquainted with researchers in other laboratories, their problems are compounded.

The more serious problem relates to the difficulty in "selling" research results to a potential industrial user. Several examples were briefly outlined in Chapter 4. These examples point out the need for demonstration plant operations by the research institutes as a coherent and necessary segment of the institute's overall responsibility. It is clear that industry in the developing country is reluctant to invest in technological developments unless it can be demonstrated that:

- The process is technically feasible;
- The process or production line can be observed;
- The economic feasibility can be shown;
- Sufficient quantities of the product can be produced for marketing and consumer acceptance; and
- A mechanism exists to train industry employees in production or process operations.

There are distinct advantages to selling the pilot plant products in the commercial marketplace. The income from sales can be used in a private laboratory fund for incentives or to purchase new pilot plant equipment. A market demand is created where none may have existed. Actual sale of a laboratory-developed or improved product increases the confidence of the public and the industrial sector in the ability of the research institute. When industry is ready to undertake the process, operating data, cost and profit figures, and customers are available.

Many advisors abhor the suggestion that research institutes involve their staff in demonstration plant operations such as these and particularly when the sale of pilot plant produce is involved. Somehow this is conceived as being unprofessional.

But, the more successful research institutes do have such programs and, at least to some extent, have increased their liaison with the public and private sectors accordingly. The PCSIR laboratories in Lahore, for example, have been instrumental in establishment of new industries in their area which are producing glass bottles and

insulators, clay products and ceramics, and essential fats and oils. The processes were developed or modified in the PCSIR laboratories, limited production undertaken, and after industry take-over, consultation has continued.

In a similar way, the CSIR Central Leather Research Institute in Madras is noted for its aggressive actions in identifying markets, both domestically and internationally, developing the process needed to produce items for those markets, training industry workers in the process, and providing assistance in marketing of the product.

The National Physical Laboratories of the CSIR system, through the Development-Cum-Production Unit for Electronic Components, has established know-how, conducted pilot production runs, and turned over to industry processes for ceramic and silver-mica capacitors, soft and hard ferrites and technical ceramics. During the period 1959 to 1971, sales from these products have amounted to US$4 million with royalties to the NPL laboratory fund of approximately US$90,000.

A number of examples can be cited in the area of food technology. Instituto de Investigaciones Tecnologicas (IIT) in Bogota uses its well-equipped pilot plant to process batch lots of canned fruit juices, banana puree, sliced bananas, etc., which have been undergoing marketing trials in Europe. IIT will undertake small-lot canning of mushrooms, for example, in order to help a small producer determine the market for the canned product. The producer provides the raw materials and pays a fee for service; IIT has an opportunity for input of new or improved technology to improve the process or develop a new process. In an attempt to exploit an enriched wheat flour substitute, IIT has set up a small bakery and is producing pasta to demonstrate to potential users the merits of the enriched product. IIT currently is involved in development of texturized protein which is expected to be exploited, after appropriate market and economic analysis studies, as a food product available both in Colombia and as a potential export product.

ICAITI makes extensive use of the pilot plant approach to demonstrate commercial feasibility of laboratory research. I mentioned earlier that ICAITI developed the enriched corn meal "TORTIYA" through the pilot plant phase, which was subsequently sold to General Mills. ICAITI is currently operating a pilot plant in El Salvador to produce animal feed supplements by fungal conversion of coffee pulp waste and molasses to protein (resulting from a four-year joint project between ICAITI and DRI). ICAITI is now constructing a pilot plant to further elaborate the processing parameters involved in degossypolinization of cotton seed cake so that this can be used for feeding chickens.

KIST has built a pilot plant to produce freon from calcium fluoride and is selling that product in competition with Japanese exports. The Cellulose Research Institute in Indonesia is utilizing an old rayon pilot plant and pulper to demonstrate the production of rayon with the hope that the textile industry might become interested in greater use of locally produced rayon. As a by-product, and to defray expenses, carbon disulfide is produced and sold to Indonesian

industry (although three months' operation of the pilot plant produces a twelve-month supply of CS_2). The Ceramics Research Institute produces glass, vitreous enamel, refractories, structural clay products, lime, white ware, and electric insulators in sizable quantities to demonstrate these new products in Indonesia.

There are many similar examples. Few of the institutes have industrial feasibility and economic units, however, or existing units lack an effective voice in program development.

The evidence is clear that the demonstration plant approach is the major potentially successful link that joins the industrial research institute to the industrial development process. Developing countries have an urgent need for institutes which are prepared, both physically and philosophically, to provide troubleshooting and technical assistance, analysis and testing services, including quality control, and technical extension services, principally to the small- and medium-sized industries which do not have access to outside assistance. These activities, coupled with a demonstration plant and adaptive research approach, lend credence to the oft-repeated suggestion by Dr. Lawrence Bass that such institutes are not research institutes at all but should more properly be called technological institutes.

CHAPTER 7

INDUSTRIAL RESEARCH INSTITUTE LINKAGES

The question may now be asked: What are the most appropriate methodologies to follow which will assist the developing country research institutes in solving or at least improving those operational problems over which they have some control? What can be done to assist these institutes in becoming more adept at recognizing and solving problems of public and private enterprise? What strategies are of value in helping the LDC institutes to achieve more effective and productive interaction with government as well as the industrial sectors, and thus become recognized contributors to their nation's socio-economic growth and development?

I hold to the philosophy that two eminently practical and proven mechanisms are available to assist in the above. I am talking about linkages--from advanced to developing, or developing to developing institutes--and networks, focused on specific problems and involving either regional institutions, or area institutions, or other mixes. I intend to exclude from this discussion the involvement of consultants or experts per se, even though admittedly they can and do exert influence on the above-referenced problems. However, the process of acquiring experts through an international agency is cumbersome and lengthy, usually involving governmental approval and execution of agreements between the government and the international agency. Obviously, while such experts undoubtedly possess broad overall knowledge of institute operations, there are limits on the ability of single experts to do other than generalize about some phases of institute operation and often limits on time to solve specific problems.

I want to focus here on institute linkages and networks because I believe these have considerable potential for providing broad-scale, appropriate technical and management assistance. I have mentioned linkages several times in earlier chapters in connection with specific institute programs or accomplishments. A few generalizations are important to set the stage for implementation of such linkages.

General Goals for Linkage

Most directors will agree that they and their colleagues lack an awareness of techniques for creating meaningful programs of promotion and project development. They recognize the need for assistance in developing increased interaction and communications with the development banks, the planning bodies, the industrial sector. They know that they must provide technical extension services, troubleshooting, adaptation of technology, product engineering and economic feasibility to industry, but lack experience in building internal institutional development strategies and tactics to accomplish this.

The majority of the institute directors have indicated a need for an integrated approach to expert assistance. They want to be able to call on several disciplines relating to institute management, promotion and development, perhaps at the same time, and quickly. Thus,

these have expressed a strong interest in creation of linkages between research institutes in developing and in developed countries--linkages created around specific problems and with opportunities for a two-way flow of people, a variety of training programs, management and technical assistance, and joint participation in research.

The nature of the linkages may vary in accordance with the level of sophistication and the needs of each participating research institute. However, in each case, the linkage should be specifically directed toward assisting the research institute in its own institutional development so that the institute will be able to improve and enhance its interrelationships with those public and private developmental and industrial sectors it is intended to serve. It should also be recognized that programs such as this, in order to be successful, must be long-term in nature and must be funded and provided with continuity for a period long enough to carry the program through to completion.

The primary objective of such linkages is to stimulate and assist developing country research institutes in achieving increased awareness of methodologies and rationale for more effective interaction with industry and in restructuring of institute research and development goals and programs in order to provide priority support toward the needs of industry.

Goals to be sought should include:

- Increased transfer of institute research results into industrial production;
- Increased industrial financial support of institute research projects and related activities;
- Increased recognition by the institute of relevance of research programs to national public and private sector needs; and
- Increased participation by the institute in early phases of public or sector planning for development of new or improved processes or products.

It is to be expected that, if these goals are achieved, the institute will have demonstrated an ability to respond quickly and effectively to the solutions of industry's problems, and industry will increasingly recognize the tangible benefits of an industry-institute relationship.

In all such linkages, it is important, if possible, to create relationships not only between the advanced country institute and the developing country institute, but also among several institutes in the same region or country, so that, with time, these institutes continue to interact with each other in a multi-directional manner, sharing experiences, problems, available or adaptable technology, etc. Also, it will be important for some of these institutes, again with time, to become the central hub of a smaller network of institutes within their own country or contiguous region and assume the leadership role of implementing and expanding within their own sub-network the goals and objectives of this program. Admittedly, it may be most difficult to overcome problems of communication and sharing of data, information, experiences, etc., among institutes in different countries. Indeed, governments may impose constraints. Nevertheless, an attempt should be made to achieve such interaction.

Examples of Linkages

In the case of most linkages which I want to describe, these developed after the developing country institute was in existence. Two linkages which resulted in establishment of an institute are germane to this discussion. These are the Battelle-KIST linkage and the ICAITI-INDOTEC linkage.

After agreement between the Presidents of the United States and Korea, the concept of the Korea Institute of Science and Technology (KIST) was formally established in February 1966 and the Battelle Memorial Institute was contracted to assist in creating a modern, fully staffed and equipped technological institute which would have as its principal objective providing technical assistance and applied research services to Korean industry. The Battelle contract required advice and consultation on the design and construction of a complex of buildings and designation of equipment necessary to undertake the research tasks visualized as necessary to meet the needs of Korean industry.

Such needs and their priorities were determined in the course of intensive industrial surveys by KIST-Battelle teams. This led also to the development of specialized training programs both at KIST and at Battelle to prepare Koreans to be able to undertake solutions to these industrial problems and to engage in promotion and program development activities, technical extension efforts, information management and dissemination, etc., which are essential elements of an institute staff intended to be largely supported by contracted services funds.

As part of its effort, Battelle was highly successful in locating expatriate Koreans who had received their educations and were employed in science and technology endeavors in the United States and to persuade many of these to accept staff assignments at KIST. The agreement between KIST and Battelle was continued for several years after KIST was formally dedicated in 1969. Since funds are no longer available to support this relationship, the linkage has diminished to little more than goodwill, although the President of Battelle continues as a member of the KIST Board of Directors.

The U. S. contribution to the development of KIST was US$22 million. There is little question that the result of this investment is a highly competent, modern research organization which will continue to have considerable impact on Korean industrial development. I mentioned earlier that approximately 57 percent of KIST's 1974 operational budget of US$6,200,000 was obtained from contracted services.

The ICAITI-INDOTEC story is quite different. I mentioned briefly this relationship in Chapter 3. ICAITI, a twenty-year-old regional research center for Central America, has, since 1969, found it necessary to obtain an increasing percentage of its annual income from contracted services to industry and Central American governments, and institutional grants and contracts from international assistance organizations, such as OAS, IDB, ROCAP, etc. A few years ago, the Central Bank of the Dominican Republic contracted with ICAITI to undertake a series of industrial feasibility studies which might be of interest to potential entrepreneurs and which might be funded by the bank. During the course of the contract, ICAITI completed 23 pre-investment studies of industrial

processes. Of these, ten are now going industrial concerns, and another six are still under consideration for implementation in the near future.

The consequence of this successful pre-investment investigation led the Central Bank to recognize the importance of creating an indigenous multi-purpose industrial research center in order to provide Dominican Republic industry with appropriate technical assistance.

Within this concept, then, ICAITI was contracted in 1973 to design and develop the Instituto Dominicano de Tecnología (INDOTEC). The approach was similar to the Battelle-KIST agreement; ICAITI designed the buildings and laboratory layouts, specified the equipment required and provided advice and counsel during construction. ICAITI provided a resident INDOTEC manager to initiate operations. A number of ICAITI staff spent time at INDOTEC assisting in establishing specific program or administrative areas; many of the permanent INDOTEC staff, as they were employed, were sent to ICAITI for training in functional responsibilities which they would assume in their own laboratories.

INDOTEC was dedicated in April 1975, thus it is too soon to really evaluate what INDOTEC's actual contribution to industrial development will be or how successful ICAITI has been in creating a viable institute. Preliminary indications are, however, that the linkage has been quite successful to date and it is probable that ICAITI will continue to have a working relationship with INDOTEC for several years.

To my knowledge, this is perhaps the first example of an institute in a developing country developing an institute in another developing country; undoubtedly there should be more of such linkages established.

WAITRO has been trying very hard for two years to encourage linkages and has identified several laboratories in advanced countries who are interested in establishing linkages with LDC counterparts. To date, the results have been marginal. The reasons are not clear, although I suspect that attempts to create linkages have been conducted vis-a-vis the mails, or through WAITRO publications. In my own experience, it has been absolutely necessary to make personal contacts, usually several, with the LDC institutes in order to resolve problems in their minds about the nature of the linkage, their commitment in terms of funds or people, and to develop a definite program which is in consonance with what the institute director wants and needs.

IPT, the Instituto de Pesquisas Tecnológicas in São Paulo, has been operational since 1936, currently has 1,400 employees and an annual operating budget of US$14,700,000. The superintendent of IPT, Dr. Alberto de Castro, feels very strongly about the obligation of IPT to help other smaller or newer technological institutes in Brazil, by exchange of personnel, performing specialized tests, training people from the other institutes, etc. As a consequence of this philosophy, IPT has created agreements with ITAL in Campinas, CIENTEC in Porto Alegre, CEPED in Bahia, CETEC in Belo Horizonte, and ITEP in Pernambuco.

The usual funding constraints hamper these linkages to a degree, however, each institute is usually able to pay for its needs or services, and both the federal government and the various state governments are

beginning to assist in supporting these linkages. In actuality, these linkages could well become the nucleus of an active and working research institute network in Brazil, however, at the present time there appears to be little inter-institute interaction except through IPT.

I described the Science and Technology Program of the State of São Paulo, Brazil, in Chapter 3. The Conselho Estadual de Tecnología (CET) has established long-term contracts, under a USAID technical assistance loan, to several U. S. institutions which call for linkages with São Paulo technological institutes. ITAL is linked with CODOT, * a consortium of U. S. universities who are providing both long- and short-term training and technical assistance to ITAL. Several CODOT personnel are in residence in Campinas. Current emphasis is on processing of frozen fish and meat, and processing of fruits and vegetables.

Under this program, IPT has linkages both with the U. S. National Bureau of Standards and DRI. The IPT-NBS linkage is designed to develop a capability at IPT to establish secondary standards for Brazilian industry, principally in the metal-mechanical area at the moment, but later to be extended in quality standards appropriate to other Brazilian manufactures being produced for the export market as well as for domestic use.

The IPT-DRI linkage is somewhat broader in scope, and is contracted for a period of five years ending in 1978, although plans are already in process to develop funding mechanisms to continue the linkage. The linkage involves long- as well as short-term training, either in Denver, or in other institutes or universities, technical assistance to IPT in the form of full-time, in-residence DRI personnel, acquisition of equipment, books and library materials, design and other manufacturing data, etc. To date, capability and facilities for explosive forming, welding and cladding of stainless-mild steel and cupronickel-mild steel composites has been established at IPT. Seven Brazilian companies are using the process in their manufacturing or processing operations. A capability for packaging, both primary and secondary, is close to completion; equipment has been ordered, and IPT staff are nearing completion of their training with a target date of January 1976.

Other specific transfer of technology and capability development activities are being initiated during 1975, principally in the field of metallurgical processing. The same procedure as above is being followed, with both long- and short-term training of IPT staff at Denver or elsewhere, depending on location of the best available training situation, use of consultants as well as DRI staff to provide technical assistance, develop facilities, etc., and full-time resident staff members from DRI to work on a daily basis with IPT counterparts in making industrial contacts, preparation of proposals, conduct of laboratory investigations, etc.

IPT is nearing a change of status from a state civil service institution to a state-owned autonomous corporation. This changeover

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*Consortium on the Development of Technology; Universities of California (Davis), Michigan State, Rhode Island, Wisconsin, and Washington.

will require extensive management and organizational changes, a realignment of some staff functions, and creation of new units for industrial liaison, promotion and program development, etc. The contract which supports the IPT-DRI linkage will enable DRI to provide management as well as technical assistance in these categories also.

An informal agreement of cooperation has existed since 1969 between ICAITI in Guatemala and DRI. Our linkage originally centered around a joint research project of interest to both institutes. This involved conversion of agricultural wastes to an animal feed supplement by an industrial fermentation process, an area of vital interest to the export beef industry in Central America.

We worked together to develop the proposal and sell the research concept to two Central American industrialists.* DRI trained some of ICAITI's staff in its laboratories and sent people to Guatemala for several months to solve operational problems. Economic feasibility studies were initiated early in the research, again resulting in a two-way flow of people. DRI microbiologists working with ICAITI microbiologists have already broadened the program to include additional agricultural wastes and other sponsors for the project. A 10,000 gallon-per-day pilot plant is operational in El Salvador, using coffee wastes during the coffee-processing season, and surplus molasses at other times of the year.

Several other joint projects have been completed. DRI and ICAITI frequently submit joint proposals for projects to be supported by governments or international assistance organizations in Central America. The ICAITI staff knows that, because of our linkage, they can call or write for help, for ideas, and that opportunities for training exist where they can work on projects of importance to Central America.

Management counsel and advice has been a continuous part of the DRI-ICAITI linkage also. Both the ICAITI business manager and assistant business manager have been in Denver several times, and DRI administrative staff have been in Guatemala in order to develop an appropriate cost accounting system--applying our procedures to ICAITI's particular problems. There is a continuing dialogue and exchange of views between the top management of both DRI and ICAITI.

Oddly enough, DRI and ICAITI have never felt the necessity to establish a formal memorandum of understanding or an agreement to cooperate. The continued success of the linkage seems to revolve around thorough understanding of each other's capabilities and weaknesses, and a history of several years of working satisfactorily together.

Mechanisms for Supporting Linkages

In 1973, DRI initiated, with financial assistance of USAID, several additional linkages with LDC institutes. The overall goal was to determine whether it would be possible to assist a few carefully

*DRI activities were supported by NASA Grant No. NGL-06-004-096, while ICAITI's support was derived from contracted services.

selected institutes in achieving more effective interaction with industry, and also to ascertain whether a single advanced country institute working with several LDC institutes was more effective than a one-on-one relationship. Institutes selected for this pilot study were: Federal Institute of Industrial Research (FIIR), Nigeria; Organization for Applied Research, Middle East Technical University (OAR/METU), Turkey; Karachi Laboratories, Pakistan Council of Scientific and Industrial Research (PCSIR); Instituto de Investigaciones Tecnológicas (IIT), Colombia.

Criteria for institute selection included:

- Relevant technical competence and stability of the institute;
- Existence of national planning which includes policy guidance on industrialization;
- Existence of reasonably active industrial community within the region accessible to the institute;
- Expressed interest of some part of the industrial community in partial financial sponsorship of the institute;
- Existence of a general long-range plan for future institute activity; and
- Willingness of the institute to make a major contribution in terms of personnel, funds, and a commitment to continue participation during the lifetime of the program.

We were also interested in selecting four institutes with diverse organizational structure and funding support. FIIR, for example, is under the civil service constraints of the Government of Nigeria; the Organization for Applied Research of METU represents a university research center similar to DRI; the Karachi Laboratories of PCSIR are part of an institute system; IIT is autonomous and largely supported by contracted services.

In the case of Nigeria and Pakistan, agreements required ratification by the governments involved; in Turkey and Colombia, informal memoranda of understanding were sufficient. In each agreement, DRI attempted to delineate, during discussions with representatives of each institute, their priorities in terms of their needs and interests as well as extent of available funding and staff support from their own institutes. From these discussions it was possible to elaborate specific patterns of collaboration and project scheduling.

On its part, DRI offered a willingness, to the extent funds permitted, to provide a variety of assistance, again on the basis of requests from the linked institute director. These included:

- Short-term, repetitive management consulting and technical assistance to the linked institutes, which would guide these institutes in their institutional development. This phase would concentrate on the solution of institute problems which relate to those external forces (development banks, planning agencies, public enterprise, industrial sector) that influence or constrain effectiveness of the institute's interaction with potential users of technology and those internal forces that might augment or inhibit the institute's ability to become involved in such external interaction. In other words, the objective was to assist the institute directors and senior staff in learning the management tactics and techniques necessary to become technological entrepreneurs;

- Identification of priority problems and courses of action to be followed by the institute director and his staff. These would include but not be limited to: organizational changes; promotion and program development; professional staff development; program budgeting; internal project evaluation; long-range planning. Also to be included were the design of R&D programs relevant to local and national needs based on: technical assistance and consulting to small and medium industry; technical extension services; problem-solving and troubleshooting; applied research through the pilot or demonstration plant phase; economic feasibility and market analysis; analysis, tests, and standards. Consideration would be given to entry into new areas of research and accountability to government or other sponsors;
- Administrative and operational problems to include fiscal controls, contracting principles, full recovery of cost versus cost sharing, and facilities administration.

To date, the DRI linkage with METU has not been particularly successful. The FIIR linkage has involved providing technical assistance (under a contract with the Ford Foundation) to strengthen FIIR's Industrial Liaison Division. As mentioned earlier, FIIR was awarded a grant by DRI to build a pilot plant for malt substitution. The grant funds were earmarked for the purchase of equipment. At the present time, there is such a backlog of imported equipment, materials, etc., in Nigerian customs resulting from Nigeria's rapid rate of growth that delivery dates for the equipment and thus initiation of the project are uncertain. FIIR and DRI continue to collaborate in research on conversion of agro-wastes into protein supplements for animal feed, as part of a seven-institute network to be described later.

The PCSIR and IIT linkages are proving to be highly successful. Techno-economic assistance provided by DRI to PCSIR for two projects which had been completed through the bench research phase (byproduct chemicals from bitterns and soluble fish protein concentrate) has resulted in preparation of proposals to the Pakistan Government to build two pilot plants, one for each process. Informal approval for these plants has already been obtained.

As a consequence of these studies, the Karachi Laboratories have established an Industrial Liaison Unit and are beginning to train some of their staff in technical extension and techno-economic activities. Building on the results of the DRI-PCSIR joint effort on evaluation of bitterns (six PCSIR staff members were involved), the Karachi Laboratories director replaced three of the first team with new people for the second evaluation (fish protein). Subsequently, he is proceeding with a process of rotation of new people into each such team, with the ultimate objective of having 20 people full-time in the Industrial Liaison Unit in three years and 40 additional people in the research divisions who have an understanding of industrial economics and marketing.

Dr. Aslam spends one month at DRI each year as "Director-in Residence" reviewing results and progress of the linkage and discussing new tactics and methodologies for research management and promotion with the DRI senior management staff. One of his assistants is in

Denver pursuing an M.B.A. degree and working half-time for DRI in on-the-job training concerning research institute administration. A variety of workshops and other short-term training programs, both in Denver and Karachi, round out the linkage activities, with PCSIR paying for local costs and salaries of its people. The Karachi Laboratories (and the other PCSIR units) make frequent use of DRI's potential for plugging into U. S. data banks of technology.

The IIT linkage is progressing along somewhat different lines. Dr. Norton Young, the Director, is determined to upgrade both his senior management staff and his technical staff. He is concerned that while IIT is 20 years old and requires approximately 70 percent of its operating budget from contracted services, the institute is stagnating and is showing little real growth other than inflation offsets. He is particularly concerned that IIT really knows very little about the Colombian infrastructure that could support R&D, such as the missions and needs of the Ministries of Agriculture, Industry and Commerce, Defense, etc.; the industrial associations (public and private); the development banking interests, and others.

An IIT Committee for Expansion and Diversification has been established consisting of the director, four sub-directors, and two senior staff members. A DRI senior staff member serves as technical advisor to the committee. Each committee member has been assigned one or more sectors within the Colombian infrastructure, with the charge of becoming fully acquainted with entities of that sector and the potential for R&D support. Their duties and responsibilities are to identify, assess and evaluate potential new areas for IIT involvement or expansion of existing areas and make appropriate recommendations for action to the IIT director.

DRI is conducting a series of workshops in Bogotá for the technical staff on topics such as project cost controls, proposal preparations, report writing, and is engaged in planning of a series of joint seminars with IIT for various industrial groups. A series of short-term training programs (two to four weeks) is underway which will contribute to professional staff development and increased awareness of this staff regarding the variety of industrial experiences required for full participation in problem-solving for the industrial sector. Implicit in these short-term training programs is the requirement that each IIT participant will present seminars to IIT staff and others on what he has learned during his training and to continue the learning process in his subject area. These programs will include: technology assessment; legislation and technical procedures for quality inspection of imported goods; evaluation of labor-intensive industries in the U. S.; identification of imports into the U. S. having high-labor content; availability of usable but obsolete (for the U. S.) equipment; industrial sources of information; orientation in industry manufacturing high nutritional value, low-cost foods; subcontracting opportunities to U. S. industry; and orientation in improving efficiency and lowering costs of marketing.

All of the above represent needs specified by the director of IIT in order to improve the operational capability of his institute. Dr. Young also tries to spend a month at DRI each year, similarly to Dr. Aslam in evaluating linkage progress and planning new activities. DRI senior staff also visit Bogotá at least every two months for consultation.

I feel very strongly that institutional linkages are a most effective means of accomplishing certain phases of technical training as well as elements of management development. Instead of providing experts who may or may not meet the particular requirements of the training mission, why not grant funds to an institutional link and let these work out their own program--more rapidly and based on a mutual understanding of institutional ability and need.

Importance of Networking

A few comments are appropriate here about networking. I mentioned earlier in this chapter a network of institutes working with DRI on the fungal conversion of agro-wastes into animal feed protein supplements, with a secondary objective of reducing water pollution. The institutes and their area of interest are: FIIR, Nigeria (wastes from production of Gari); EAIRO, Kenya (pineapple wastes); ITAL, Brazil (cassava wastes); INT, Brazil (sugar wastes); IIT, Colombia (commercial fruit and vegetable wastes); and ICAITI, Guatemala (coffee and sugar wastes).

At the present time, each research institute is proceeding somewhat autonomously in the conduct of research on their particular waste but utilizing the fungi, techniques and mechanisms developed by DRI-ICAITI during their joint research on the conversion of coffee wastes. Each institute circulates information about current results, problems, etc., via a network newsletter. DRI staff, in connection with other project activities, are able to make periodic visits to each institute to discuss progress and problems. The network is seeking funds which will support training of people and permit the establishment of specialized capabilities or facilities at network institutes, which will be available to the other participating institutes.

ICAITI is coordinating an information network of organizations in the five Central American countries. This includes exchange of technical information, interpretation and evaluation of such information, responding to requests for technical, design, manufacturing specifications, and other data from industrialists or industrial associations, etc. Each member of the network is self-supporting.

Mention should be made of the OAS pilot technology transfer program which created a network of major Latin American institutes for the purpose of responding to inquiries for specific technical information from potential users. The future of this network is uncertain due to cessation of funding, although there is some hope that the institutes will continue to work together on the project.

Similarly, SISIR is coordinating a technical information program called TECHNONET for a group of Southeast Asian countries, with the financial and technical support of the Canadian International Research Development Corporation (IRDC). The objectives are similar to those of the ICAITI network and the OAS program. TECHNONET appears to be functioning effectively and has a potential for stimulation of inter-institutional activities in areas other than information exchange.

CHAPTER 8

THE UNIVERSITY AS AN ADAPTOR OF TECHNOLOGY IN A DEVELOPING COUNTRY*

The Role of the U. S. University

Active participation of the educational institution in the technology transfer process is widely understood, indeed expected in the United States. There are many examples which demonstrate the active role of the university in the innovative process of converting or adapting existing technology to other uses. University faculty--engineers and scientists, economists, marketing specialists, social scientists and lawyers--serve as consultants to government and industry. The conduct of applied research both for government agencies and the industrial sector has led in many instances to the establishment of university-applied research centers or affiliated research foundations. Spinoffs stimulated and encouraged by the universities have occurred with great frequency, enhancing the base of sophisticated, technologically oriented industry.

Naturally, there are pros and cons to such involvement by the university and its faculty. On the positive side, it is apparent that such interaction sharpens the faculty member's awareness of industrial problems and needs, which in turn is translated, in a practical way, into the classroom. Research, resulting from this increased awareness, tends to be more directed toward real world problems. Graduate students find both enhanced part-time employment opportunities and more meaningful training and experience which will enable them to assume a professional role more quickly upon entering into the industrial environment.

Detractors of such programs fear that professors so involved will neglect their academic duties, particularly at the undergraduate level, and that basic research, the recognized responsibility of the university, suffers due to the more immediately tangible rewards of applied research.

Clearly, a balance is required. Further, there are some indications that these programs of interaction are no longer meeting fully the needs of society. Students have become disenchanted with educational programs of high technological skill orientation which may or may not prepare them to assume positions which will contribute in a meaningful way to the betterment of life.

Engineering schools at many universities are now beginning to respond to the pressures of society to produce a new kind of engineer with the creativity and broadly based multidisciplinary experience required to attack the complex technological problems which are beginning to dominate our lives. These schools are starting to re-define their goals and restructure their curricula to place stronger emphasis on problem-solving. University research is shifting to more contemporary

*Technology Transfer: Successes and Failures, Edited by George Manning, Reprinted by Permission, San Francisco Press, 1974. See also, H. E. Hoelscher and M. C. Hawk, Eds., Industrialization and Development, San Francisco Press, 1969, for a comprehensive review of the interdisciplinary aspects of engineering education in developing countries.

projects such as transportation, housing, pollution--the whole spectrum of urban and environmental problems. From this new emphasis, students can be expected to incorporate into their educational experience more direct participation in and practical understanding of the major problems which face our society in a competitive economic system.

At the same time, there is growing recognition of the importance of technical innovation in order to maintain international competitiveness and to meet growing domestic needs. I mentioned in Chapter 1 the experimental R&D incentives program being supported by the National Science Foundation. The program calls for linkages between university or research institute and industry or government laboratory in order to: ". . . determine ways in which governmental action can affect the innovation process and from these experiments and studies derive alternative strategies for increasing the conversion of new or under-utilized technologies into socially and economically viable products, processes or services."

The Emerging University in the LDC

As an aside, there are many similarities, perhaps varying only in level of sophistication, to the problem of encouraging and stimulating the innovative process in the developing countries. This suggests creation of linkages between universities of the advanced as well as advancing countries to devise ways of overcoming the variety of barriers to innovation and to create programs which will lead to meaningful interaction between the developing country university and its contiguous industrial sector.

It is difficult to draw appropriate generalizations about the functioning of universities in developing countries. Their modes of operation, problems, and extent of involvement in community and national affairs are as varied as are their geographical locations and level of internal development. The programs of the universities in Singapore, for example, a small highly developed country with near zero industrial unemployment and increasing emphasis on limiting industrial growth to skill-intensive industry, can be expected to have different objectives than the Bandung Institute of Technology in Indonesia, or the University of Lagos in Nigeria, where both countries are large, rich in natural resources, but principally agrarian in nature.

Many of the universities have suffered in recent years because of government intervention occasioned in many instances by faculty and student dissidence, and a fear that freedom for intellectual thinking may endanger the governmental process. There is often a mismatch between relevance of university programs to national needs and the government's desire for prestige programs of sometimes questionable national significance. It is interesting to observe, for example, that in the Asian and Latin American regions, there are more government policy-making bodies for atomic energy research than for agriculture, medicine, or industrial research (see Tables III and IV, Chapter 3).

There are problems of promoting close interrelationships between science, agriculture, engineering and technology related to development. Operational procedures to accomplish this apparently are not yet evolving. Objectives of the educational systems tend to favor

the traditional approach to education used elsewhere but are frequently inappropriate. Course content may be out of date or erroneous; because of lack of appropriate instructional aids, curricula tend to take on a theoretical nature.

Professorial salaries are much too low, moonlighting is common, heavy teaching schedules or university policy often preclude faculty consulting, particularly for professors on "full-time" status. Research equipment and facilities are limited or inoperative because of lack of spare parts or maintenance, even if time for research is available. Since the faculty member generally has little direct contact with the private sector, he has limited knowledge of potential industrial research problems, and his research, if any, will tend toward the fundamental.

In this environment, the professor is inclined to teach his classes in a classical, often theoretical manner, frequently without an awareness and appreciation of the real world around himself and his students. The university graduate who elects to enter industry finds that he is really unprepared to do so. Much is written about the external brain drain, but the "internal brain drain" problem is usually neglected even though it may have more lasting ramifications. This refers to the university graduate who remains physically in his own country, but is not, in actual fact, making a contribution--in his professional area--to the development of his country. Industrialists complain that university graduates are not appropriately trained to meet their needs, and feel that the university faculties are often indifferent to these problems.

Those university graduates or faculty members who seek advanced training abroad are confronted with a problem of a different nature. It is seldom that these people are able to carry with them a thesis topic indigenous to the needs of their own country; usually they are assigned research topics appropriate to the advanced country where they are studying. They return to their countries as professors or researchers trained in methodologies which may not be usable or appropriate or in the use of sophisticated equipment which just is not available. There is a recognized acute shortage of scientists and engineers suitably trained for problem-solving to meet the needs of the industrial sector. But it is clear that such overseas training programs are seldom directed toward preparation of graduates qualified for and interested in application of technology to industry's problems and to creation of new commercial processes.

University Applied Research Programs

There are, however, an increasing number of indications that government agencies and university administrators are initiating a radical departure from classical education in the areas of science and engineering. These take the form of encouragement of faculty, provision of research facilities, creation of university-applied research centers, and a stimulus for industrial consulting and contract research.

A number of factors are perturbing the traditional university research and teaching patterns in some developing countries. Young faculty members are returning from advanced training with an increased awareness of the importance of university involvement in industrial

development. They are demanding a greater voice in departmental management; increased opportunities for research and consulting; higher salaries and incremental income, on an incentive basis, from participation in applied research sponsored by industrial and government entities. Departmental programs are developing in engineering and applied sciences, in the social sciences, economics, and other areas which have a potential for impact on national development.

In several instances, university-applied research centers have been created or are contemplated. The reasoning behind establishment of such centers is realistic. Cooperation in sharing of scarce human and physical resources becomes more effective. The administrative heads have a clearer picture of the non-teaching activities of their faculties and thus better management of the proper balance between research, consulting and teaching. Future planning for staff and facility development, particularly where new areas must be developed, becomes more effective. While such centers are not always enthusiastically endorsed by the faculty members initially, the advantages are usually recognized as important to institutional stability.

There are many universities in the developing countries who will not become actively engaged in applied research and who will continue to concentrate on expansion of an indigenous base of knowledge, preparation of teachers, education of young people which will enable these to assume an appropriate place in their society.

Perhaps the question should be asked: Is it appropriate for universities in developing countries to become involved in the identification, modification, and adaptation of technology? Obviously, such involvement will take place only if faculty attitudes encourage such action, and if university management, governmental agencies and the private sector take aggressive steps to finance the programs and exploit the results.

On balance, it is logical for some universities to become involved in applied research--because of the need to train students who can apply technological know-how--because of the need to solve technological problems confronting the industrial growth and development of their nation. However, due to scarcity of human resources and physical facilities, as well as potential clients, it does not make sense to create such applied research programs until other opportunities have been explored, such as linkages or agreements with nearby industrial research institutes, other universities, government laboratories, etc. For example, the Bandung Institute of Technology has established an Institute for Affiliation with Industry (LAPI) to coordinate and stimulate research in its 17 engineering and four science departments. The institute will seek research support from government agencies and the private sector.

At the present time in Bandung the following research institutes exist, sometimes at a sub-critical mass level, and generally competing for research dollars, clients, staff and facilities. These are:

<u>Indonesian Atomic Energy Commission</u>
- National Nuclear Reactor Center

<u>Indonesian Institute of Science</u>
- National Institute for Chemistry
- National Institute for Physics

National Institute for Metallurgy
National Institute for Electrotechniques
National Institute for Instrumentation
National Institute for Geology and Mining

Ministry of Industry
Materials Research Institute
Cellulose Research Institute
Textile Research Institute
Ceramics Research Institute

Ministry of Mining
Geological Directorate
Research Institute for Mineral Processing

Ministry of Public Works and Power
Institute for Hydraulic Research
Institute for Soil Investigation and Highway Research
Building Research Institute

It is distressing to see such proliferation of science and technology emphasis. The rationale for proceeding with the Bandung Institute of Technology LAPI is really only partially valid until close cooperation, interaction, agreements and procedures for working together have somehow become clarified. LAPI has taken a positive role in attempting to interact with other technological institutions in Bandung. It is uncertain at this point whether meaningful cooperation and coordination can be achieved.

It is clear, however, that, with increasing frequency, universities will initiate applied research programs and centers, and that possible detrimental proliferation, such as that mentioned above, will take place. International aid and technical assistance programs must be restructured to provide appropriate guidance and counsel to these universities. People are needed who have practical experience in innovation, in adaptation of technology, in working as a "broker" between university and industry. Linkages with institutions in advanced countries are of utmost importance. There is no better way of building scientific maturity in an institution in a developing country than to develop a live cooperative bond with a counterpart in some advanced country.

As an example, the School of Chemical Engineering* of the University of Paraná in Brazil operates a number of semi-commercial pilot plants geared to actual production problems. Students gain practical experience in process design and operations and in production economics. The faculty of the school stands ready to assist local industry with consulting, in factory guidance, troubleshooting and related research. The school will set up a pilot plant if a new industrial type appears in Paraná or it may establish a program to develop a new industrial process of potential interest to the state.

Pilot plant operations have been established for ceramic tile and raschig rings, for resins and plastics, essential oils and fats, and

*Includes analytical and organic chemistry, microbiology, food technology, organic and inorganic chemical technology, electrochemistry, metallurgy, ceramics.

industrial fermentation products. The output of the pilot plants is sold commercially, so that production cost and marketing data are obtained. Income from such sales is utilized for future expansion of the pilot plant program.

Industrial entrepreneurs are encouraged to take over commercial production of these items. They have access to actual operating data as well as established marketing feasibility which established credibility for the process, and an opportunity to employ technical people who have been trained to appreciate industrial operational modes and problems in addition to economic and marketing considerations. Every attempt is made to bring appropriate technology, scaled down and modified for local need, to the industrial community.

Middle East Technical University (METU) in Ankara, Turkey, is a young university patterned after the U. S. system in contrast to the other major European-oriented universities in Turkey. METU is not yet handicapped by tradition or the ultraconservative views of long time faculty and thus can and does reach rapidly to the changing needs of METU in consonance with the changing needs of Turkey. Its staff is young, largely trained in the United States, active in affairs of Turkish development and growth. There is no tenure system; faculty members are appointed on three- and five-year contract conditions.

METU, which was established by a special act of the Turkish Congress, has three principal objectives. These focus on the training of professionals, conduct of basic research for the enhancement and advancement of the Turkish science base, and applied research which is oriented toward solving the problems of Turkish society. These objectives are being well met. The president and administration of METU encourage research and attempt to keep teaching loads around six hours per quarter so that time is available for research. Applied research is recognized as important to upgrade young faculty in an understanding of Turkish development problems. The Congressional directive which created METU specifies that M. S. and Ph. D. theses be selected to relate to the needs outlined in the national plan. This mandate is currently sometimes difficult to achieve for Ph. D. candidates due to the present level of sophistication of Turkish industry. Thus, university-industry cooperation is greatest at the M. S. research level. In many instances, M. S. students do their thesis research in an industrial location or spend three to six months after completion of their research in an "internship" with an appropriate industry, thus translating the results of their findings into practice.

Applied research is conducted under contract with various industries, government enterprises and the Scientific and Technical Research Council of Turkey (TUBITAK). University policy permits an extra stipend as an incentive to undertake contract research, a practice which will undoubtedly create management problems in a few years, but which currently encourages aggressive faculty interaction with potential contract research sponsors. All contracts are with the university. Faculty members have not been permitted to consult except under certain limited and unusual circumstances. This constraint is now being modified in recognition of the fact that consulting can enrich the professional experience and stature of the faculty member, contribute to improved

teaching, serve to bring new sponsored programs to the university and enhance the reputation of the university within the industrial community.

A wide variety of research programs is underway with, in many instances, interdisciplinary cooperation between colleges. Examples of these are: programs in terrain photogrammetry of earthquake movements and development of earthquake codes adapted to local conditions and materials (architecture, geology, civil engineering, electrical engineering, industrial engineering, sociology).

Chemical engineering research is primarily related to processing of materials and pilot plant demonstration units which provide a direct bridge with industry. Current projects include production of smokeless fuels from lignite, processing boron into boric acid, chemical aspects of sugar beet processing, cement production, marketing and feasibility analysis of a petro-chemical industry (joint with Department of Economics and Statistics). The Department of Chemistry has contracts to study the surface chemistry of mineral beneficiation processes, corrosion protection with polymer coatings, thermo-setting, thermo-plastic mixes for improved properties, synthesis of small-ring organic compounds, etc. Electrical engineering is involved in research on power transmission systems, improvements in the Turkish microwave telecommunications network, and analog analysis of the water table changes in Turkey.

Initially, applied research projects were reviewed by the dean and departmental representatives to determine appropriateness, availability of personnel, recovery of costs, etc. Expansion of these programs has led to creation of organized research units within the School of Architecture, the School of Engineering, and the Department of Chemistry. The working principles for these units defined the operational conditions to be met, such as scheduling, personnel to be involved, level of incentive payment, extent of recovery of costs, obligations of the university and the client, etc.

In July 1972, the METU faculty senate approved an all-METU Applied Research Center which incorporates the aforementioned research units and broadens and further clarifies organizational and administrative procedures for all university faculty participation. Provisions have been made for support of related basic research, patents, and copyright assignments and rewards, incentive pay scales for participating faculty, determination of indirect cost rates applicable to projects, and so on. Provisions are made for creation of research programs around a specific topic such as an earthquake research center and for disbanding such centers when they are no longer needed. All projects are expected to recover both direct and indirect costs so that the university will incur no financial burden in carrying out the project. Generally speaking, the faculty is enthusiastic about the creation of this applied research center and believes that they will have increased opportunities for involvement in applied research. Of particular importance is the proviso that permits employment of full-time professional researchers as assistants to the faculty members and which will permit them to broaden their research base and still meet classroom obligations.

The importance of the TUBITAK Industrial Relations Unit in identification of industrial problems to be solved by Turkish research institutions was briefly delineated in Chapter 3 and was further described

in Chapter 6. The significant point is that the TUBITAK group is seeking for problems that plague Turkish industry and then arranging for an appropriate solution to these problems. Response is rapid, since the researcher is not paid until the project is completed.

For example, a cement factory asked TUBITAK for assistance in improving the efficiency of grinding of clinker. The problem was assigned to a professor in the METU Applied Mathematics Department who conducted a mathematical analysis of planetary and rotary grinding techniques. Through a computer modelling program, a series of design parameters was developed to be used in producing all sizes of grinding mills. In order to explain his results and convince an equipment manufacturer of their feasibility, the mathematics professor became involved in translation of his research results into practical application. Similar projects have occurred--modification of resin production, based on a foreign license, to utilize local raw materials; redesign of a motorcycle muffler to meet local noise level codes; redesign of a braking system for trucks assembled under foreign license, to compensate for the mountainous terrain of Turkey. One of several projects being considered at the moment has to do with bacterial leaching of copper ores.

Based on the experiences of TUBITAK's Industrial Relations Unit to date, it is clear that an excellent model is being demonstrated, a broker to translate problems and answers to these between the industrial sector and the researchers in universities.

The Asian Institute of Technology in Bangkok is developing a strong potential as a technology transfer agent for Southeast Asia. AIT was founded in 1963 and is now a chartered, private, nonprofit, apolitical corporation. Academic programs are at the graduate level only in earth sciences, fluids, structures and materials, chemical engineering and biochemistry, electrical engineering, systems engineering and management. Currently, 220 students from 20 Southeast Asian countries are enrolled (25 at the Ph. D. level), with an anticipated enrollment of 450 to 500 students by 1975. Degree offerings are Diploma (nine months), M. S. (21 months), and Ph. D. (69 months). Approximately 20 graduates of AIT remain on one- to two-year appointments as research associates to work with the faculty.

Less than five percent of AIT graduates leave Southeast Asia, and AIT has established good credibility with Southeast Asian governments and industry. Applied research programs are expected to develop in the above divisional areas with particular emphasis on projects for harbor development, improving water quality of rivers and canals in Thailand and other related problems of the Mekong River Basin. Projects now underway or programmed for the immediate future include studies of algae growth on sewage, control of aquatic weeds in rivers and canals, development of standards for water quality in rivers which, in turn, relates back to industry (e. g., fish, sugar cane, etc.). Once these programs are underway in Thailand, they can be expanded and modified to meet the needs of other Southeast Asian countries with similar problems. Thus, an effective multiplying program can be expected to occur, having considerable impact on Southeast Asian industrial development.

The Influence of External Forces

It is clear from the examples presented that external forces are an essential element of the transfer process. Such forces are created by industries and government enterprises, the development banks, government planning bodies, ministries of science and technology, etc. In seeking solutions to the problems of growth and development, these exert a "pull" on the technology inherent within the university. The tendency will be to pull only that technology appropriate to need, thus, initially at least, demands on the university for assistance may be of limited professional interest. There is, however, little to be gained by the university's attempting to thrust technology on users who are not yet ready.

Therefore, in order to respond to a pull, instead of a push, process, the university should create an environment which motivates such interaction, to include:

- Faculty experienced in industrial problems;
- Research relevant to regional or national needs;
- Willingness of staff to undertake small problems;
- Encouragement by administration in terms of available time, incentives, recognition, rewards, etc.; and
- Official posture of the university with regard to necessity for and desirability of industrial and governmental intercooperation.

The ministries of science and technology, the national planning agencies, and the development banks must be equal and important partners in the process. The aggressive role of the TUBITAK Industrial Relations Unit in linking industry and university has been mentioned. Unfortunately, not all of the developing countries have ministries or councils of science and technology; existing ones are often preoccupied with science and devote minimal attention to technology.

The Brazilian Government has undertaken an extensive program for scientific and technological development for the decade of the seventies. This program includes provisions for strengthening Brazil's educational, scientific, technological and industrial sectors by keeping abreast of scientific and technological progress in the world, by adapting imported technology to national conditions and need, and by solving Brazil's own technological problems leading to broader technological elaboration in the country and substitution of nationally developed technology for imported technology. A wide variety of tools has been devised to encourage greater participation of the private sector in scientific and technological development. These include:

- Fiscal incentives designed to stimulate research and utilization of innovations;
- Protection of Brazilian engineering and technology through constraints on indiscriminate imports of engineering and technological services;
- Stimulation of increased foreign enterprise participation in the national research plans; and
- Increased integration between university and industry.

Many government agencies having to do with science and technology are involved in the overall program, but the principal impetus is in the hands of a group consisting of representatives of the National Research Council (CNPq), the Ministry of Planning (MINIPLAN), the National Bank for Economic Development (BNDE), and the National Fund for Scientific and Technological Development (FNDCT). Both financial assistance and coordination are provided in a series of 21 major projects designed to provide:

- Large-scale financial support of the nation's industrial research institutes;
- Establishment of centers of postgraduate excellence in each of four regional graduate centers with particular emphasis in the areas of science and technology for relevance to regional need;
- Advanced training of professionals in Brazil or abroad; and
- Creation of specific laboratories in selected universities* which are crucial to industrial development and for which inadequate facilities exist.

Brazil is undergoing a fantastic period of growth and industrial development. All facets of the science and technology base are included in the planning and execution of this expansion, and these are being added to as rapidly as funds and human resource development programs permit. The top echelons of the Government of Brazil recognize fully the impact which their universities and research centers can exert on industrial growth, and these are being exploited to the fullest extent.

If the assumption is valid that universities should indeed assume an aggressive role as adaptors of technology and contributors to the industrial development of their countries, then it is important to examine the technical assistance programs which they will need in order to meet these goals. In discussicns with university administrators, deans, department chairmen, and faculty members, a consensus of assistance requirements shows four major categories.

Young faculty members pursuing advanced degrees or post-graduate programs need practical training at a level of sophistication in consonance with the level of need for their institution and contiguous industry. Ideally, they should take real problems with them for theses or doctoral dissertations and should work under professors in advanced countries who are knowledgeable about the student's country and its state of development.

Guidance and counsel are required from people in advanced countries who are experienced in applied university research and development. Assistance is needed in a variety of planning, managerial and administrative categories, to include: contractual agreements;

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*These special projects include: Bituminous Shale Laboratory, Chemistry Institute, Federal University of Rio de Janeiro; Semi-conductor Laboratory, Politechnic School, University of São Paulo; Permeation of Gases Laboratory, Coordination for Graduate Programs in Engineering (COPPE) of the Federal University of Rio de Janeiro; Laboratory for Electronics applied to Biology, COPPE; Industrial Biological Problems Laboratory; Natural Products Research Center, Federal University of Rio de Janeiro.

balance between teaching, research and consulting; incentives for faculty-staff participation; the role of the student in the research activity, particularly where thesis research is involved; operational procedures such as cost recovery, patents, proprietary rights of clients, accountability, etc.; mechanisms for identifying problems; and a host of related topics having to do with organized research.

Guidance and training programs are particularly important which will assist the university and its faculty members in creating meaningful interaction with the development banks, the government planning bodies, the industrial research institutes and the industrial sector. Probably two-way programs will be required in order that representatives of these external forces will learn to utilize effectively the resources of the university.

Linkages with universities experienced in applied research and in interaction with industry are deemed particularly important. Such linkages, in many instances, would provide opportunities for providing the above desired technical assistance. A two-way flow of people and joint participation in research programs of importance to the developing country would provide particularly meaningful training opportunities, guidance and assistance.

If the developing countries are to close the ever increasing gap between their level of development and that of the advanced countries, full utilization must be achieved of scarce human resources, of technological facilities and know-how, of financial support. Close intercooperation must take place between the university, the industrial sector, the banking system, the government. But this interaction is not the sole responsibility of the university or of any of the others, and perhaps coordination can most effectively occur through a ministry or council of science and technology. At the working level, however, interaction must take place between the people involved, so that an understanding of each other's problems, modes of operation, constraints, etc., is required.

Universities in many developing countries tend to devote their entire energies to increasing the educational base and contributing to the indigenous reservoir of knowledge. Admittedly, these are important facets of the university contribution to society, but it is also necessary to contribute to the strengthening of the private sector which is necessary for industrial growth and development and a better way of life for the nation's people. It is important, therefore, that the university in a developing country assume an active role as an adaptor of technology, to share its knowledge, experience and people with industry and to take an active part in the developmental process.

Dr. W. M. Batt, a former researcher turned industrialist, made the following suggestions during a recent CENTO meeting:

> There is a need for better coordination between the industry, the universities, and the national research institutes. It is suggested that an advisory committee of experts from the universities, the industry, and the research institutes be constituted in order to create close and effective coordination between these three agencies. The function of this body would be to:

(a) determine the facilities available at the universities and the research institute and the type of service which these bodies can provide to industry,
(b) identify the future service requirements of the industry for the next five to ten years and plan the development of the universities and the institutes in order to take care of these needs,
(c) explore the possibilities of interchange of personnel between industry, universities and research institutes,
(d) arrange refresher courses for personnel working in industry for continuing education of in-service personnel from industry.[66]

[66]CENTO Workshop on Improving Interaction Between Universities and Industry, Lahore, Pakistan, 9 through 12 December 1974.

CHAPTER 9

CONCLUSIONS

A number of conclusions can be drawn from the results of this study. It is clear that the world body of literature is sated with recommendations designed to improve effectiveness of developing country institute management, staff, and operations. Certainly, such recommendations have merit. As I have commented earlier, these do not always fully recognize the constraints which confront the LDC institutes, and which often vary from one country to the next. I feel also that it is particularly important to recognize the fact that some of the difficulties which confront the LDC institutes pose barriers over which they have no control, nor can they persuade government representatives or other influential persons to ameliorate these difficulties. At the risk of incurring the animosity of some of the expert consultants who are providing advice and counsel to LDC institute directors, I must state that, in my opinion at least, such visits are all too short and do not often involve follow-up visitations to learn what has happened. I believe that the expert should stay long enough, not only to advise, but also to begin the implementation process, and then return at frequent intervals to oversee completion of the implementation. Admittedly, part of the problem here is controlled more by international organization funding availability than by the interest and willingness of the expert to devote more energies to working with the institute.

There is no question about the need for increased and more effective interaction among the institute, the development banks, government entities, public and private enterprise. But, this interaction must result from a partnership in which each of the above-mentioned partners makes a concerted effort to exchange views on the others' needs, capabilities, problems, priorities, etc. In the case of industry, government, and development banks, this requires developing mechanisms such as two-way flow of people to better understand the institute's potential for contribution to industrial growth and economic development, and how the institute's capabilities can be integrated with their priorities and needs.

The institute, on the other hand, must acquire or train staff members who are experienced and interested in industrial or developmental problem-solving and who are willing to sally forth into the industrial environment to seek problems, learn about industry's future planning, examine the national needs, and relate these to the capabilities of themselves and their colleagues. This requires an aggressive plan for promotion and program development on the part of the institute.

If the institute is going to interact effectively with contiguous entities mentioned above, then it should provide research and technological services, to include but not be limited to: technical information services; techno-economic studies, pilot plant and semi-commercial development work; industrial standards and specifications surveys; testing and quality control services; in addition to laboratory basic and applied research.

Institute management has been a continuing thread throughout this report. Progress is being made, however, by the admission of most LDC institute directors that programs of technical assistance in this area are still urgently needed, particularly at second- and lower-echelon staff levels. But, I find that many directors themselves are also seeking management assistance inputs at their own level.

Progress in solving the above problems is being achieved by many of the institutes with which I am familiar. Those institutes with civil service status do suffer an impediment in increasing their effectiveness, although PCSIR, IPT, and ITAL can be cited as outstanding exceptions. Those institutes who depend on contracted services for a substantial portion of their income are faced with different constraints in that they often lack funds to send staff away for extended training, or to develop a capability to enter into new and potentially salable areas of institute activity.

I have also commented several times about the apparent disinterest of industry in utilizing the services of research institutes. I am of the opinion that if institutes will follow the SISIR approach (that is to provide services in consonance with industry's needs) and also pursue a course of aggressive and frequent industrial contacts, such industrial reluctance can be overcome.

Finally, I am personally convinced that formal linkages between advanced country and developing country institutes, established around specific programs and training activities, and designed to continue for a number of years, are most important aids to research institute improvement in developing countries. DRI's experience to date with its linked institutes has demonstrated clearly the enthusiasm of the linked institute directors for such a program. It is too soon to tell whether the course of these linked institutes is drastically changed, however, there are strong indications of improvement in their relations with public and private enterprise in their country.

APPENDIX A

PARTIAL LISTING OF INDUSTRIAL RESEARCH INSTITUTES

Government Corporations

Center for Research and Development (CEPED)
Executive Commission for the Economic Recuperation of Cação Region (CEPLAC)
Technological Center of Minas Gerais (CETEC)
Technical Institute of Rio Grande do Sul State (CIENTEC)
Applied Scientific Research Corporation of Thailand (ASRCT)
Institute for Industrial Development (INDI)
Research Institute for Estate Crops (BPPB)
Marmara Scientific and Industrial Research Institute
Nuclear Reactor Center (NRC)
Building Research Institute
Metals Industry Research and Development Center (MIRDC)
Venezuelan Institute of Scientific Research (IVIC)

Separately Incorporated Institutes

Shri Ram Institute for Industrial Research (SRIFIR)
Institute for Technological Research (IIT)
Singapore Institute of Standards and Industrial Research (SISIR)
Korea Institute of Science and Technology (KIST)
Foundation for the Development of Scientific and Technological Research (FICITEC)
Institute for Industrial Technological Research and Technical Standards (ITINTEC)
International Rice Research Institute (IRRI)

Regional Institutes

Central American Research Institute (ICAITI)
East African Industrial Research Organization (EAIRO)

University Applied Research Centers

Bandung Institute of Technology (ITB)/Institute for Industrial Affiliation (LAPI)/Development Technology Center (DTC)
Middle East Technical University (METU)/Organization for Applied Research (OAR)
Monterrey Institute of Technology/Institute for Industrial Research (III)
Asian Institute of Technology (AIT)

Government Civil Service Institutes (State and Federal)

- Federal Institute of Industrial Research (FIIR)
- National Institute for Scientific and Industrial Research (NISIR)
- National Institute of Technology (INT)
- Institute for Technological Research (IPT)
- Laboratory for Materials Testing and Technological Research (LEMIT)
- Institute of Food Technology (ITAL)
- Institute of Standards and Industrial Research of Iran (ISIRI)

Research Institute System

- Council of Scientific Industrial Research (CSIR)
- Pakistan Council of Scientific and Industrial Research (PCSIR)
- National Institute of Industrial Technology (INTI)
- National Institute of Science and Technology (NIST)
- Indonesia Institute of Sciences (LIPI)
- Institute for Industrial Research and Training (LPPI)

APPENDIX B

ANNOTATED DESCRIPTIONS OF IRIs INCLUDING ORGANIZATION CHARTS, LEVEL OF FUNDING AREAS OF SPECIALITY, ETC.

GOVERNMENT CORPORATIONS

Centro de Pesquisa e Desenvolvimento (CEPED)
Center for Research and Development
Rua Rio São Francisco, 1
Monte Serrat, 40.000
Salvador, Bahia, Brazil

Type: State-owned foundation operating within the Secretariat of Planning, Science and Technology of the State Government of Bahia. Although subject to the rules of civil service, the foundation is permitted to operate under technical, administrative, and financial autonomy.

Administrative Council: Secretary of Science and Technology (President of Council); Director General of CEPED; Director General of the Foundation for Development of Science in Bahia; representatives of Ministries of Planning and General Coordination, Industry and Commerce; Bank of Northeast Brazil; two representatives of industry and commerce in Bahia; one representative of the CEPED technical staff; and one representative selected by the State Governor (total of ten).

Acting Director-General: Irundi S. Edelweiss

Staff: 250 employees of which 100 are professional research scientists and engineers.

Affiliations:
State Secretariat of Planning, Science and Technology; State Secretariat of Mining; Federal Ministry of Industry and Commerce; Federal Ministry of Planning; the State Development Bank, DESEMBANCO; and several regional development agencies.

Finances:
1974-1975 operating budget was US$8,815,790, derived from the above-mentioned affiliates, and a small amount from industrial clients.

CEPED was established as a state-owned science and technology organization in 1969, with dual responsibilities. CEPED, as a part of the State Secretariat for Planning, Science and Technology, is responsible for all applied science and engineering research (either in its own laboratories or contracted elsewhere) in the State of Bahia. CEPED also serves, in effect, as coordinator for technological development in the State, since DESEMBANCO, the state development bank, requires mandatory automatic review by CEPED of all development projects financed by the bank.

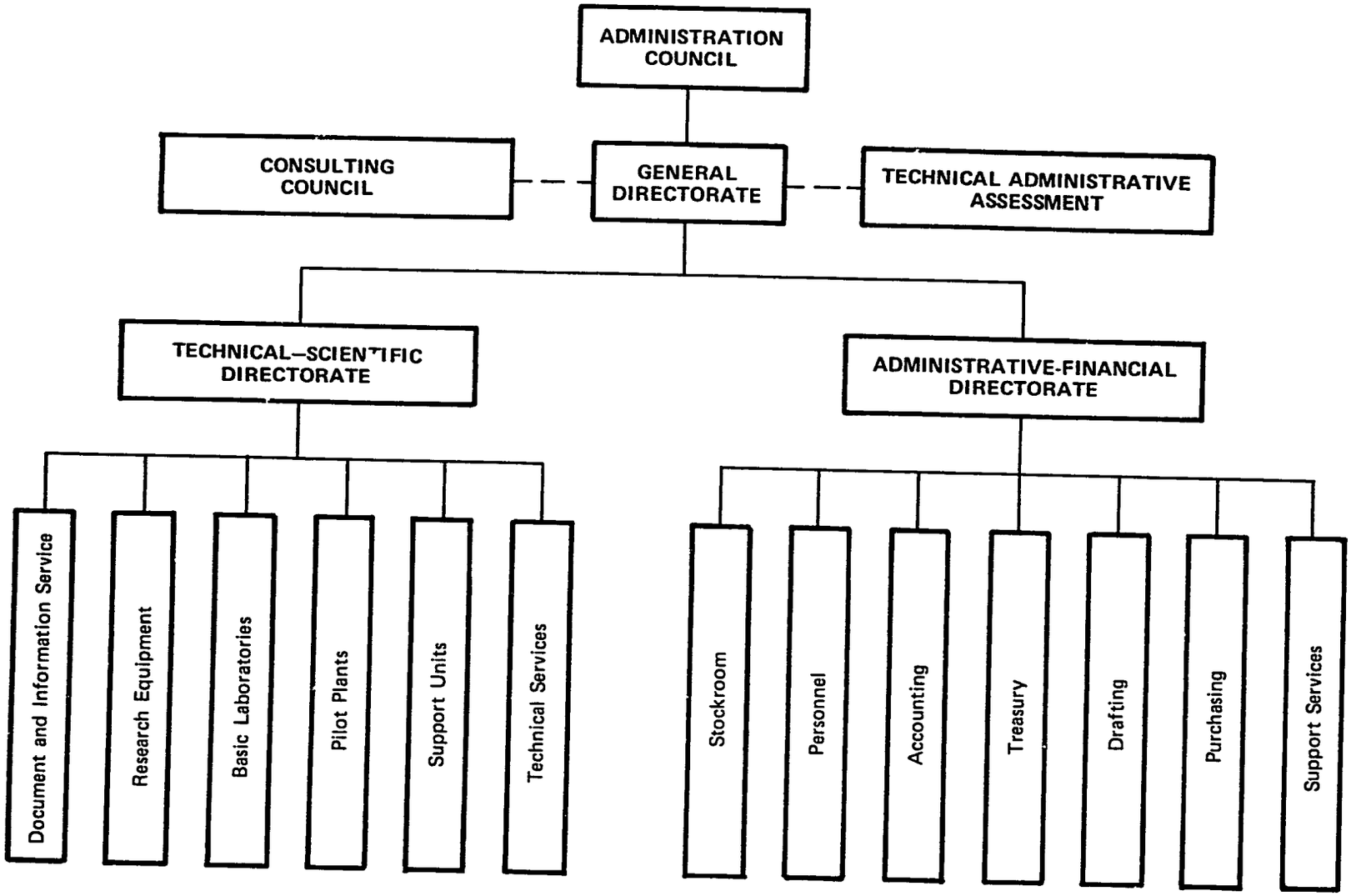
CEPED laboratories are: chemistry, instrumental analysis, biochemistry, microbiology, physics, and pilot plant operations. In addition, CEPED contracts with state, regional or other Brazilian organizations, with international organizations, when services are required that are not available through CEPED's laboratories.

CEPED's principal emphasis is directed towards government agencies and private industry in Northeast Brazil, although they do accept projects from other parts of the country.

Typical services offered include: adaptation of imported technology to local conditions; developing standards and product quality control; improving existing production methods or developing new processes which industrialize locally available raw materials; economic analysis and marketing studies; utilization of by-products; environmental protection and routine services--chemical and physical analyses, corrosion studies, etc. CEPED charges a fee for services rendered, based on costs incurred. The institute is hopeful of being self-sufficient in ten years, although, based on the experiences of other institutes, this goal will be difficult to achieve.

The State charges a circulation goods tax of 15 percent of the goods value, 60 percent of which is deposited to DESEMBANCO as a credit in the name of the industry. These funds can be used for equipment replacement, facilities expansion, R&D, either in-house or contracted elsewhere, or for the purchase of technology. Irrespective of the intended use for such credits, CEPED reviews the request on behalf of DESEMBANCO, in order to assess validity of the request; appropriateness of equipment; licensing agreement, etc.; technological soundness if a proposed new process; and other factors, before DESEMBANCO will release the funds. This control measure insures that obsolete or over-priced technology is not purchased by unwary industrialists; but it also provides an outstanding opportunity for CEPED to achieve close interaction with industry.

CENTRO DE PESQUISAS E DESENVOLVIMENTO
CEPED



Executive Commission for the Economic Recuperation
of Cação Region (CEPLAC)
KM 26 Rodovia Ilheus-Itabuna
Itabuna, Bahia, Brazil

Type: Autonomous federal organization under the Ministry of Finance.

Executive Board: Under the chairmanship of the Ministry of Finance, consisting of representatives of the Ministry of Agriculture, the Ministry of Industry and Commerce, the Governor of the State of Bahia, the Governor of the State of Espirito Santo, the Fund for Rural Credit of the Bank of Brazil, the Central Bank of Brazil, the Bahia Institute for Cação, the Producers of Cação.

Director of CEPEC and Technical Superintendent of CEPLAC: Paulo de T. Aluim

Staff: 1974: 2,450 people including 225 professional researchers, 24 senior administrators, 717 administrative and technicians, 1,484 support staff.

Administrative Body For: Cacao Research Center (CEPEC), Extension Department (DEPEX), Department of Credit and Incentives (DECRI), Junior School of Agriculture in the Cação Region (EMARC).

Finances:

Largely financed by a producer's tax on cacao: 15 percent on beans and five percent on processed products. Estimated 1974 budget of US$27,740,700. Some income from DEPEX's sales, also for research in non-cação areas, e.g., rubber, oil palm, etc.

CEPLAC was established in 1957 by the Federal Government of Brazil to serve principally as a debt relief organization to assist the cacao farmers in regularization of their financial problems. After four years it became evident that debt relief and credit were not sufficient to solve the production problems of the cação farmers. In 1962, the Cação Research Center (CEPEC) was established, followed in 1964 by the Rural Extension Department (DEPEX).

CEPLAC has responsibility for the development of agriculture and improvement of living standards within the cação-producing regions of Brazil. This includes implementation of an integrated agricultural development program of research, extension, agricultural training, credit, strengthening of rural infrastructure, and inputs into the modernization of agriculture. CEPLAC is gradually increasing its activities outside of cação, and is now conducting research in rubber, palm oil processing, bananas, animal husbandry, other fruit crops, etc.

CEPEC in addition to its main laboratories operates experiment stations at five locations in the State of Bahia, and in three other states. CEPEC consists of 17 specialized divisions, grouped into three departments. These are: Department of Biological Sciences--botany, genetics, plant physiology, plant pathology, entomology, and crop diversification;

Department of Physical Sciences--pedology, soil fertility, soil physics, photointerpretation, geology, technology, rural engineering, and climatology; Department of Social Sciences--agricultural economics, sociology, and socio-economic surveys.

DEPEX has 28 extension offices in the State of Bahia, plus offices in two other states. Each extension agency is a depository for materials where farmers can obtain, on credit, fertilizers, fungicides, insecticides, sprayers, dusters, farm implements, etc. Such sales amounted to around US$6 million in 1971, and an estimated US$8.5 million in 1973-74.

CEPLAC is a unique organization blending R&D, extension services, and training activities, all focused on improving the quality of life in rural areas producing cação. In some ways, CEPLAC can be likened to INTI and CSIR-India, although CEPLAC appears to have more autonomy and mobility to change direction quickly as required.

Centro Tecnológico de Minas Gerais (CETEC)
Technological Center of Minas Gerais
Av. Bias Fortes 401
Caixa Postal 2306
Belo Horizonte, M. G., Brazil

Type: Non-profit institute established by the João Pinheiro Foundation, linked with the State Council for Development under the Government of Minas Gerais State.

Board: Seven members from government and industry.

Director: Paulo Gazzinelli

Staff: 1974 total 126; 54 professionals, 37 administrative, 30 technical supporting, five others.

Affiliations:

Cooperation with the university; 50 or 60 students working at CETEC. Cooperative agreements signed with: Universidade Federal de Minas Gerais, Universidade Federal de Vicosa, Universidade Federal de Ouro Preto, Instituto de Tecnologia de Alimentos de Campinas, Fundação Universidade Mineira de Artes, Banco de Desenvolvimento de Minas Gerais, Companhia Brasileira de Tecnologia Nuclear, Conselho Estadual de Tecnologia de São Paulo, Financiadora de Estudos y Projetos, Secretária de Cooperação Económica e Técnica Internacional, Conselho Nacional da Indústria Siderúgica, Secretária de Tecnologia Industrial do Ministério da Indústria e Comércio, Engenharia para a Indústria Mineral S/A, Instituto de Pesquisas Tecnológicas, Centro de Assisténcia Gerencial de Minas Gerais, Escola de Engenharia da Universidade Federal de Minas Gerais.

Finances:

1974 operating budget US$2,500,000; US$2,000,000 from government subsidy; US$500,000 earned from contracts.

CETEC was established as a non-profit government-owned corporation in 1972 by the Fundação João Pinheiro in collaboration with the Minas Gerais Development Bank and CEMIG, the State Electrical and Power Utility. CETEC's founding objectives were to serve as a center of applied technology for Minas Gerais industry and in regional areas contiguous to the State. CETEC engages in a number of activities, including training of professionals, technical information collecting, chemical analysis, physical testing, standards and performance testing, industrial troubleshooting and research. CETEC technical divisions are: mineral technology, food technology of animal origin, metallurgical technology, environmental engineering, physical tests and chemical analysis, industrial chemical processes, industrial design, information and documentation, and international marketing.

CETEC has established a number of agreements with other Brazilian organizations, both to give and to receive assistance. To date, major emphasis (and contracts for services) has been concentrated in areas of minerals technology and industrial design. The CETEC

Analysis and Tests Division has taken over the equipment and facilities of the defunct Institute of Industrial Technology and is attempting to provide better analytical services to industry. Food technology projects are being assisted with the help of ITAL, and assistance in areas such as industrial chemistry, mineral analysis, etc. are being provided through working agreements and use of facilities of the Institute for Radioactive Research, and the Federal University of Minas Gerais.

CETEC attempts to plan its R&D programs according to priority needs of industry or government, either resulting from direct requests for assistance or through staff contacts. An International Marketing Division within CETEC is attempting to assist and organize medium- and small-scale industries to increase or establish export capabilities.

Fundação de Ciência e Tecnologia (CIENTEC)
Science and Technology Foundation
R. Washington Luiz 675, Caixa Postal 1864
Porto Alegre, Rio Grande do Sul, Brasil

Type: Non-profit foundation chartered by the State Government of Rio Grande do Sul to operate under Brazilian private law.
Planning Council: Composed of the President of CIENTEC, three representatives of the private sector, one representative from the Federal University of Rio Grande do Sul, two representatives of the other universities in Rio Grande do Sul, one representative of the Ministry of Planning and General Coordination, one representative from the Board of Financial Coordination of the State, one representative from the State Department of Industry and Commerce, and one representative from the State Department of Coordination and Planning.
The Council of Trustees (fiscal control): three members selected by the State Governor.
President: Maier Avruch
Executive Director: Orion Herter Cabral
Staff: 1974: 78 professional staff.
Finances: 1974: development expenses and investments--US$3,849,740. Operating budget--US$1,028,570. Total: US$4,878,310.

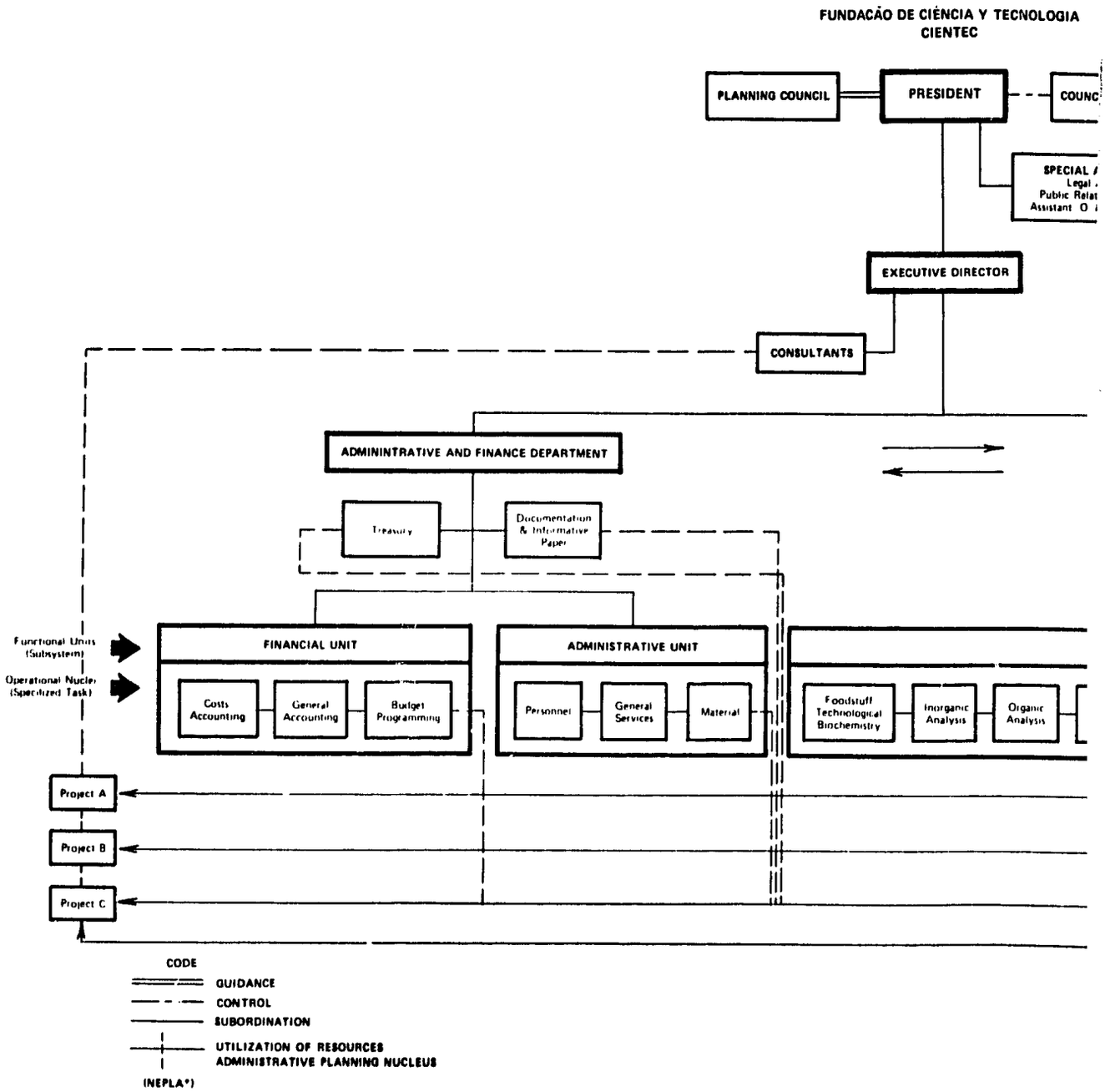
CIENTEC was created by State decree in June 1972 as a non-profit foundation for science and technology, supported and largely financed by state and federal funds, but to be operated under the terms of Brazilian private law. Establishment of CIENTEC incorporated and dissolved the Technological Institute of Rio Grande do Sul (ITERS) which had been created as a civil service laboratory by merger in 1942 of a State Materials Testing Laboratory and a Concrete and Aggregate Testing Laboratory. The limitations imposed by civil service constraints resulted in departure of most qualified staff so that ITERS gradually reverted to a testing and analysis entity, and ITERS management encountered increasingly greater difficulty in maintaining the flexibility and mobility necessary to meet the requirements of a rapidly expanding industrial sector. Creation of CIENTEC as a foundation operating under private law has largely overcome these constraints. The President of CIENTEC has the option of retaining civil service employees from ITERS until their retirement, or alternatively, transferring them to a State Special Staff, where their salaries and other benefits (such as retirement pensions) are assured until normal retirement age is reached.

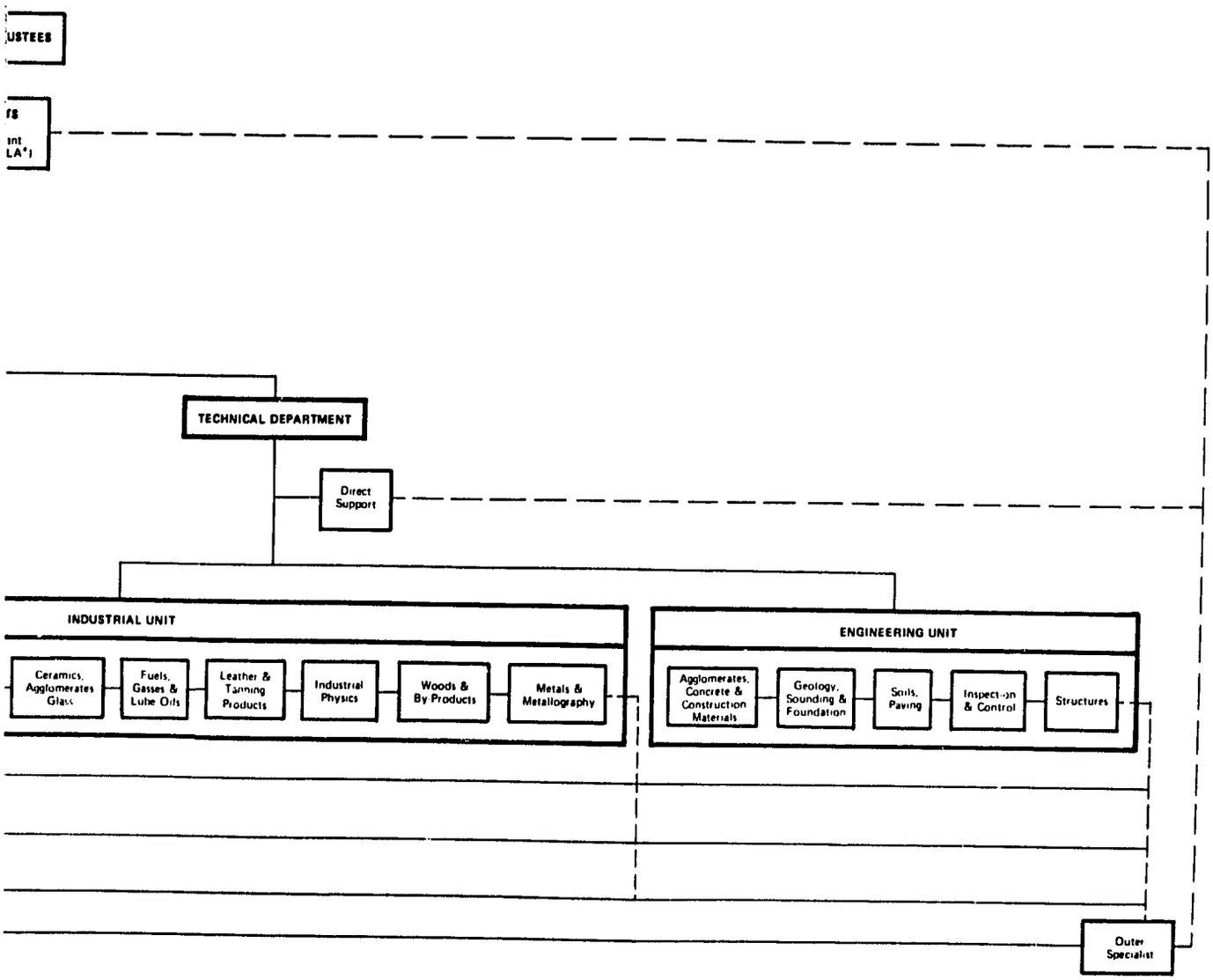
CIENTEC has been charged with responsibility for study and application of scientific and technological methods to the solution of problems peculiar to private and government entities so as to promote the economic growth of the State of Rio Grande do Sul (however, it is interesting to note that CIENTEC, located in the southernmost state in Brazil, intends to conduct programs in the Amazon Basin and Northeast Brazil.) In addition to documentation services, R&D, and technical

assistance to public and private enterprise, CIENTEC is charged with the responsibility to function as the State's official laboratory for analysis, tests, inspections and product evaluation, establishment and enforcement of standards and quality control measures, and to issue hallmarks, quality certificates, etc. It remains to be seen whether such regulatory power will impede free use of CIENTEC's R&D capability by industry which may suspect possible duplicity in such an arrangement. CIENTEC also conducts training programs and in-industry extension courses in order to prepare technicians for industry.

CIENTEC's Technical Department is responsible for all technical activities including technological studies, research, analysis, and tests (the Documentation Center is under the Administrative and Financial Department). Operating units are Engineering, consisting of programs in: aggregates, concretes and construction materials, geology, soundings, foundations, soils and paving, survey and control, structures. The Industrial Unit includes programs in: food products and technological biochemistry, rubber and plastics, ceramics, agglomerates, and glasses, fuels, gases and lube oils, leathers and tannery, industrial physics, wood and by-products, and metals and metallography.

CIENTEC is expanding considerably its effort to educate Rio Grande do Sul industry in the advantages which can accrue from technical assistance. Since Rio Grande do Sul industry is highly diversified and expanding rapidly, CIENTEC has an outstanding opportunity to meet its objectives stipulated by the State Governor when CIENTEC was created. Some 120 government agencies and private industries have utilized CIENTEC (and ITERS) services during the past few years. These services have ranged from techno-economic analyses, studies on new production techniques, adaptation and improvement of processes and products, and, of course, analysis and tests of raw materials as well as finished products.


FUNDACÃO DE CIÊNCIA Y TECNOLOGIA
CIENTEC
PLANNING COUNCIL
PRESIDENT
EXECUTIVE DIRECTOR
CONSULTANTS
ADMININTRATIVE AND FINANCE DEPARTMENT
Treasury
Documentation & Informative Paper
Functional Units (Subsystem)
Operational Nuclei (Specilized Task)
FINANCIAL UNIT
Costs Accounting
General Accounting
Budget Programming
ADMINISTRATIVE UNIT
Personnel
General Services
Material
Foodstuff Technological Biochemistry
Inorganic Analysis
Organic Analysis
Project A
Project B
Project C
CODE
GUIDANCE
CONTROL
SUBORDINATION
UTILIZATION OF RESOURCES
ADMINISTRATIVE PLANNING NUCLEUS
(NEPLA*)


USTEES
TECHNICAL DEPARTMENT
Direct Support
INDUSTRIAL UNIT
Ceramics, Agglomerates Glass
Fuels, Gasses & Lube Oils
Leather & Tanning Products
Industrial Physics
Woods & By-Products
Metals & Metallography
ENGINEERING UNIT
Agglomerates, Concrete & Construction Materials
Geology, Sounding & Foundation
Soils, Paving
Inspection & Control
Structures
Outer Specialist

Applied Scientific Research Corporation of Thailand (ASRCT)
196 Phahonyothin Road
Bangkhen, Bangkok 9, Thailand

Type: Autonomous governmental applied science corporation. Reports to the Prime Minister and a board appointed by the cabinet on recommendation of the National Research Council.

Board: Not more than three governors, four expert consultants and two special governors.

Governor: Wadanyu Nathalang (also Chairman of the Board)

Director, Technological Research Institute: Dr. Kasem Balajiva

Staff: 1974 total of 392: 130 professionals, 42 administrative, 119 technical supporting, 101 other

Administrative Body For: Four institutes: The Institute for Development Studies, Agricultural Products Research Institute, Environmental and Ecological Research Institute, and Technological Research Institute, which is the most advanced and active (TRI was established in 1964). The Center for Thai National Reference Collections is also part of ASRCT.

Affiliations: Informal linkage with the Commonwealth Scientific and Industrial Research Organization in Australia. Linkages with institutes in Great Britain, U. S., Canada and The Netherlands.

Finances:

Funds from various U. N. agencies, the Colombo Plan and local and overseas sponsors. 1965-70 U. N. Special Fund provided US$846,300. 1971-73 U. N. Special Fund provided US$541,000. U. S., Australia and Israel provided technical services. ASRCT 1973 budget was US$1,165,200, of which US$87,250 derived from grants, and US$24,600 derived from contracted services. In 1974, ASRCT obtained contracts in the order of 15 percent of government funds, although not all of these funds were expended or collected. TRI's major support from UNDP and UNIDO; foreign (expert) personnel provided by Australia, U.S.A., Sweden, Belgium and The Netherlands during its formative years. Established as UNIDO's five-year TRI Project. TRI's annual operating budget is approximately US$400,000 per year and currently around five percent was derived from contracts with industry in 1973. In 1974, however, contracted services increased to approximately 12 percent.

ASRCT is the main center for government research, established in 1963 and in operation by 1964, undertaking applied scientific research and coordinating research programs involving government departments and other government organizations. It is responsible for promoting the application of its findings in order to benefit national development and contribute to the utilization of natural resources. ASRCT provides scientific services and technical assistance to both internal and external agencies, and participates in a

number of activities including technical information collection and dissemination, standards and performance testing, industrial trouble-shooting and research projects. Capability lies in the areas of bio-technology, chemical technology, metallurgy and agricultural products. Four types of research are undertaken--that concerning utilization and upgrading of local raw materials, research into problems of existing industries, adaptation of known technology to local conditions, and research into feasibility studies on potential new industries. Activities in the past have centered on the following: pre-investment studies, utilization of agricultural products, pulping studies, industrial wastes, solar and terrestrial physics, minerals and metals studies, exploitation of natural products, chemical industry, building industry, physics and engineering, socio-economic studies, environmental and ecological studies, water pollution and sewage treatment.

Today, research at ASRCT is devoted primarily to applied work which tends to be short term. Some projects originate from government requests and some through surveys, contacts with industry and requests from sponsors. Research of a general nature is usually provided free, on a non-exclusive basis, to industry; a fee is paid when ASRCT undertakes a specific project, if exclusivity is required by the client, etc.

The primary objective of the Technological Research Institute (TRI), established in 1964, is to provide services for industry. The staff actively contacts industry to develop contracts and cooperation with the private sector. Although less than five percent of the budget is from industrial contracts, firms are increasingly beginning to recognize and contact TRI for assistance. Most attention is directed towards the industrial and trade associations rather than with industry or the Ministry of Industry, which seem to show less potential. Sub-divisions of TRI are: Minerals and Metals Group, Chemical Technology, Biotechnology and Environmental Engineering Unit.

ASRCT is still relatively young, so that it is difficult to evaluate accomplishments. Some research results are considered to be economically significant. Most important has been the stimulus to other research groups provided by ASRCT's aggressive approach to industry. The Corporation has worked hard to improve its image and relations with industry, but has been hampered by lack of an advertising budget and little government incentive for import substitution.

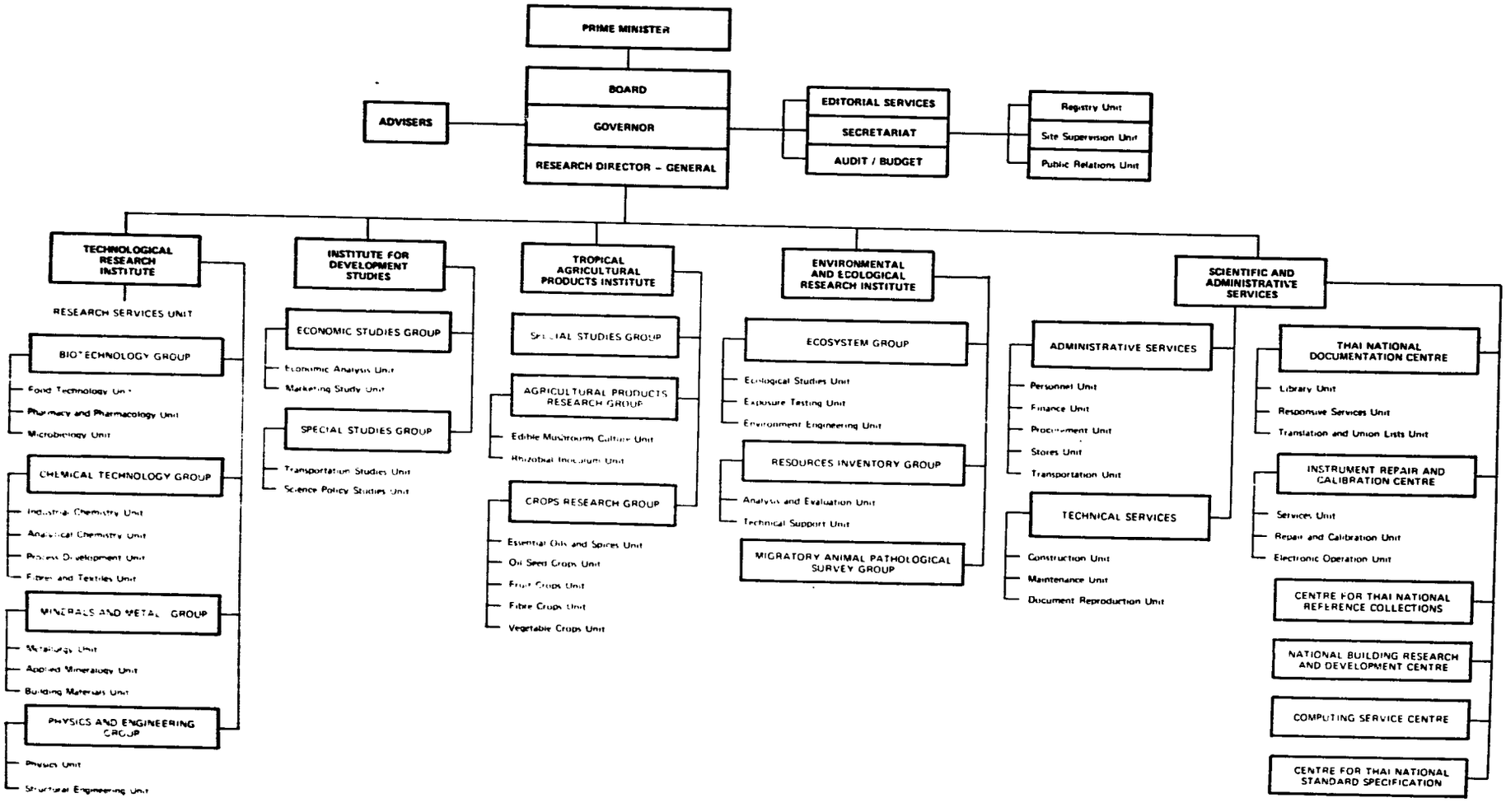
Although contact with industry has led to approximately 70 formal contracts, only a few are over US$5,000 contracts. Cost-sharing is limited and it is feared that the more subsidy and free services are given, the more will be expected. Recently, it has been decided that the fee should be considered as a grant to ASRCT with only a small down payment required. Staff salaries are one and one-half times those of civil service, yet there is difficulty in recruiting and retaining personnel capable of independent research. Part of this is attributed to a lack of fringe benefits and, in the past, strict rules concerning passage of an English test.

TRI has particular problems in staff development. The

Institute receives fellowship money to send staff away for a higher degree, but has difficulty getting money for on-the-job training or short-term practical training of any kind. It is hard to attract skilled people, as ASRCT salary policy does not properly recognize experience level and competition with industry.

There is little incentive for contract research, as fees received from projects go to a special fund managed by the ASRCT Governor. There is no project budget and cost control system so that it is difficult to budget money specifically to research for industry. The staff recognizes the need for short-term training and increasing internal incentives. They are seeking linkages with other IRIs which will hopefully contribute to the solution of these problems.

APPLIED SCIENTIFIC RESEARCH CORPORATION OF THAILAND
ASRCT



Instituto de Desenvolvimento Industrial de Minas Gerais (INDI)
Institute for Industrial Development
Rua da Bahia 888, Caixa Postal 992
Belo Horizonte, Minas Gerais, Brazil

Type: Non-profit corporation under the State Secretary of Industry and Commerce.
President: Agripino Abranches Vianna
Staff: 50 engineers and economists.
Affiliations:
Working agreement with Arthur D. Little; cooperation with Fundação João Pinheiro, Centro Tecnológico de Minas Gerais, and Companhia Distrito Industrial.
Finances:
1975 operating budget of US$2.5 million. Jointly supported by CEMIG, state-owned electric company; BDMG, a bank dedicated to financing industries within Minas Gerais; and by SICT, agency of the state government.

The Minas Gerais Development Bank (BDMG) was one of the first development banks to be established in Brazil and has been in the vanguard of industrial development activities, usually on an integrated industry approach, e.g., cattle-meat-milk-leather-shoes, by-products, etc. Until 1968, BDMG was the only agency for planning for development in the state and supported its own economic planning and R&D group.

INDI was established in 1969 as a result of a spin-off of BDMG's planning groups, in order to make more readily available outside expertise. CEMIG, the state power utility, and BDMG are principal financial supporters of INDI; however, INDI is a corporation under the Secretary for Industry and Commerce. Interaction between INDI, state government entities, CEMIG, BDMG, CDI (a state-owned company which provides necessary industrial infrastructure for lease or sale to entrepreneurs) results in an effective integrated process for industrial development.

INDI's prime purpose is to serve as a broker between the entrepreneur and the development bank. INDI engineers and economists are responsible for advising the bank on appropriate industrial projects and assisting industry in preparation and presentation of projects. The activities of INDI thus include pre-feasibility studies, special studies for investors, information and collection of data needed by entrepreneurs, and market forecasts which identify investment opportunities in Minas Gerais. Their research and service carry them into the areas of economics, management, city planning and technology. Special studies thus far have centered on specification of products, use of raw materials, market characteristics, size of undertaking, production process investments, income and costs, cash flow, and profitability. INDI is particularly concerned with regional or macro-regionalization studies, mineral resources utilization and exploitation, and management of a regional economic and investment data bank.

INDI attempts to match entrepreneurs and their interests, with available resources, targets of opportunity or need, projects with a potential

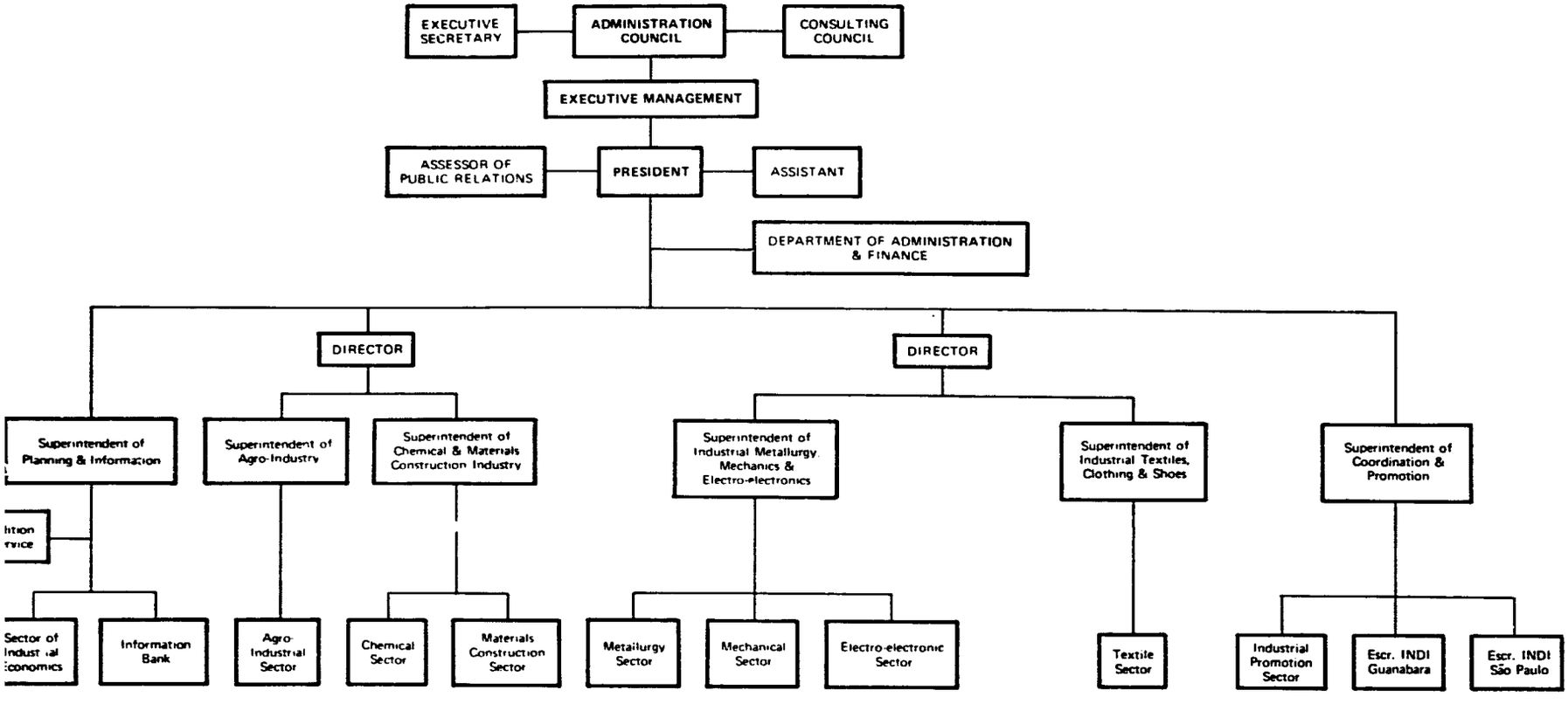
for implementation, available funding, and future profit. INDI does not sell its services on a contract or fee basis, and works without fee for entrepreneurs who approach them. INDI undertakes general studies, the results of which are available to the public in Minas Gerais as well as the rest of Brazil. Such studies may result from INDI awareness of a potential for export markets in the U. S. or Europe, a shortage of manufactured products (e.g., plastic items) in Brazil, or an understanding of the potential for exploitation of the state's extensive mineral resources.

In some instances, INDI will provide technical assistance to help industries solve existing operational problems, although generally such assistance is limited to small companies. As CETEC develops capability to provide such technical extension activities, INDI will withdraw from such activities.

The principal problem confronting INDI is that requests by entrepreneurs for techno-economic studies have increased to the point that INDI can not accommodate the requests. In 1973, over 2,000 contacts were handled; in 1974, such contacts were running at the rate of about 300 per month. This pressure is expected to result in an INDI policy to charge fees for services in order to limit requests for services and to ensure that the requestor really will use the data, information study results, etc.

INDI also plays an important role in matching interests of foreign investors with Brazilian companies or investment groups. Branch offices are maintained in Rio de Janeiro, São Paulo, Boston (ADL) and Brussels (ADL).

INDUSTRIAL DEVELOPMENT INSTITUTE OF MINAS GERAIS
INDI



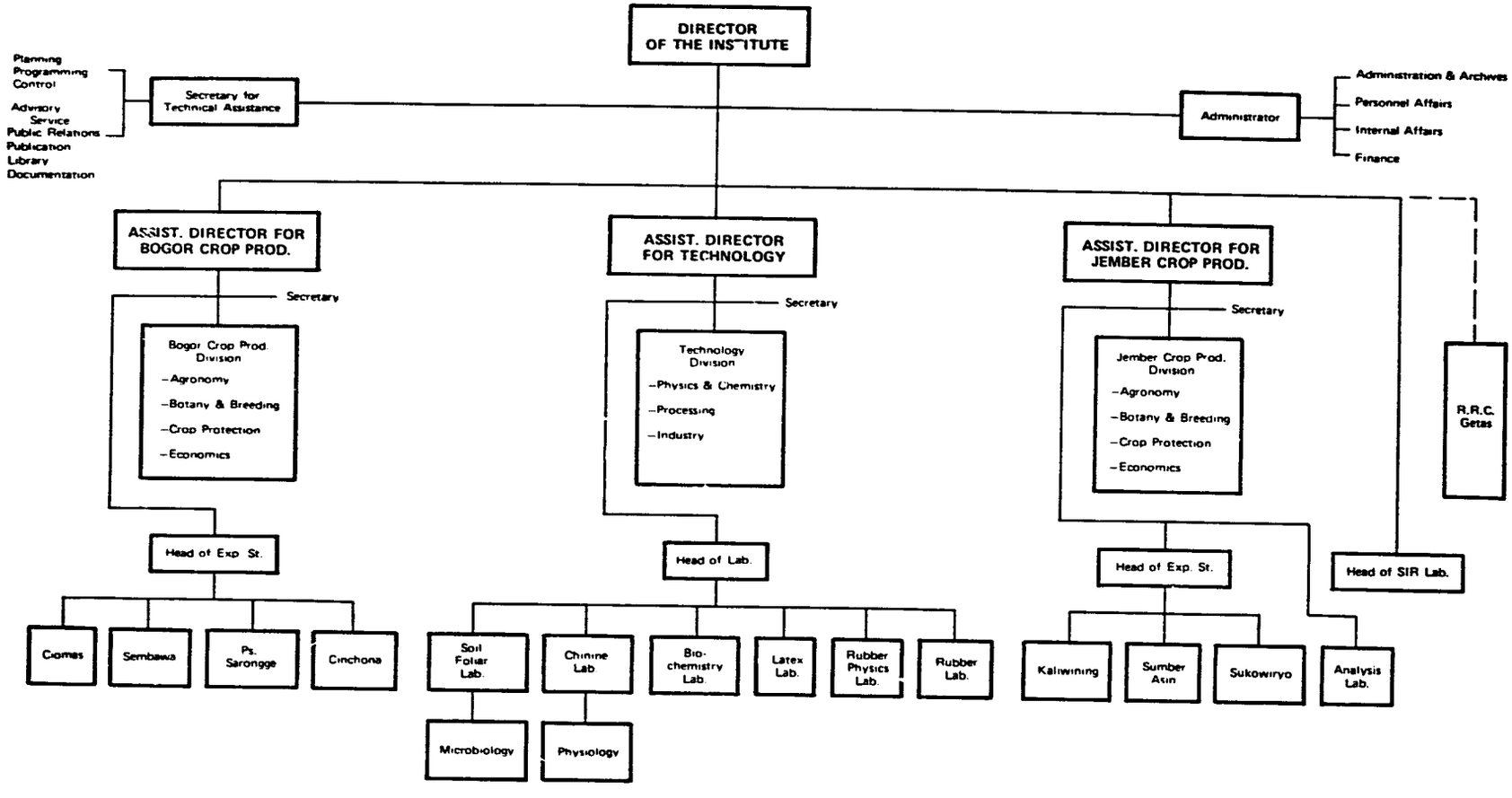
Balai Penelitian Perkebunan Bogor (BPPB)
Research Institute for Estate Crops
P. O. Box 05
Bogor, Indonesia

Type: Semi-autonomous department under the Ministry of Agriculture
Board: Managed by Council of Plantation Crops Research
Director: Ir. Moh. Saleh
Staff: 1974 total of 350; 38 research staff members
Administrative Body For: 12 laboratories
Affiliations:
Cooperation with university, other local and foreign research institutes, private plantations and enterprises.
Finances:
1974: US$1,300,000. Until 1968, financed and managed by the Foundation of Research and Educational Funds under Ministry of Agriculture (funds from a levy to support R&D for the benefit of export crops). From 1969 on, financed by the government, plantation enterprises of South Summatra, Lampung and Java and by private plantations.

The Institute for Estate Crops evolved from a number of experimental stations working on cultivation in 1900. These stations grew and their responsibilities expanded until 1968, when two groups of stations, INIRO, Industrial Institute for Rubber, and BBPK, Institute for Rubber Research and Development, fused into one institute. Since then, the Research Institute for Estate Crops has worked to improve productivity, quality and presentation of plantation crops. There are three main divisions: Crop Production in Bogor for Rubber, Crop Production in Jember for Rubber, Coffee, Cocoa, and Tobacco, and the Technological Division in Bogor. Research today is concentrated on the pre- and post-harvest problems, as well as the socio-economic impact of the crops mentioned above. Special projects have included research in agronomy, plantation crop protection, plant breeding, soil and fertilization, technology, agriculture, economics, statistics and intercropping.

A number of groups are interested in the work carried on by the Institute. Consumers of results thus far have included government and private estates, industry, the trade community, and the scientific community.

RESEARCH INSTITUTE FOR ESTATE CROPS



Marmara Scientific and Industrial Research Institute
Gebze, Kocaeli
Istanbul, Turkey

Type: Founded by the Scientific and Technical Research Council of Turkey (TUBITAK). The Institute Director reports to the Secretary General of TUBITAK, however, the Institute is financially and administratively autonomous.
Board: The Executive Council of TUBITAK.
Director: Professor Lütfullah Ulukan
Staff: 1975 total of about 410; 170 professionals, 60 technicians, 180 administrative and secretarial.
Finances:
1974 budget: US$7,850,000, of which approximately three percent or US$215,000 is from contracted services. Funded through TUBITAK. Majority of funds come from the federal budget, with the balance from contracts with government enterprise and private industry. Anticipated 1975 operational budget is US$10,000,000.

Marmara is one of two research institutes under TUBITAK. In 1965, TUBITAK set up the Institute to organize, coordinate and conduct fundamental and applied research. Activities began in 1965 and now include applied biology, chemistry and physics, engineering, operations research techno-economic studies and productivity studies. There are six units now in operation: Applied Mathematics, Operations Research, Electronics, Materials, Industrial Chemistry, and Nutrition and Food Technology. Research units of Life Sciences, Forestry Products, and Machinery have not as yet been implemented. Full operation of all units at Gebze is not expected until 1977.

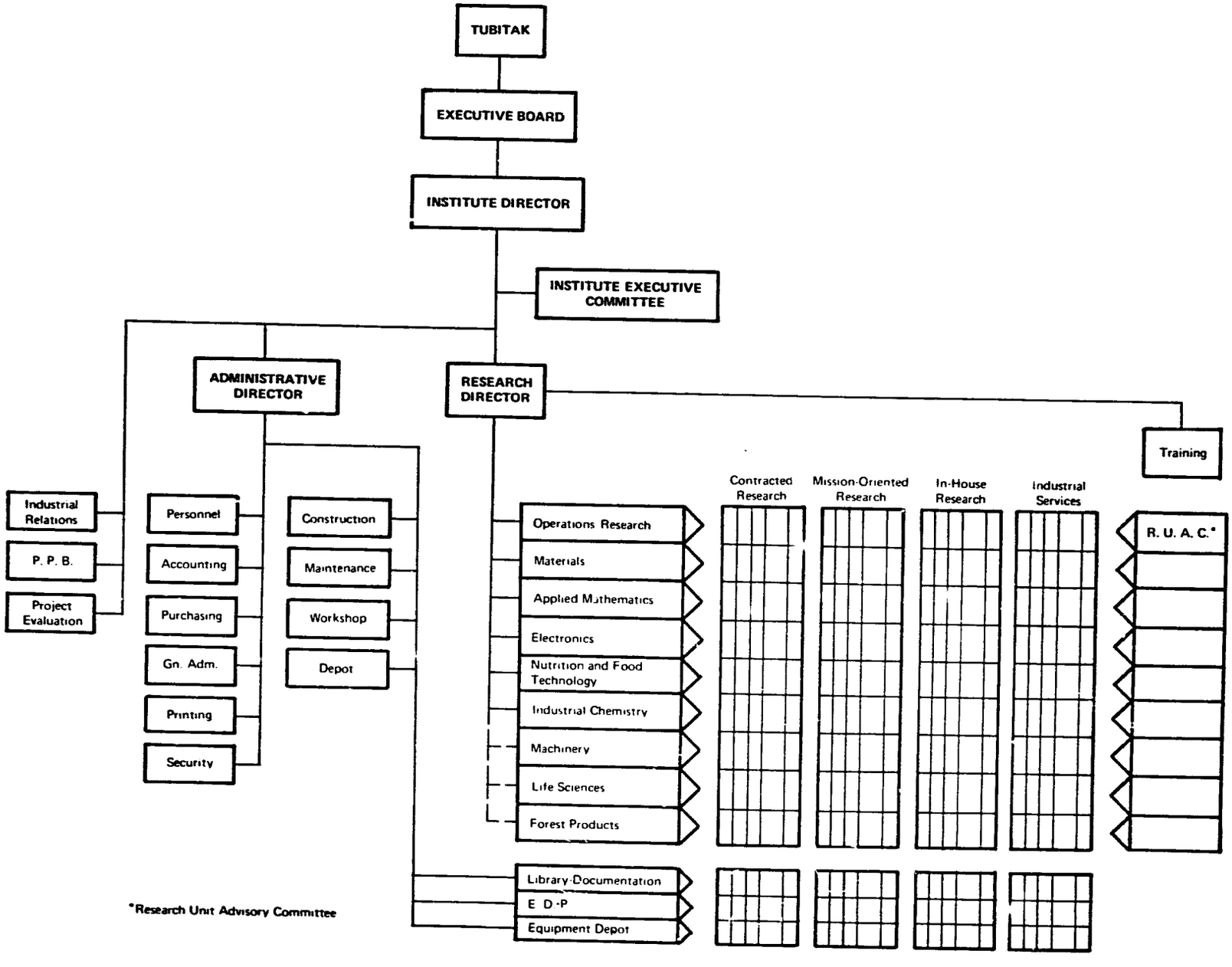
Marmara's main function is to help industry by problem-solving and by undertaking research activities compatible with national social and economic objectives. The Institute is thus developing a close relationship with industry by offering both specialized and qualified research capabilities. Projects are selected from proposals both to and from industry and undertaken on a contract basis. Marmara places considerable emphasis on an interdisciplinary approach to problem-solving, both at the individual as well as at the research unit level.

Two advisory bodies provide guidance to Marmara. The Institute Advisory Board is charged with evaluation of the performance of Marmara within the framework of the Institute's goals and objectives and with making recommendations regarding the design of research policy and better management of the Institute. There are also research unit advisory committees for each technical unit, such as materials, composed of two university professors, three to five people from specific interested industries and a representative of the state planning organization. These advisory committees meet frequently to scope the extent and nature of the problems of the particular industries concerned and recommend action to be taken by the Marmara Institute and industry. The composition of the committee can be varied with the nature of problems

to be resolved. Such advice and counsel provides an invaluable assist to the Marmara unit director and his staff in undertaking research of practical relevance to Turkish industry.

Since Marmara controls its own budget and salary schedule, many traditional IRI problems will be avoided. Recruitment and retention of qualified research personnel continue to be a problem. Faculty from nearby universities are either untrained in technological research or do not want to devote extra time to research at Marmara over and above teaching. University policy limits incentive payments to faculty for only one project, so there is no incentive to increase involvement. The existing research staff is of extremely high caliber. Approximately 40 percent (1975) hold Ph. D. s, which is a rather high ratio in comparison to other similar research institutes. Moreover most of the Ph. D. degrees were obtained from universities in the U. S. A. and European countries. Recruitment should improve with a training program that is being organized for periods of one to three years. Marmara expects to train a minimum of 200 research staff in a four- or five-year period. There is also a special program planned for visiting research scientists.

MARMARA SCIENTIFIC AND INDUSTRIAL RESEARCH INSTITUTE



*Research Unit Advisory Committee

Nuclear Reactor Center (NRC)
Bandung, Indonesia

Type: Research, training, isotope production center, operated jointly by the Indonesian Atomic Energy Commission and the Bandung Institute of Technology

Affiliations:
Trying to establish regional cooperation in Southeast Asia. NRC undertakes cooperative projects in neutron spectrometry with counterpart centers in India, Korea and the Philippines.

Finances:
Funding is derived from the Indonesian Atomic Energy Commission, the International Atomic Energy Commission (IAEC), grants and fees for testing and isotope production. NRC has five grants from the IAEC, and receives technical assistance from UNDP, and through bilateral agreements with France and the Netherlands.

The Nuclear Reactor Center was originally part of the Indonesian Medical Isotope Clinic but now is located at the University Hospital. NRC's main activities are focused on research, isotope production, and training. The original Triga II, 250 KW reactor has been upgraded to one megawatt capacity, utilizing solely the capabilities of NRC staff. NRC hopes to install a power reactor by 1980, in order to stimulate government interest in nuclear energy.

The NRC has been justified in Indonesia's priority programs on the basis of potential contributions to industrial development. Some 30 to 35 graduate students annually conduct thesis research at the Center, in addition to undergraduate students who obtain employment as laboratory assistants. ITB faculty conduct research at the Center; NRC staff give lectures and seminars at ITB, and also supervise graduate student research. The IAEC sends experts to NRC for periods of six months to one year to conduct research, training, etc.

Research activities include not only isotope production but industrial uses of these in nuclear hydrology, surface water measurements, dam seepage, flow, etc. Other areas of research include nuclear metallurgy, analysis of minerals, agricultural products, etc., based on isotope measurements.

Some analysis and testing is undertaken for industry, on a fee basis. NRC staff offer courses in industrial applications of isotopes and on nuclear power. Industry representatives usually attend.

NRC is responsible for producing all isotopes used for medical purposes, other AEC facilities, universities, and agricultural institutes. It has been speculated that the activities of the NRC have made isotope medicine readily available to the hospitals ten years earlier than would have been the case had the NRC not been established.

Building Research Institute
Directorate General of Housing, Building,
Planning and Urban Development
Ministry of Public Works and Electric Power
Jalan Tamansari 124, P. O. Box 15
Bandung, Indonesia

Type: Semi-autonomous government institute, under the Ministry of Public Works and Electric Power.*
Board: Seven members appointed by Minister.
Director: A. Kartahardja
Staff: 1974 total of 100; 11 senior research, three senior administrative, 60 administrative, 14 technical supporting.
Affiliations:
Close relationships with Jakarta Research Center for Housing and Environmental Problems, Indonesia Chamber of Commerce, Indonesia National Scientific Documentation Centre, Indonesian Institute of Science, National Institute of Standardization, Indonesian Council for Engineering and Construction, Professional Association of Engineers and Architects, and leading international bodies.
Finances:
1974-75: total project budget US$1,253,000; routine budget US$80,000. 1955-65, 1966-67: main source of funds was from the U. N. 1967 to date: main foreign aid from the Netherlands; experts sent from the U. N.; fellowships, publications, experts, and volunteers from Britain; equipment from Belgium.

The Building Research Institute was established in ECAFE's ninth session in Bandung, 1953, to provide host facilities to the regional housing center there. Two regional housing centers had been set up with U. N. assistance to work on the development of building materials, one in the hot dry area and one in the hot humid area. The Institute's main objective is to develop, organize and undertake studies, investigation, and research in the field of housing, building, and planning. The Institute participates in a number of activities, including dissemination of information, training, library and documentation service, publications, restoration of traditional construction, research and liaison between local and foreign institutes. Research is conducted on the feasibility of developing building materials, on building construction and on the quality of building materials. Wood from non-productive trees in rubber plantations is being used to produce particle board. The Institute is encouraging planting of secondary woods for building material production use. The Building Research Institute undertakes very little testing, the majority of which is undertaken by the LPPI Materials Research Institute.

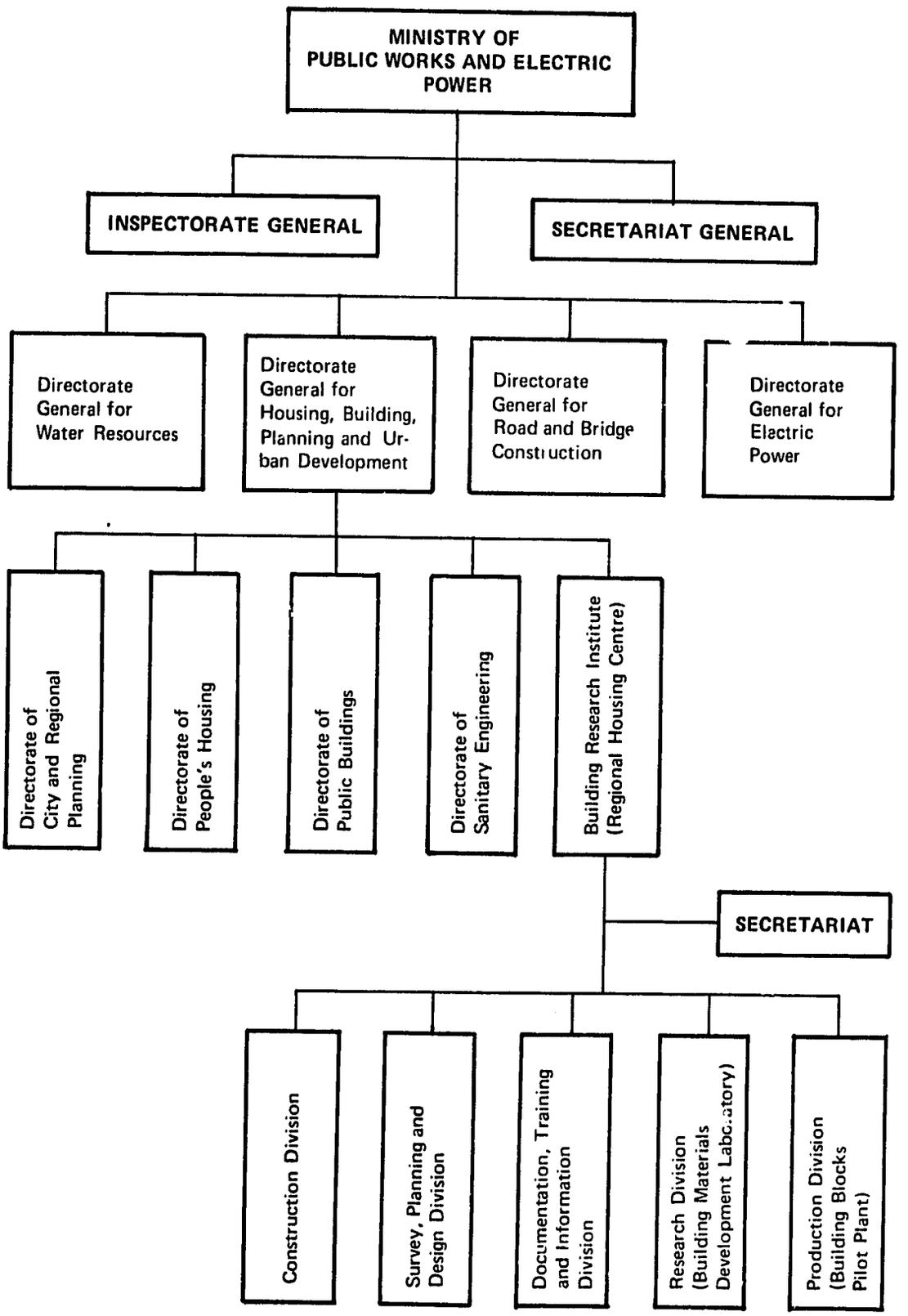
*Under the Ministry are also research institutes for energy and electric power, road and bridge research, housing, buildings and urban development, and hydrology.

Five projects are now underway: building and housing research, pre-fab housing construction, standardization for housing and building construction, low-cost housing, and building information center. Most emphasis is currently given to research on building materials. There is active interaction with the private sector, and products such as hollow block are sold at a profit.

The Institute is responsible for organizing the Industrial Council for Engineering and Construction and establishing jointly with the Council, regulations for building construction. The Institute has successfully developed contact with the construction industry and, at times, is unable to meet their demands. Pilot processes for products such as hollow block are being transferred as rapidly as possible to industry. Profits from sale of processes and products are used to build other pilot plants and for incentive payments to staff. The Institute is encouraging staff from universities, other institutes, the construction industry, etc., to work on joint projects.

The Institute is creating information centers in each province to promote good construction and use of new materials. Building material and construction industries are beginning to form industrial associations and to agree to voluntary compliance with the standards established by the Institute and the National Institute of Standardization. The Institute schedules industrial seminars at frequent intervals on new techniques in production of materials and construction. Construction industries and building material producers are encouraged to send their staff members to the Institute for specialized training.

BUILDING RESEARCH INSTITUTE



Metals Industry Research and Development Center (MIRDC)
Fifth Floor, Ortigas Building, Ortigas Avenue
Pasig, Rizal, Philippines

Type: Non-profit, semi-government, semi-private organization created by charter of the Government of The Philippines; autonomy under its board of directors.

Board: Seven-man board, four of whom are government agency representatives. Board chairman is chairman of National Science Development Board (NSDB).

Director: Antonio V. Arizabal

Staff: 1975: total of 270.

Affiliations:

Connections with industrial associations and government agencies such as the Board of Investment. Attached to National Science Development Board which is equivalent to the Ministry of Science. Southeast Asia Iron and Steel Institute, Philippine Foundry Society, Philippine Iron and Steel Institute, Society of Manufacturing Engineers.

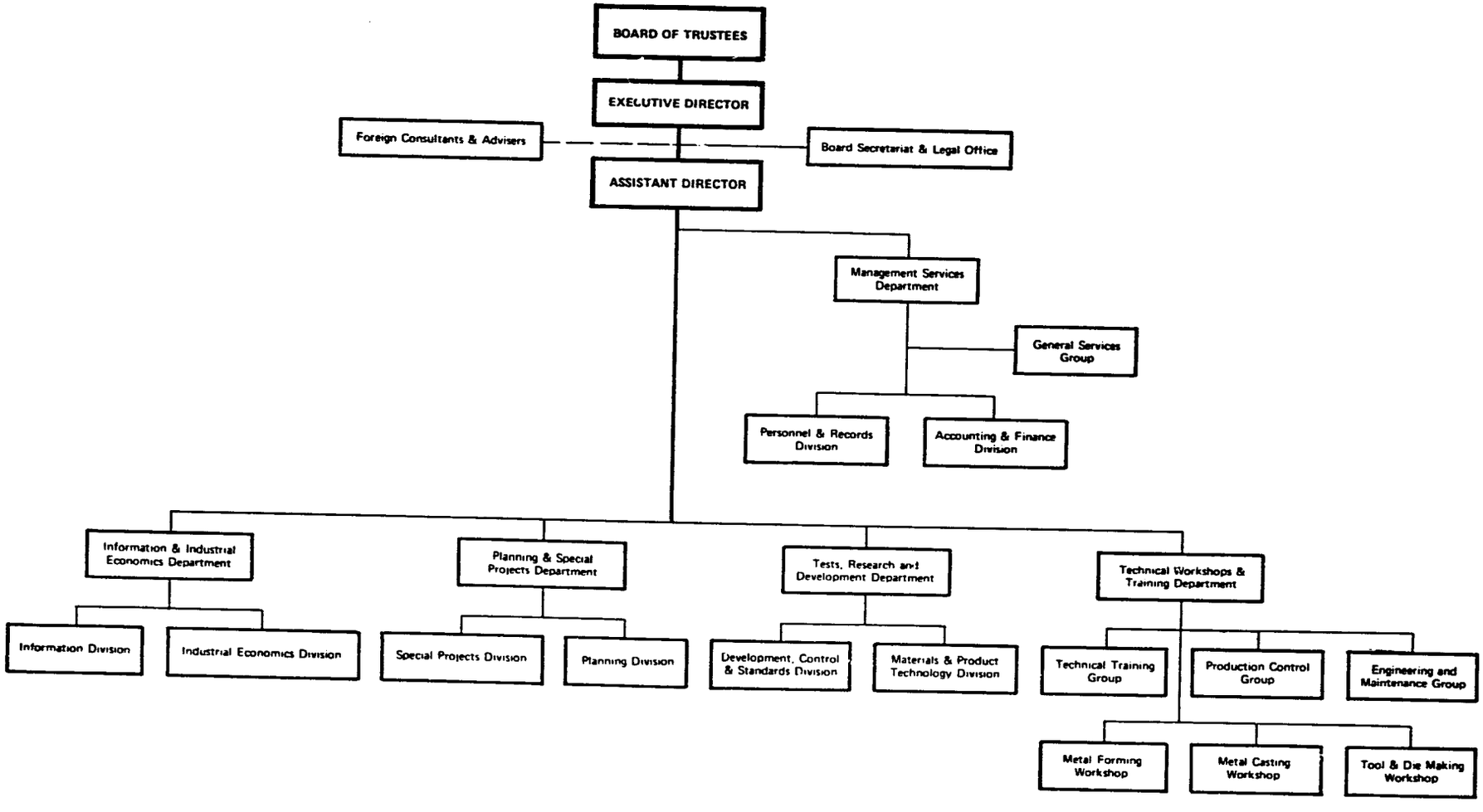
Finances:

1975 operating budget US$960,000 derived through contributions from the government and private sectors and from earned income. In five years, MIRDC expects 50 percent funding from government, 25 percent from the private sector and 25 percent from service fees.

MIRDC is a semi-private, semi-governmental organization which originated from the Metals Industry Development Center established in 1966. In 1972 President Marcos gave the Center its present name, along with corporate powers. Initially the Center focused on close rapport between the government and the private sector in order to foster the advancement of the metals, engineering and allied industries in the Philippines. Now, the Center provides both government and private sectors with technical expertise on such activities as training of engineers and technicians, skills accreditation, quality control and testing of metal products, information exchange, and research and advisory services. There are four divisions within the institute. They are: Technical Workshop and Training, Tests, Research and Development, Information and Industrial Economics and Planning and Special Projects. Specific projects have involved chemical analysis of metallic materials, metallographic analysis, micro- and macrophotography, testing of metallic materials and products, standardization of metallurgical laboratory equipment, pattern making and sampling stocks.

The institute works hard to develop contracts with industry and publishes industry studies for use by decision-makers in the government and in private industry. The staff is continually visiting industry and promoting interaction with MIRDC. Training courses, seminars, workshops, etc., are offered to local industries and multinational corporations. Technical services, problem-solving and feasibility studies are provided on a fee basis to both medium- and small-scale industry. The money collected goes into a MIRDC-managed revolving fund which can be used for incentive payments to staff, facilities development, etc.

METALS INDUSTRY RESEARCH AND DEVELOPMENT CENTER
MIRDC



Instituto Venezolano de Investigaciones Científicas (IVIC)
Venezuelan Institute of Scientific Research
Apartado 1827
Caracas, Venezuela

Type: Semi-autonomous institute under the Ministry of Health.
Board: Five directors; the IVIC Director and Sub-Director, and one representative each from the National Council of Universities, the Ministry of Education, the Ministry of Health. A Commission for Technology advises the IVIC Director on programs for applied R&D, industry contacts and promotion, national priorities and needs, and IVIC entry into new activities. The Commission consists of the IVIC Director, the two technological center directors and Executive Secretary, the president of the national metallurgical company, the president of the national petroleum company, one representative from private industry, and one representative from an industrial training foundation.
Director: Luis M. Carbonell
Staff: 1975 total of 1,100; 200 professional, 200 administrative, 300 technical supporting, 400 other.
Finances:
1975 operating budget US$14.3 million, of which US$1.5 million is from contracted services. Anticipated 1976 budget of US$21 million, including US$4 million from contracted services.

IVIC was established in 1959 as a semi-autonomous, government-owned institute with principal emphasis directed toward basic research in the areas of biophysics, biochemistry, microbiology, experimental medicine and nuclear physics. A technological center was established in 1971 so that IVIC could enter into applied research and development. In 1973, the Centers for Chemistry and Petroleum, and Engineering and Computation were established, which are dedicated primarily to applied research, pilot plant operations, commercial testing, and contracted services. Areas of emphasis are: petroleum, chemistry, organic, analytical and organometallic chemistry, metallurgy and materials, electronics and electrical engineering, mechanical engineering and environmental engineering. The original IVIC departments continue to focus principally on basic research, although attempts are being made to link such research more closely into the R&D activities of the IVIC technological center.

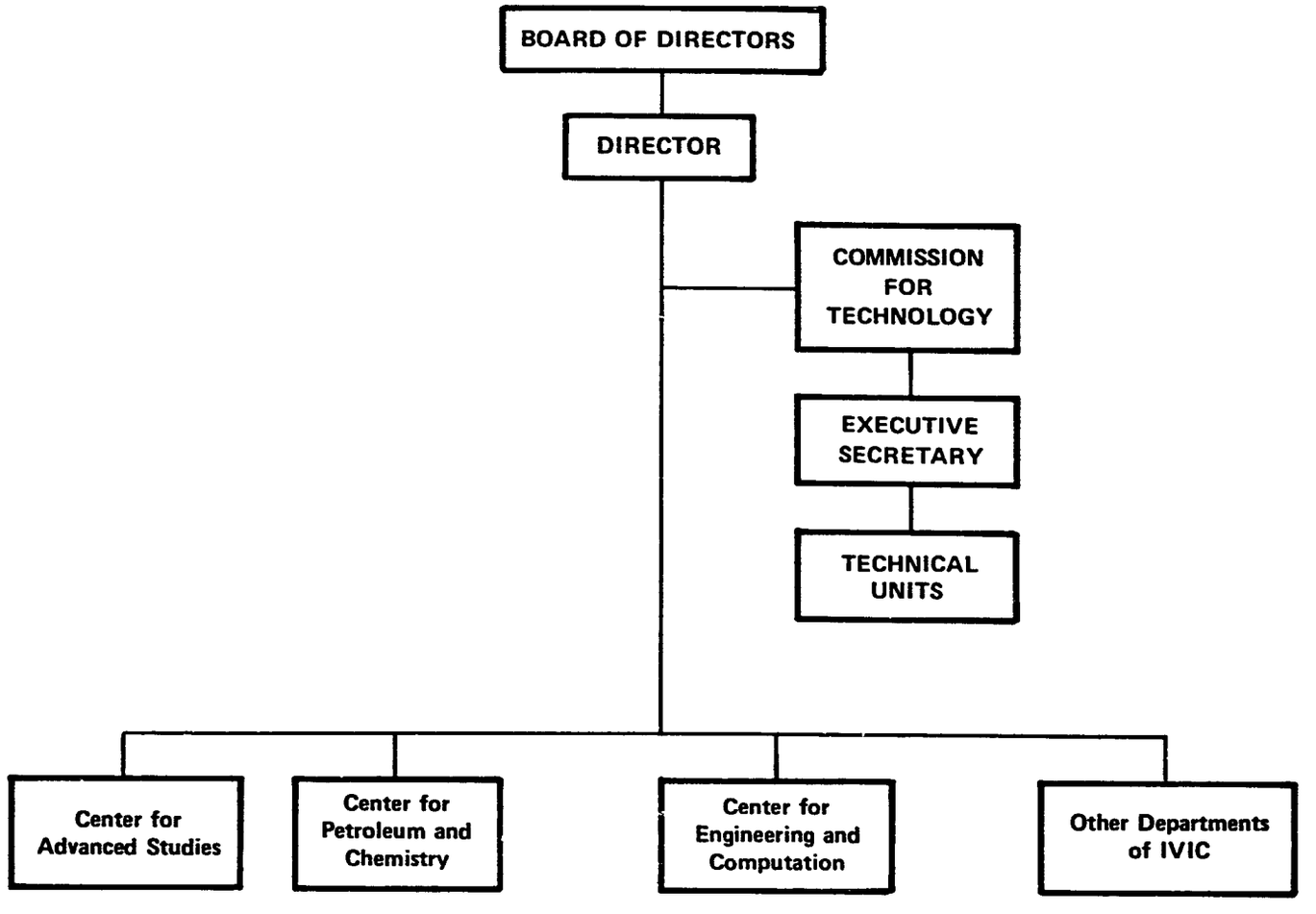
The IVIC Center for Advanced Studies is accredited by the Government to offer academic and research programs leading to the M.S. or Ph.D. degree. Classes are taught by IVIC professional staff and students do their research on IVIC projects. Specialized short courses and professional training are also offered to persons from industry, public enterprise, and government agencies.

IVIC is in the process of building a pilot plant park which will be used to carry bench research results into a demonstration phase. Units of the park will also be available to industry on a lease basis to undertake trial runs, investigate product improvement possibilities, train their own staff, etc.

The IVIC Technological Center is undertaking an aggressive program of industrial contacts and promotion of applied R&D. IVIC-industry seminars have been initiated to acquaint industry with IVIC capabilities and interests and so that IVIC can learn about industry needs. Analysis and test activities are recognized as essential to effective IVIC-industry liaison, but the volume of such activities is beginning to create conflicts with organized research activities using the same laboratories and equipment.

IVIC salary schedules are tied to a national professional salary schedule, and are considerably lower than comparable industry schedules, thus creating staff recruitment and retention. A policy, relating back to IVIC's original emphasis on basic research, ties salary increases and promotion to publication of papers in refereed journals, and thus imposes an additional constraint on those IVIC staff who are involved in contract research which may or may not provide publication opportunities.

INSTITUTO VENEZOLANO DE INVESTIGACIONES CIENTIFICAS
IVIC



Mathematics
Chemistry
Physics
Biology
Engineering

Petroleum
Petrochemistry
Organic Chemistry
Analytical Chemistry
Organometallic Chemistry

Metallurgy & Materials
Electrical Engineering
Electronics
Mechanical Engineering
Environmental Engineering
Computation

Microbiology
Biochemistry
Biophysics
Nuclear Physics
Ecology
Anthropology
Experimental Medicine

SEPARATELY INCORPORATED INSTITUTES

Shri Ram Institute for Industrial Research (SRIFIR)
19 University Road
Delhi 7, India

Type: SRIFIR is a unit of the Shri Ram Scientific and Industrial Research Foundation, a private non-profit organization.
Governing Board: Ten members drawn from science, industry, government and business.
Director: Dr. R. T. Thampy
Staff: 1974 total of 184; 78 professionals, 52 administrative, eight technical supporting, 46 other.
Finances:
1973-74 operating budget of US$357,900, of which US$268,300 was from sponsors, and US$11,180 was from royalties.

SRIFIR is a non-profit organization established in 1950 by the late Lala Shri Ram to undertake research of strategic importance to the people of India. The Institute has become one of India's foremost centers of applied research contributing to the advancement of industrial research and the national economy. SRIFIR is involved in contract research for defense services, industrial organizations and other government and semi-government agencies. The Institute either initiates its own project or responds to client suggestions. Projects are selected according to their economic feasibility, availability of expertise, and societal needs. The Institute conducts frequent seminars/symposia to provide a forum for the exchange of scientific views, opinions, accomplishments, etc., in India, and holds annual Founder Memorial Lectures to honor the top scientists in India.

Most attention is directed towards the utilization and development of indigenous raw materials and resources. Activities involve the collection of technical information, industrial troubleshooting, techno-economic studies, pilot plant studies and research. Expertise is found in the general fields of applied chemistry and applied physics. Areas of speciality have involved improvements in various polymers, development of new polymers and their technology, research and development on all chemical and mechanical processing techniques of natural and synthetic fibers and development of textile auxiliaries.

The Institute has two research divisions: Polymers and Plastics. The Polymer Division has two units: plastics (styrene plastics, PVC, engineering plastics, elastomers, polymer intermediates and auxiliaries, raw materials, etc.); and the fundamental studies unit works on evaluation of new synthesized derivatives of a variety of polymers and resins, processing characteristics of PVC resins, polyesterification, etc. The Fiber Division is concentrating on improvements in natural fibers, modification of fibers for better performance, spinnability, improvement in physical and mechanical properties, natural-synthetic fiber mixes, etc.

Recently, Shri Ram Test House has been established as an analytical and testing center (chemical, pharmaceutical, mineral, electrical, plastic, rubber, textiles, etc.), which is widely used on

an annual contract basis by an increasing number of industries. Product certificates are issued, standards and quality control guidelines are developed, and made available for use by industry. The number of samples tested increased from 1,614 in 1972 to 3,693 in 1973.

SRIFIR has published over 400 technical papers since its inception, and has more than 160 patents, many of which have been leased to industry and are producing some royalty income.

Instituto de Investigaciones Tecnológicas (IIT)
Institute for Technological Research
Avenida 30 No. 52-A-77
Apartado Aéreo 7031
Bogotá, D. E., Colombia

Type: Autonomous institute under Ministry of Economic Development.
Board: Board of Directors, five members.
Director: Dr. Norton Young L.
Staff: 1974 total of 122; 38 professional, seven administrative, 36 technical supporting, 41 other and six part-time.
Affiliations:
Cooperation with a number of international organizations and agencies. Linkage with Denver Research Institute. Associated with a development company.
Finances:
1975 operating budget US$780,000; 30 percent provided by the Agriculture Bank, Bank of Republic, Federation of Coffee Growers, Colombia Petroleum Company and Industrial Development Institute; 70 percent provided by industry, government, and international sponsors.

IIT was established in 1958 through the patronage of the Banco de la Republica, Caja de Cudito Agrario, and Federación Nacional de Cafeteros to undertake applied research directed toward the industrial and economic development of Colombia. The former Armour Research Foundation (now Illinois Institute of Technology Research Institute) provided organizational guidance and assistance. UNIDO provided funds for equipment and provided experts on a counterpart basis. The subsidy received by IIT has increased very little since IIT's founding, so that today such subsidy amounts to 30 percent of IIT's operational budget requirements. The balance is derived from contracts (mostly short-term) from the private sector or government enterprise.

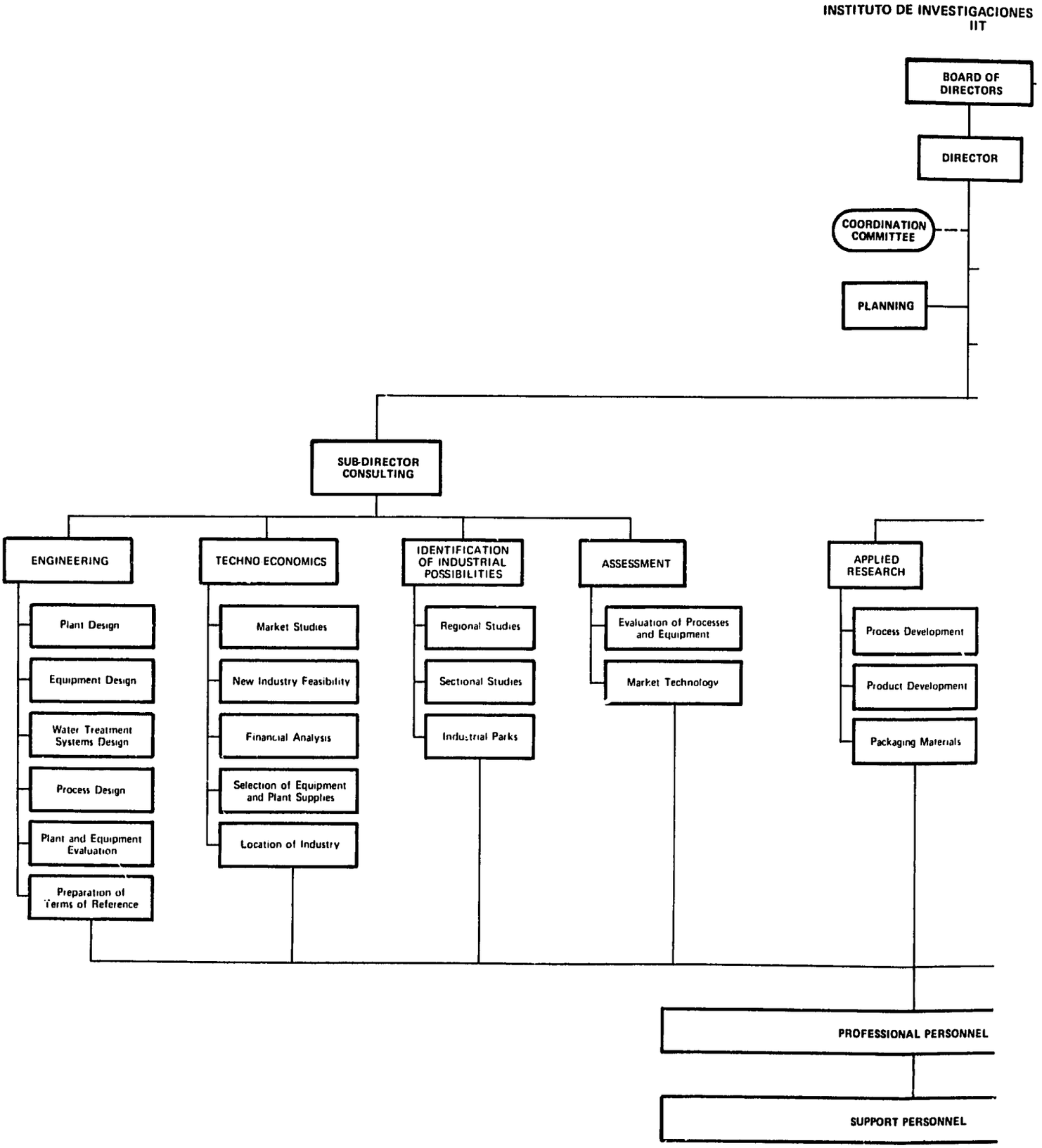
IIT's activities are conducted through four operating divisions: Applied Research, Consultation, Industrial Services, and Administration. Major areas of involvement include: applied research in chemistry, food technology, industrial microbiology, mineral products and raw materials, technical assistance and consultation in food production, metal-mechanical, natural resources, construction, etc. Activities carried out by the Institute include: techno-economic analyses; collection of technological information; quality control, standards, and performance testing; chemical, biological and physical properties testing; industrial troubleshooting; and pilot plant operations. Specific areas of study have included food processing and dehydration, protein enrichment of bread and pasta flours and milk substitutes, concentrated fruit juices, quality control of agricultural chemicals, coal, brick, clays, metal products.

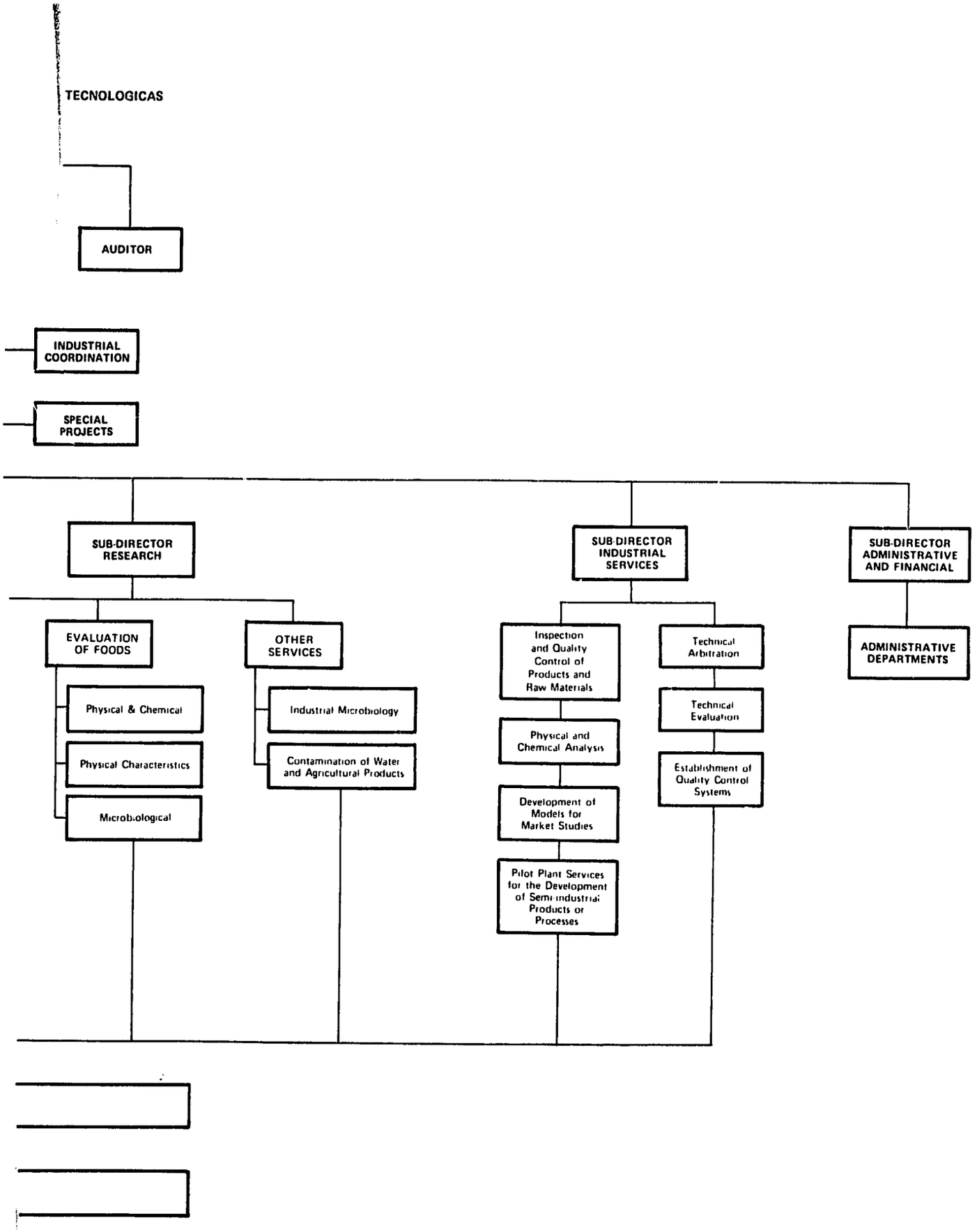
IIT is establishing an aggressive promotional campaign with frequent staff visits to industry, topical seminars for industrial sectors, training of industry staff, etc. The Institute provides technical assistance on a full cost recovery basis, although very small industries are assisted,

to the extent possible, on a no-fee basis. IIT does not have a long-range plan at the present time, although this is in the process of development through its linkage with DRI. IIT staff members are being brought to various centers in the U. S. for specialized training which will establish in IIT capability and experience in problems of quality control and standards, tariffs and trade barriers, technological information and technology transfer, food and drug restraints, etc., all directed toward assisting Colombian industry to increase its exports.

IIT has a good record of assistance to industry and government enterprise. Investments resulting from completed research and technical assistance in recent years have amounted to more than US$55 million. IIT has conducted 2,200 projects for industry, provided more than 500 consultations, and completed 83,000 product analyses.

IIT is faced with the same general research difficulties that persist throughout Latin America. Industry in Colombia is retarded, private capital is hard to attain, and markets are limited. Large industry goes to foreign institutes for their answers, medium-sized industries do not recognize their research needs, and small industries cannot afford the service. Industry remains ignorant of the concept behind research institutes and feels services should be free. IIT and DRI are jointly conducting a series of seminars for the Colombian Industrial Association for Development (ANDI) in an attempt to partially overcome this problem. Further efforts are directed toward joint research and technical assistance, through the linkage, to specific needs of small industries.


INSTITUTO DE INVESTIGACIONES
IIT
BOARD OF DIRECTORS
DIRECTOR
COORDINATION COMMITTEE
PLANNING
SUB-DIRECTOR CONSULTING
ENGINEERING
Plant Design
Equipment Design
Water Treatment Systems Design
Process Design
Plant and Equipment Evaluation
Preparation of Terms of Reference
TECHNO-ECONOMICS
Market Studies
New Industry Feasibility
Financial Analysis
Selection of Equipment and Plant Supplies
Location of Industry
IDENTIFICATION OF INDUSTRIAL POSSIBILITIES
Regional Studies
Sectional Studies
Industrial Parks
ASSESSMENT
Evaluation of Processes and Equipment
Market Technology
APPLIED RESEARCH
Process Development
Product Development
Packaging Materials
PROFESSIONAL PERSONNEL
SUPPORT PERSONNEL


TECNOLOGICAS
AUDITOR
INDUSTRIAL COORDINATION
SPECIAL PROJECTS
SUB-DIRECTOR RESEARCH
SUB-DIRECTOR INDUSTRIAL SERVICES
SUB-DIRECTOR ADMINISTRATIVE AND FINANCIAL
EVALUATION OF FOODS
OTHER SERVICES
Physical & Chemical
Physical Characteristics
Microbiological
Industrial Microbiology
Contamination of Water and Agricultural Products
Inspection and Quality Control of Products and Raw Materials
Physical and Chemical Analysis
Development of Models for Market Studies
Pilot Plant Services for the Development of Semi-industrial Products or Processes
Technical Arbitration
Technical Evaluation
Establishment of Quality Control Systems
ADMINISTRATIVE DEPARTMENTS

Singapore Institute of Standards and Industrial Research (SISIR)
179 River Valley Road
Singapore, Republic of Singapore

Type: Autonomous government-owned organization
Board: Two Deputy Chairmen and Seven Members
Chairman and Chief Executive: Lee Kum Tatt
Staff: 1974 total of 254; 60 senior officers, 70 junior officers, 100 laboratory assistants, remainder administrative.
Affiliations:
Linkage with University of Wisconsin to provide training in instrumentation and electronics. Linkage with Department of Scientific Research of New Zealand with purpose of providing training to SISIR staff in field of metallurgy. Working relationships with Singapore Manufacturers Association, National Trade Union Congress, Consumers Association of Singapore and various chambers of commerce.
Finances:
1975/76 operating budget US$2,136,750. 1973/74 expenditure US$1,097,860; revenue US$634,615; US$714,800 grant from government; 58 percent recovery of expenditures from industrial projects. Assistance received from New Zealand, International Development Research Center of Canada, Asia Foundation, and the United Nations.

SISIR is a multi-purpose technical and consulting agency under the Ministry of Finance. It was founded in January of 1964 and served as an industrial research unit under the Economic Development Board (EDB). In October of 1973, it became an independent statutory body responsible for extension services previously assigned to the EDB. In 1974, SISIR underwent reorganization so that now the institute consists of three divisions: Engineering Services; Scientific Services and Standards; and Extension Services Division. The administrative and finance group is a separate unit under the secretary.

The Institute was organized to provide expertise and technical service to Singapore industry. SISIR offers manpower development and training, technical and consultant services, testing and research. Major effort is concentrated on SISIR's role in problem-solving, standardization and quality control. Service and research are provided in the areas of mechanical engineering, electrical engineering, instrumentation, microbiology, materials science and non-destructive testing, environmental pollution and troubleshooting, industrial technical information services, design center and standardization and quality control.

The Institute serves today as an advisor both to government and to industry. In the past few years, the Institute has increased its contact with the latter and now recovers over 55 percent of its total costs from industrial projects. Quality certification is a regular function paid by participating firms. Promotional activities have recently been stepped up and continue to stimulate interest and interaction with industry. Seminars are offered to industry for

training and as a platform for the interchange of ideas. Efforts to bring industry in on the initial stages of work have resulted in bringing about good communication and greater confidence in SISIR. Multinational corporations, as well as small local industry, now use SISIR for day-to-day research projects.

The success of SISIR is demonstrated by the voluntary acceptance of local industries. Singapore is one of the few countries where an inspector has been accepted without government legislation. SISIR's highly trained professional staff has completed test reports and quality certificates for over 1,000 clients. Technical service has increased from 146 jobs in 1963 to over 6,000 in 1970. By 1972 the income to the Institute had doubled; between 1973 and 1976, an additional 50 percent expansion in income is expected.

SISIR faces a continuing shortage of research equipment and personnel. Contact with industry is very good and much better than that in other countries. Industry's approach remains speculative; there is still some reluctance to pay for services, and a prejudice against locally made goods continues, not because of inferior products, but psychological prejudice for foreign-made products.

SISIR has a good philosophy on financing and staff incentives and is well aware of its special needs. Regional and international cooperation are expected to increase as will contact with industry and universities.

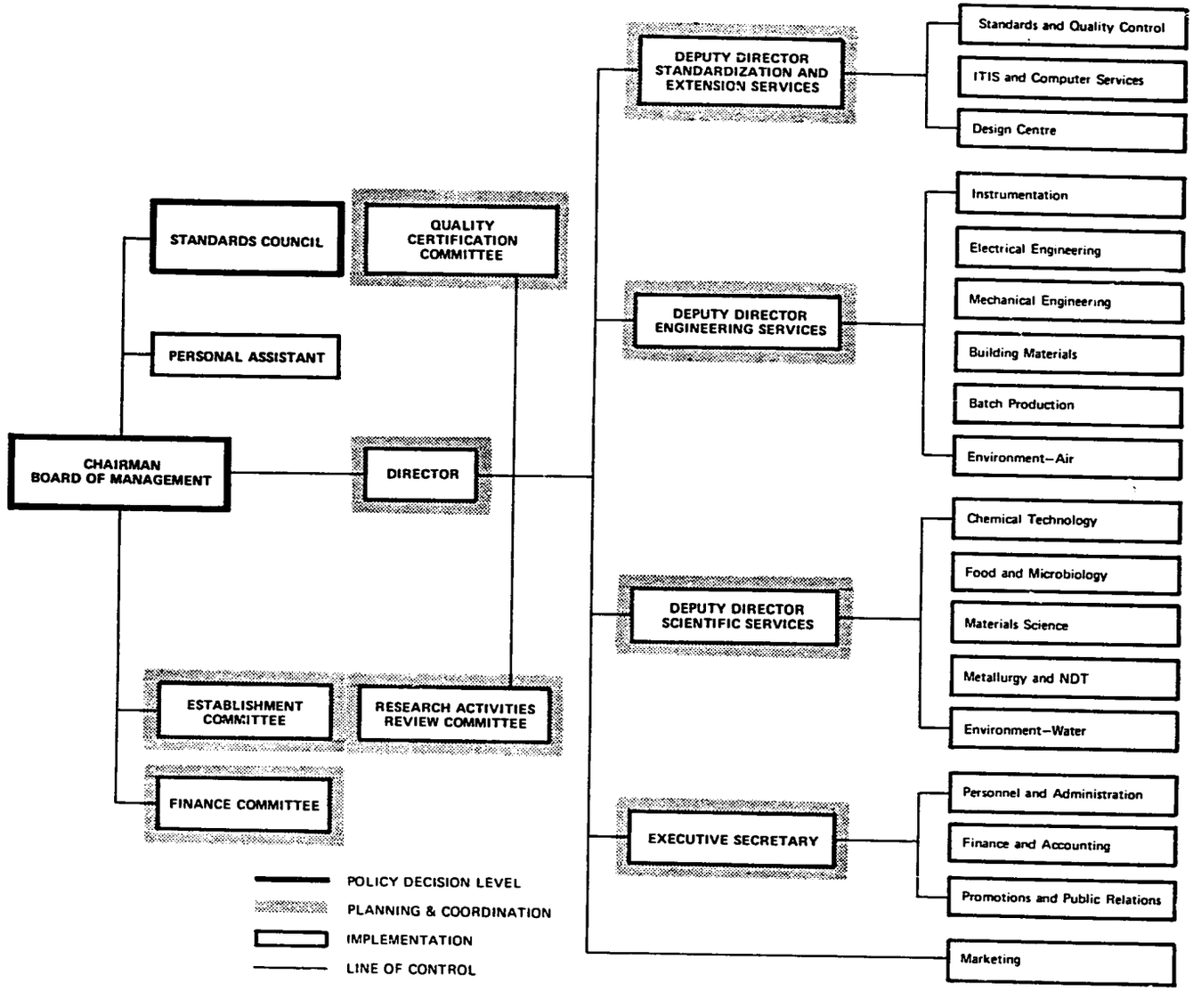
New areas of interest are likely to be urbanization, transportation and pollution. The goal is to improve technology and cultivate the indigenous technological base by providing adequate services, facilities and expertise to industries. Mixing new foreign technology with indigenous expertise is meant to improve the latter and lead to a gradual introduction of locally produced equipment.

SISIR is an active partner with the Singapore Manufacturers Association and the National Trades Union Congress in an intensive "Prosperity through Quality and Reliability (PQR)" campaign which involves all facets of Singapore's industrial development infrastructure. The program is designed not only to project an image of the quality and reliability of Singapore products, but also to stimulate a conscious and systematic effort by management, labor and government to:

- establish rapport and dialogue between management and workers and create a favorable industrial relations climate to cater for the future technological society;
- provide suitable training for the work force in the necessary technical skills and attitudes expected of them for modern industries;
- educate the consuming public to discard their prejudice against locally made quality goods;
- attract the right type of investment and know-how to Singapore.*

*From a speech by Mr. Hon Sui Sen, Minister for Finance, at the official launching of the PQR Campaign, 23 February 1973.

SINGAPORE INSTITUTE OF STANDARDS AND INDUSTRIAL RESEARCH
SISIR



Korea Institute of Science and Technology (KIST)
P.O. Box 131, Dong Dae Mun
Seoul, Korea

Type: Autonomous institute, able to receive funds and other support from the government, but without audit control or fiscal expenditure approval controls.

Board: Board of Trustees of 12 members; three are industrialists. Others include: Vice Ministers of the Economic Planning Board, Science and Technology, Commerce and Industry; representatives of Korea Advanced Institute of Science, Sogang University, Battelle Memorial Institute, USAID/Korea; the KIST auditor, and the KIST Vice President for Administration.

President: Hahn, Sang Joon

Staff: 1973 total of 765; four top management, 300 professional R&D staff, 58 in administration, 185 skilled workers, 202 assistants, 20 others.

Affiliations:

Associated with 22 national associations and organizations. Working agreements with three universities in Korea. Affiliated with Battelle Memorial Institute; New Nippon Steel Corporation, Japan; Sharp Corporation, Japan; Mitsubishi Research Institute, Japan; and Research Triangle Institute, U. S. Affiliated with Ocean Research and Development Institute and Shipbuilding Industry Technical Services.

Finances:

1973: US$4,880,235 in gross research volume, US$417,960 in gross overhead, US$2,540,800 in gross operating expense, US$2,951,850 in non-research income (interest income from endowment fund deposits), US$738,630 net income. Of this, 52 percent was derived from contracts and 46 percent from government sources. In 1974, the gross research income was US$6,200,000 with 57 percent derived from contracted services.

During the first Five-Year Economic Development Plan for Korea (1962-1966), the manufacturing and mining sectors in Korea were growing at an annual rate of 14.8 percent. It became obvious to the government that an organized effort was required leading to long-range development of science and technology to support such industrial growth, starting with the nucleus of a strong, autonomous R&D center in Korea.

As a result of an agreement reached between President Park of Korea and President Johnson of the United States, the U. S. agreed to provide assistance and guidance to Korea in establishing a multidisciplinary, industrial R&D institute in Korea--the Korea Institute of Science and Technology. Battelle Memorial Institute became KIST's "sister institute" and provided advice, counsel, assistance in determining areas of research needs for Korea, etc. Principal facility designs, selection of staff, primary areas of research concentration, and relevance to Korea's priority technological needs were, however, managed by the first President of KIST, Dr. Choi, Hyung Sup, now Minister of Science

and Technology and Dr. Hahn, Sang Joon, now President of KIST. Perhaps the most important aspect of KIST's development was the successful effort to persuade experienced Korean scientists and engineers, trained and working abroad, to return to Korea for employment in KIST.

KIST was incorporated in February 1966 as a not-for-profit corporation existing for the purpose of conducting applied research and providing technical services for industry and government and for the general benefit to the country's economy. KIST was intended to be the focal point for transfer to Korea of world technology and the adaptation of this technology to Korea's needs, rather than a basic research institute whose primary purpose would be to conduct basic research and impart new knowledge. This distinctive applied R&D emphasis remains as the cornerstone of KIST goals and objectives today.

It is difficult to estimate accurately the impact on KIST's effectiveness and productivity, of strong Korean-U. S. Government support, strong Korean leadership, and ample funds to build a well equipped institute and develop a highly capable professional staff. Certainly, it is clear that in a short span of ten years, KIST has achieved an enviable position as an effective technological institute; the extent of KIST contracted services to industry demonstrates this.

During KIST's formative stages, techno-economic surveys were conducted to determine Korean industry priority technological needs. Surveys were made in 25 different industrial sectors involving some 600 industrial plants. On the basis of this survey, KIST established the following as principal areas of concentration: materials science and metallurgical engineering; electronics and electrical engineering; mechanical engineering; chemistry and chemical engineering; food technology. Subsequently, industrial economics, information management and dissemination, computer services, and model machine shops activities have been added.

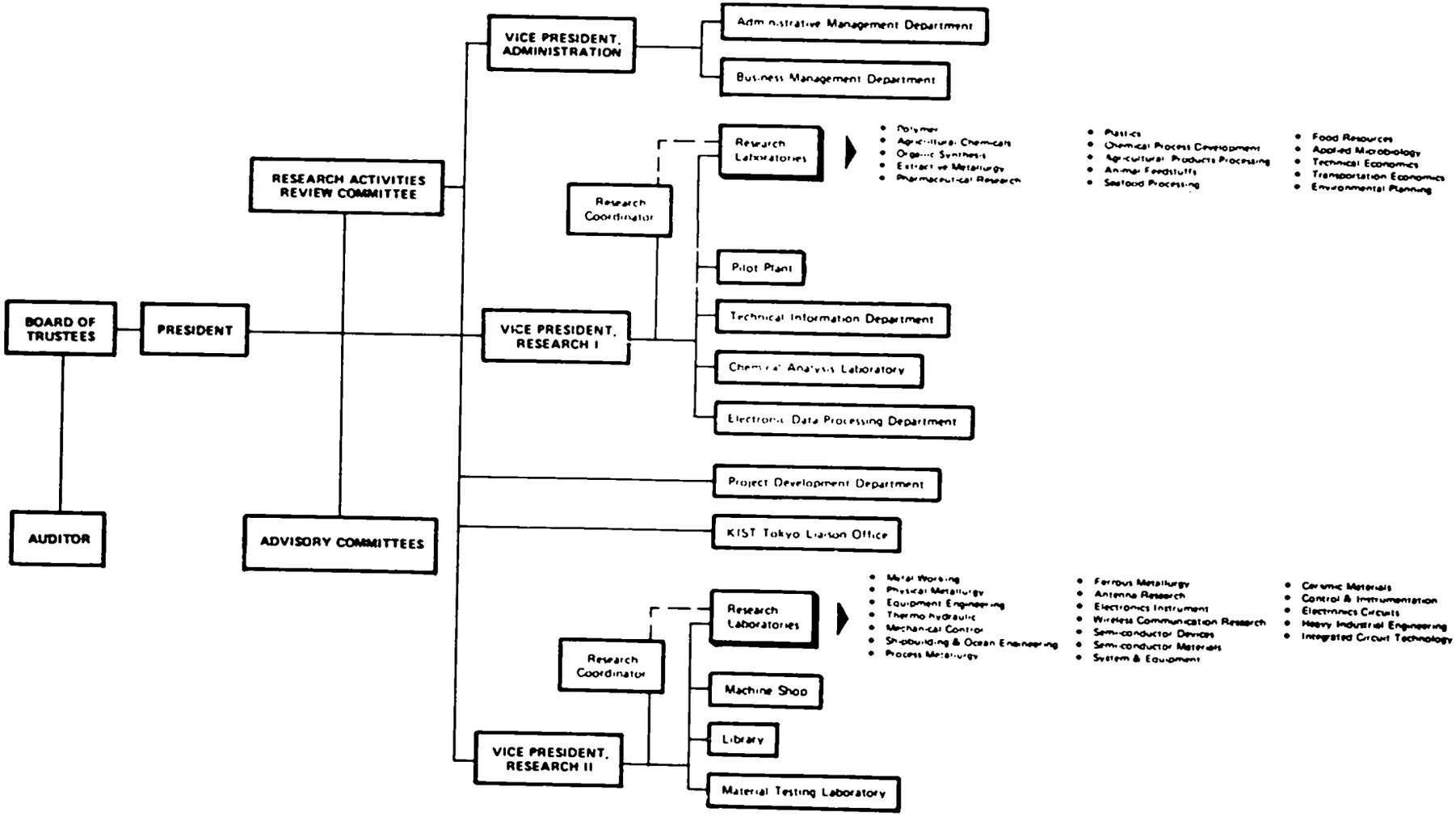
Specific projects have included work on high temperature materials, solid state physics, physical metallurgy, thermo-hydraulics, control and instrumentation, shipbuilding, ocean engineering, electronics, semi-conductor devices, agriculture products processing, animal foodstuffs, food processing, food resources, polymers, liquid state chemistry, lubricant technology, extractive metallurgy, plastics, construction engineering, technical economics, city and regional planning, packaging development. Several pilot plants are in operation. The products are sold and revenue is used to further develop the pilot plant activity.

During the period 1967-1973, KIST received 831 contracts from clients, totalling approximately US$4,200,000. During this period, industrial contracts amounted to an average 26 percent of income. In 1973, industry-sponsored projects accounted for 51.9 percent of contract income (out of a total income of US$4,880,235).

KIST does conduct a small amount of in-house research (two percent) from its own funds, and permits senior staff to undertake research of their own choosing, so long as the research is directed toward an anticipated applied or industrial need. Nearly all staff time however (75 percent to 90 percent) must be devoted to sponsored programs.

During 1973 about 20,000 advanced foreign technologies were analyzed, and some 4,000 of these were included in the KIST "General Survey of Overseas Technology." Over the period 1967-1973, 131 patent applications were made, of which 52 had been approved and registered. KIST estimates that its R&D program have contributed about US$20 million to the Korean economy.

KOREA INSTITUTE OF SCIENCE AND TECHNOLOGY
KIST



Fundación Para el Fomento de la Investigación
Científica y Tecnológica (FICITEC)
Foundation for the Development of Scientific
and Technological Research
Carrera 11A No. 69-75
Apartado Aereo 27872
Bogotá, Colombia

Type: Private non-profit institution.
Board: Seven members including the Minister of Finance and Public Credit, each founding institution and three representatives from industry and commerce.
Director: Guillermo Llinas
Staff: 1974: 12 professionals.
Affiliations:
International Executive Service Corps, National Research Council of Canada, Corporación Financiera Popular.
Finances:
1974 operating budget US$250,000. Contracts cover only about 25 percent of total costs. Subsidization mainly from founders, donations from multinationals and industry in Colombia, and international assistance organizations such as AID, OAS, Interamerican Foundation, and National Research Council of Canada.

FICITEC was created in 1970 by the Banco de la República, the Banco Cafetaro, and the Compañia Agrícola de Seguros as a private, non-profit foundation, dedicated to the study and implementation of those processes for planning, expansion, and daily operations which relate to small and medium industry. FICITEC's goals have focused on applying modern technology to the needs of Colombia's industrialization efforts through providing management and technical assistance, particularly where this assistance might be expected to impact creation of employment, promotion of the country's general and social and economic welfare.

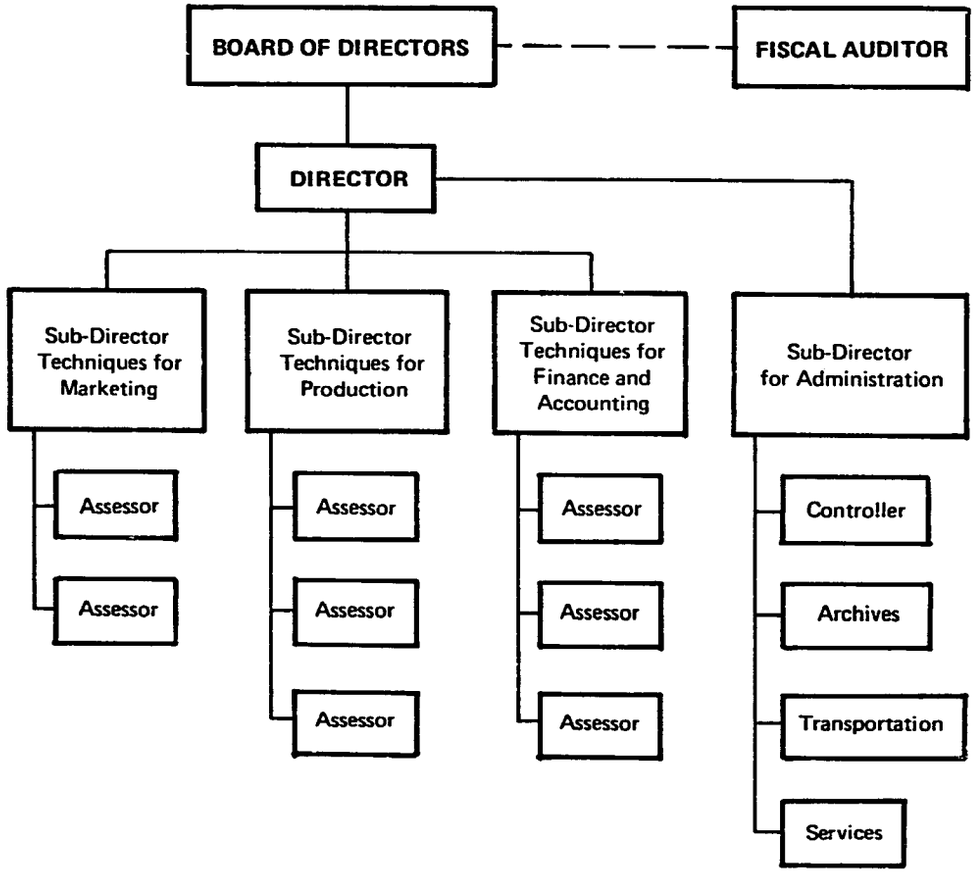
Industries which receive assistance are expected to pay 50 percent of the costs (although actual recovery is nearer 25 percent). Since FICITEC receives far more requests for assistance than its staff can adequately handle, a preliminary screening is conducted to determine whether the organization requesting assistance meets the following requirements:

- measurable economic potential growth,
- adequate leadership within the community,
- labor-intensive where it is technically and economically feasible,
- demonstrated interest in the workers social welfare,
- company policies consistent with the industrial development policies adopted by the Colombian Government.

FICITEC staff follow-up on all projects of technical assistance for several months after completion to assure that recommendations have been followed, and to facilitate implementation of future plans.

FICITEC is beginning to initiate R&D activities specifically relating to rural industrialization which would utilize simple technology and training of unskilled workers with a minimum of time and modest investments in capital. Examples are simple manually operated electrical generation apparatus, clothing, leather working, doll making, handicrafts, etc. The objective is to devise industries which can have positive effects on rural employment and family economies and thus provide economic incentives to slow down rural to urban migration.

FUNDACIÓN PARA EL FOMENTO DE LA INVESTIGACIÓN CIENTÍFICA Y TECNOLOGÍA
FICITEC



Instituto de Investigación Tecnológica Industrial
y de Normas Técnicas (ITINTEC)
Institute for Technological Industrial Research
and Technical Standards
Av. Abancay 1176-2º Piso
Lima 1, Perú

Type: Non-profit legal entity with administrative and economic autonomy.

Board: Directive Council consisting of a President, three representatives from the Ministry of Industry and Commerce, a representative from the National Council of Investigation, a representative from the National Institute of Higher Learning, and a representative of the workers at ITINTEC. The Council President is named by Supreme Resolution on proposal by Ministry of Industry and Commerce.

Director: Isaias Flit Stern

Finances:

Administrative and special costs covered by resources assigned from the working budget of the Republic. Two percent from net income before taxes of industrial corporations can be used by industry to pay for R&D, or if not used, put aside in special account for use by ITINTEC to support R&D programs relevant to Peru's industrial development.

ITINTEC was created by law in 1972 to promote, coordinate, orient, and execute industrial technological R&D in accordance with the policies for development and promotion of the Ministry of Commerce and Standards, to stimulate, develop and approve national technical standards. In 1973 the Government of Peru passed a law which requires all industry within Peru to deduct two percent of their net income before taxes, to finance R&D projects.

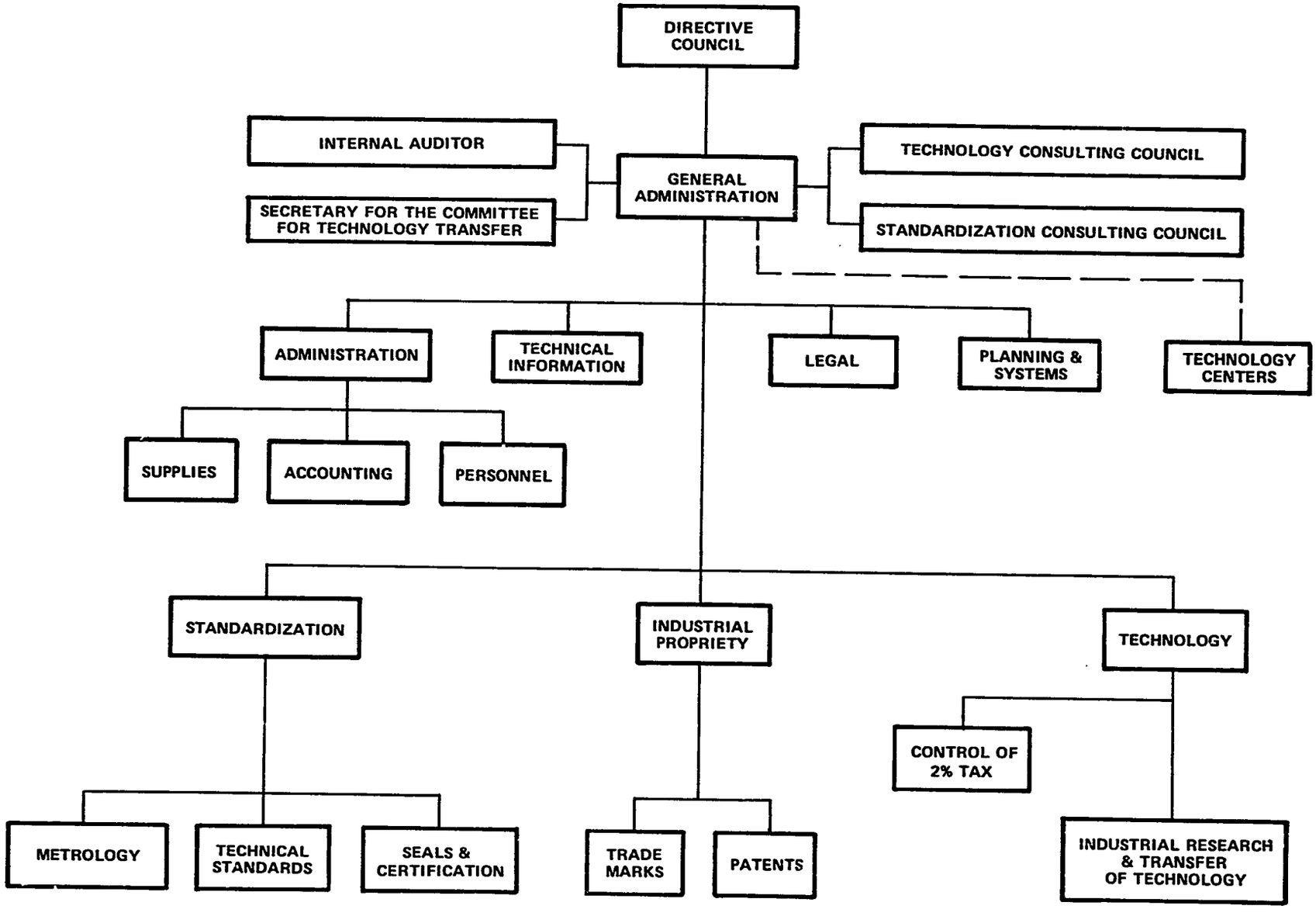
The projects may be individual or collective, carried out by a company itself (or a group of companies), or these projects may be assigned to university or research institute laboratories, other public or private agencies, or to ITINTEC. The projects can be financed from these funds up to a maximum of five years. If the company, for a variety of reasons, does not use its tax credit to support R&D, the funds revert to ITINTEC who will utilize such funds in support of R&D programs relevant to Peruvian national priorities, and which may or may not bear on the particular problems of the industry contributing the funds. ITINTEC usually will contract such projects out to existing university or research institute facilities, although it reserves the right to conduct such projects in its own facilities.

Needless to state, Peruvian industrialists have suddenly developed an intense interest in the role of R&D in industrial development, now that they have been forced to directly support R&D through a direct tax. Since ITINTEC must approve all R&D projects undertaken by industry, whether internally conducted or externally contracted, interaction between industrial representatives and ITINTEC

staff is frequent and continuous.

ITINTEC collaborates closely with the Ministry of Industry and Commerce and the National Research Council to formulate policies for technological and scientific research required for industrial development and to identify national technological priority needs.

INSTITUTO DE INVESTIGACIÓN TECNOLÓGICA INDUSTRIAL Y DE NORMAS TÉCNICAS
ITINTEC



International Rice Research Institute (IRRI)
Los Banos, Laguna
Manila, Philippines

Type: Autonomous international institute.
Board: Twelve members representing Ford and Rockefeller Foundations and principal rice-growing countries.
Director: Dr. Nyle C. Brady
Staff: 1974 total of 650; 25 scientists representing eight nations, nine scientists assigned to international projects.
Affiliations:
IRRI, USAID, and Indian Government-supported program on rice production through all India. Coordinates several international testing programs. Coordinates in regional rice research with International Institute of Tropical Agriculture and WARDA in Africa and CIAT in South America. Cooperation with Bangladesh Rice Research Institute. One-third of staff in outreach projects in Bangladesh, Egypt, India, Indonesia, Philippines, Sri Lanka and South Vietnam.
Finances:
1973 cash grants totaled US$4,265,105: Ford--US$1,549,097, AID--US$1,170,364, Rockefeller Foundation--US$672,535, International Development Association--US$120,000, Overseas Development Administration of U. K.--US$338,897, US$34,374 reimbursed from contract with U. S. National Institute of Health, Imperial Chemical Industries--US$500, International Potash Institute--US$2,195, Shell Chemical Company--US$3,000, Bayer, Philippines--US$8,333, NSDB--US$1,816, NFAC--US$29,677, Japanese Government--US$228,780, Indonesian Government--US$120,000, Australian Government--US$6,375, and Netherlands Government--US$64,700.

IRRI is a world center organized in 1960 by the Ford Foundation and the Rockefeller Foundation in cooperation with the Philippines Government to study improvements in rice and the machinery used in its production. In 1970, the U. S. Agency for International Development became a third major contributor to the Institute's activities. The Institute's activities include research on the rice plant and its management, international workshops for identification of problems, in-resident training programs, regional rice research projects with international scientists, and operation of a library and documentation center. The areas of study are: Genetic Evaluation, Pest Control and Management, Water Management, Soil and Crop Management, Environmental Influences, Machinery Development and Economics, Post-Harvest Management, Constraints to Rice Yields, Pilot Extension Program and Rice Cropping Systems. Special projects have dealt with plant breeding, genetics, cereal, chemistry, agronomy, plant pathology, multiple cropping, soil chemistry, soil microbiology, plant physiology, entomology, agricultural economics and statistics.

All work at IRRI is aimed at the improvement of rice quality, use, and production for international benefit. Currently, scientists are working on accelerating rice research progress in India, Bangladesh,

Sri Lanka, Indonesia, South Vietnam and Egypt.

IRRI has developed, through breeding, several strains of new and better quality rice. Resistance to insect damage has been established as well as the ability for farmers to obtain reasonable yields in spite of drought, floods, or poor soil. Stable control of blast fungus disease has been established for some varieties of rice. IRRI research has led to design parameters for a multiple crop system.

Since its inception, IRRI has trained over 400 scientists in rice technology and published 2,500 documents in the "International Bibliography of Rice Research." Some thirteen institutes in major rice-producing countries cooperate with IRRI in a network-wide "Genetic Evaluation and Utilization Program." Additional research is underway to improve disease resistance and high yield potential. Improvement is sought in low-cost weed control, varietal differences in tolerances to problem soils, and on reducing the number of days needed for rice maturity.

IRRI has underway a sizable program for development of suitable farm equipment for rice production and processing (and tropical agriculture in general) under a contract with the U. S. Agency for International Development. The IRRI program is based on the concept of equipment design utilizing, to the maximum extent, already available components or designs which can be adapted and utilized by small machine shops and local manufacturers. IRRI engineers work closely with such small industries, modifying designs as necessary, and providing seed monies to the industries to undertake initial production.

Ten equipment designs have been established to date. IRRI holds the patents, if any. Each participating company signs an agreement stating that it will not give design details to another company and that design improvements will be provided to IRRI. An IRRI-supported outreach program maintains constant contact with manufacturers of IRRI-designed equipment, in order to provide technical assistance, solve on-the-spot problems, or refer major problems to IRRI.

IRRI management estimates that approximately US$20 million worth of farm implements, based on IRRI designs, have been produced by Southeast Asian industry during the past seven years.

REGIONAL INSTITUTES

Instituto Centroamericano de Investigacion
y Tecnologia Industrial (ICAITI)
Central American Research Institute for Industry
P. O. Box 1552
Guatemala City, Guatemala, C. A.

Type: Autonomous institute established as regional integration. organization by Governments of Central America to provide research services to industry.
Board: The Ministers of Economy of Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua.
Director: Gabriel Dengo
Staff: 1974: 79 professionals, 104 administrative, 20 trainees.
Affiliations:
United Nations Development Programme, Organization of American States (OAS), Secretaria del Integración Económia de Centro América (SIECA), Banco Central de Integración Económia (BCIE), linkages with Denver Research Institute (DRI) and CODOT (Universities of California, Michigan State, Rhode Island, Wisconsin, Washington), working agreements with Universities of San Carlos, Guatemala, Costa Rica, Honduras, the Food Technology Institute of the Banco Central de Nicaragua, and a large number of national and regional organizations involved in Central American common market economic and industrial development.
Finances:
1955-1969: U. N. provided the majority of funds through its special assistance program, with US$52,000 per year subsidy from each Central American country. Since 1969 ICAITI has operated with funds from the governments, industry and outside sources. 1974 operating budget was US$1,446,000 of which the government subsidies were US$260,000 or 17.9 percent, the balance was earned from contracts or agreements with industry, governments, and international sources.

ICAITI was established as a regional research organization in 1955 as a result of action taken by the Central American Governments of Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua on the recommendations of the Economic Cooperation Committee of the Central American Isthmus of the United Nations Economic Commission for Latin America. ICAITI's objectives, originally and now, are to provide advice, counsel, and technical assistance to Central American Common Market industry, government entities, and public enterprise.

ICAITI, since its inception, has focused major effort on research directed to utilization and exploitation of natural resources, development of standards and test procedures for agricultural production, mining, domestic and export industries, artisan occupations and trades, etc., technical assistance and troubleshooting related to reducing industry production costs, improving production techniques, discovering useful by-products, cooperation with government entities, CACM integration organizations, universities, and other technical organizations

in the promotion of scientific and industrial research, and the training of researchers, technical experts, artisans, and specialized workers.

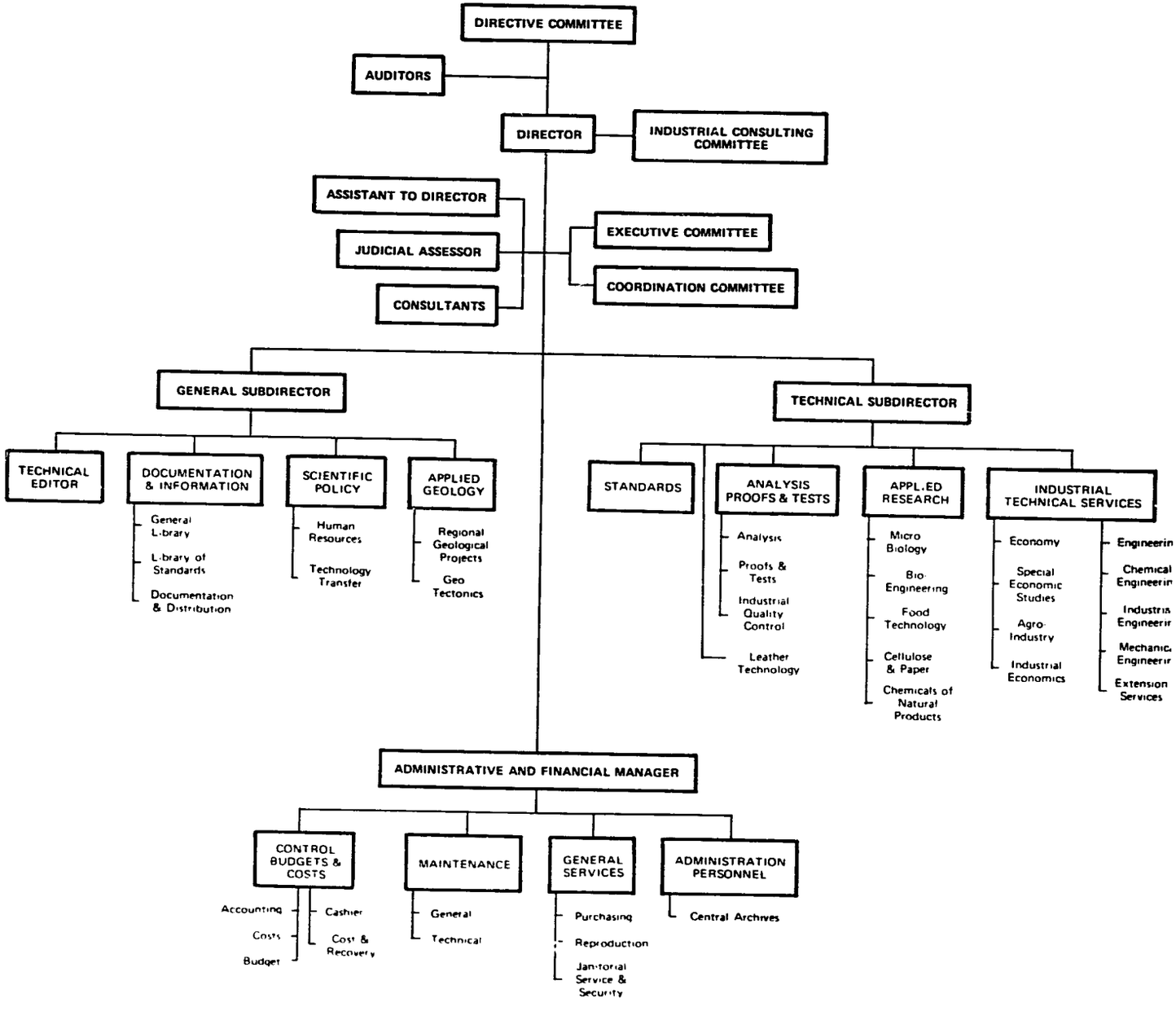
The current ICAITI divisions are: Applied Research, Industrial-Technical Services, Standards, Applied Geology, Analysis and Tests, Scientific and Technological Development, Documentation and Information.

ICAITI has gained considerable experience in methodologies for identification and assessment of technologies, suitable to use in Central America, as a result of involvement with regional as well as international organizations. In the past decade, ICAITI has conducted 400 research studies, completed 2,800 certificates of quality, 11,000 analyses and tests, and has established 209 standards relating to raw materials, production intermediates, and finished products.

ICAITI has well equipped and staffed laboratories for organic and inorganic chemistry, leather, pulp and paper, textiles, food technology, industrial microbiology, and operates pilot plants as an essential element of the investigations undertaken in the above laboratories. In addition to R&D, testing, etc., ICAITI conducts feasibility studies, economic analysis and marketing studies, and industrial consultation. Applied research programs include industrial use of agricultural products, industrial microbiology, fermentation, geology and mining. ICAITI is a focal point in Central America for management and dissemination of technological information, and provides direction and leadership to a Central American network of organizations who disseminate needed information in their own countries.

Until United Nations financial support came to an end in 1968, ICAITI tended to concentrate more on internal projects of general interest than on specific contracts to solve industrial, national, or regional priority problems. Cessation of U. N. support, coupled with awareness that the governments were not inclined to increase their subsidy, forced ICAITI to undertake aggressive promotion and program activities and to seek financial support from a wide variety of entities, through the mechanism of contracted services. That this effort has been successful is best demonstrated by considering the following: in 1969, the ICAITI budget was approximately US$480,000, of which 54 percent was derived from government subsidies; in 1974, the government subsidies amounted to less than 18 percent of the ICAITI operating budget of US$1,446,000.

INSTITUTO CENTROAMERICANO DE INVESTIGACÍON Y TECHNOLOGÍA INDUSTRIAL
ICAITI



East African Industrial Research Organization (EAIRO)
P. O. Box 30650
Nairobi, Kenya

Type: Regional institute providing R&D and technical services to Kenya, Tanzania and Uganda.
Board: Common Market Council of East African Community (Kenya, Tanzania and Uganda); 12 members.
Director: C. L. Tarimu
Staff: 1974: total of 55; 12 professionals, six administrative, ten technical supporting and 24 others.
Finances:
1972-73 operating budget US$270,000; 90 percent provided by the East African Community, ten percent through contracts. Contributions received from Great Britain. Experts provided by UNIDO.

EAIRO is the only institution in East Africa which is devoted exclusively to multi-purpose industrial research requiring laboratory experimentation and pilot plant operations. EAIRO was established in 1942 by combining a number of government laboratories for the purpose of initiating, developing, and strengthening industries in East Africa to relieve the shortages being brought about as a result of the Second World War. Prior to the war, except for a few agricultural processing and mining activities, there was very little industry in East Africa.

During the war the industrial development activities of EAIRO resulted in the establishment of a number of industries such as paint manufacture, caustic soda, sulphuric acid, hydrochloric acid, domestic pottery, vegetable oil refining and processing. Some of the industries which were established at that time still exist and have grown considerably over the years.

In 1955, the decision was reached to continue the EAIRO on a permanent basis to provide R&D and technical services to industry and government in Kenya, Tanzania and Uganda. In 1967, the EAIRO was brought under the control of the East African Community Common Market Council which serves as the EAIRO's Board of Directors. An attempt is being made to establish an EAC Research Council to supervise the activities of EAIRO and any other regional industrial research institutes that might be established in East Africa in the future. Such a council is visualized as consisting of representatives of governments, industry, technically qualified people from interested associations and institutions, development corporations, etc. To date, a decision to implement this suggested change has not been made.

EAIRO's activities are almost entirely sponsored research and technical assistance carried out on behalf of industrialists, and on a fee basis, although the fees have been nominal. EAIRO consists of chemical, ceramics, and workshop sections, and specialty laboratories in chemical engineering, industrial chemistry, and food technology. Specialists are consulted, as required, in areas such as fuel technology, agriculture, metallurgy, etc.

In addition to R&D, EAIRO also provides technical information, chemical and biological testing, industrial troubleshooting, quality control and standards development and pilot plant studies. Projects have included different types of food processing, ceramics and clay technology, chemical engineering, plant design, natural fiber technology, and industrial chemistry, coffee processing and sorghum processing. The aim in the latter project is to find a new, attractive, nutritious source of food.

EAIRO seeks opportunities to second its staff to industry for varying lengths of time, and provides training seminars and on the job training programs for industrial staff. All of these serve to increase confidence of industry in EAIRO. Difficulties are often encountered in initiating major new problem areas, since all three governments must approve such actions and provide the funds. As a consequence, delays frequently are experienced which can result in a loss of interest on the part of an entrepreneur, loss of staff, etc. Unlike ICAITI, which has nearly complete autonomy, EAIRO must refer nearly all policy, personnel, research, and other decisions to the EAC Council.

UNIVERSITY APPLIED RESEARCH CENTERS

Institut Teknologi Bandung (ITB)
Bandung Institute of Technology
Djalan Ganeca 10
Bandung, Indonesia

Type: National Technological University, which includes in addition to academic departments, an Institute for Industrial Affiliation (LAPI) and a Development Technology Center (DTC).

Staff: 459 permanent faculty, 168 part-time faculty (70 Ph. D., 80 M. S.), 6,500 students.

Affiliations: Technological Development Institute of East-West Center, Hawaii; Nuclear Reactor Center, Bandung; University of Indonesia; LIPI and LPPI Institutes in Bandung.

Finances: Funds for research projects in LAPI. 1971: US$36,000 from the Minister of Education, US$480,000 from contracts, surveys, consulting, etc. 1973: anticipated contract volume--US$1 million. Development Technology Center: March 1973-March 1974, organizational stage, operating budget, US$7,600; fund raising program, US$25,000; overhead, US$11,000; totalling US$43,600. 1974-1975: operation phase estimate - - US$440,000. 1975-1978: implementation stage--US$1,940,000. Funds are anticipated from commitments by ITB, and grants and contracts from domestic and international organizations. Note: The above figures do not reflect private consultation by faculty which is usually permitted up to one to two days per week.

The Bandung Institute of Technology (ITB) evolved from the School of Engineering established in 1920. ITB was affiliated with the University of Indonesia from 1947 until 1959, at which time ITB achieved full autonomy as the National Technological University. ITB enjoys considerable prestige within Indonesia and is increasing its working relationships with Southeast Asian and other international educational and research organizations. ITB's operational objectives are to: achieve a high standard of technological education, establish and maintain meaningful research and development capabilities, develop ITB as a center for appropriate intermediate as well as advanced technology, create mechanisms for increased interaction with other universities in Indonesia, foster closer cooperation with other Indonesian scientific and technological institutions and industry, and assist in improvement of elementary and high school level education.

ITB has three faculties (colleges) and 21 departments. The Faculty of Mathematics and the Physical Sciences: Departments of Mathematics, Physics, Geophysics and Metrology, Chemistry, Biology and Pharmacy. The Faculty of Civil Engineering and Design: Departments of Civil Engineering, Geodesy, Sanitary Engineering, Architecture, Fine Arts, and Regional and City Planning. The Faculty of Industrial Technology: Departments of Mechanical Engineering, Electrical Engineering, Industrial Engineering, Engineering Physics, Chemical Engineering, Geology, Petroleum

Engineering, and Mining Engineering. There are separate departments for humanities, social studies, etc.

Faculty academic loads approximate 24 hours per week, with the balance of time available for institute or contract-supported research or individual consultation. In an attempt to more effectively utilize such "free time," ITB established the Institute for Industrial Affiliation (LAPI) in 1959 as a department within ITB which would coordinate and promote utilization of faculty expertise and facilities by public and private sectors. The largest customer has been the government. The majority of requested services has been in areas of engineering design and manufacture, surveys, staff consultations, etc. Funds from contracts have been used for incentive payments to participating faculty members, acquisition of needed equipment to expand R&D programs, and other development programs within ITB.

Students are used as technicians on such projects which give both them and faculty members an opportunity to engage in real world instead of empirical engineering problems. Some critics of LAPI, however, point out the obvious: faculty members tend to become too involved in contracted services programs because of salary incentives. Further, the non-selective influx of conventional engineering job orders (testing, etc.) does have a potential for reducing faculty involvement, sensitivity, and capacity to solve higher order, but real, urgent problems which arise from Indonesian development needs (and which generally do not offer incentives for participation). Other problems exist which relate to the appropriate management structure for LAPI, mechanisms for achieving effective collaboration and approval by faculty deans and department chairmen, the proper balance between academic and research duties, and of course the general unwillingness of faculty members with lucrative consulting practices to revert these to LAPI.

The ITB development board initiated a plan in 1972 to establish as a non-profit foundation the Development Technology Center (DTC) which hopefully will ameliorate some of the above problems. DTC has been conceived as a "project management group" which will dedicate its activities to solving the problems of ineffective and underutilization of professional talents within ITB as well as in other government research institutions (e.g., LIPI and LPPI). DTC will focus on mechanisms of appropriate technological innovation and delivery, on training of entrepreneurs and associated difficulties in productive utilization of available technology in public and private enterprise. DTC's innovative management scheme will be based on an interdisciplinary and cooperative approach using an integral coordinative framework in order to provide linkages between input technology, the entrepreneur, the financial institution, skill levels, demands of the market, and government intervention. The question which is as yet unanswered is whether or not this scheme can be achieved in actuality.

The Governing Board of DTC is to be comprised of a judicious mixture of prominent leaders from government agencies, universities, the Chamber of Commerce, industry and financial institutions. An Executive Council consisting of the DTC chief executive and three division chiefs will be responsible for day-to-day execution of DTC programs. The envisioned divisions are: Division of Entrepreneur and Skill Level Development and Training, Division of Technology Development, and Division of Planning, Feasibility, and Evaluation Services.

The DTC will draw upon ITB faculty members, staff from other universities and research institutes, and will undoubtedly develop its own technical staff.

The concept of DTC is perfectly valid in theory, but as so many other universities throughout the world have discovered, may be inordinately difficult to achieve in practice. Vested interests and small empires of deans, faculty members, research institute directors and staff members have to be overcome, a perhaps insurmountable obstacle. Certainly, the DTC approach of one year planning and preparation, three years of operation, followed by thorough evaluation, before proceeding into a long-term program is demonstrative of the sound thinking behind the concept of DTC. Many universities in developing countries will be watching the experiment with considerable interest.

Middle East Technical University (METU)
Halkla Munasebetler ve Yayin Müdürlüğü
Ankara, Turkey

Type: Independent institution of higher education created by the Turkish Congress. Organization for Applied Research (OAR) in formative stages.

METU President: Tarik G. Somer

OAR Director: Dr. Mustafa Doruk, appointed by the President upon recommendation of the deans and approval of the Faculty General Council.

Staff: 1972 faculty of 819; student enrollment of 7,000, including approximately 500 students from other countries, and 1,400 graduate students pursuing M.S. and Ph.D. degrees.

Finances:

Funding from the Turkish Government, AID, Ford, CENTO, OECD, and the U. N. Income from publications, seminar symposium registration fees, allowance from general University budget and accumulated research funds. Fees collected from contracts (20 percent to University overhead, 80 percent to institute fund). In 1974, METU received US$407,200 income from research contracts, 75 percent from public enterprise, and 25 percent from the private sector.

METU was established in 1956 by the Turkish Congress as an independent institution of higher education. The METU mandate was to: (1) train professionals, (2) perform basic research for the enhancement of Turkish science, and (3) undertake applied research to solve problems of Turkish society. METU currently has four faculties: architecture, administrative sciences, engineering, and arts and sciences.

Of the above, No. 1 has been successfully fulfilled, and the level of education is high. Basic research is fairly advanced in comparison with other universities in Turkey. Unlike other European-oriented Turkish universities, METU is young, dynamic, and modern. Its faculty is largely U.S.-trained and aggressively determined to undertake research and other investigations directed toward practical problems related to the economic and industrial development of Turkey and to train engineers and scientists in the process. However, applied research in METU has not been developed to the full extent of potential, and the faculty and students of METU are still functioning in traditional departments, along traditional lines. Such research, on an individual basis, has been fragmented. In comparison to other universities in the area, the level of METU faculty research is substantial.

METU faculty visit industry to identify problems. The Industrial Relations Unit of TUBITAK (the Turkish Council on Science and Technology) contacts industry frequently to identify problems and passes this information along to the appropriate researcher. No priority for research has been established, but this is needed to conserve resources.

Current Turkish Government policy specifically states that M.S. and Ph.D. theses will be selected to relate to the needs of the

National Plan. It is usually difficult to accomplish this as yet for Ph. D. dissertations, due to the present level of industrial sophistication, thus Ph. D. research tends to be more long range in nature. Therefore, prime industry-university cooperation evolves around M. S. research. As a general rule, M. S. candidates do their research on an industrial problem. Where possible, the students are assigned to that industry or government enterprise for a period of three to six months to put the results of their study into practice. Upon satisfactory completion of the internship, they are awarded the M. S. degree.

METU has established the skeletal structure of an Organization for Applied Research (OAR) which is intended, with time, to better coordinate the diverse R&D activities of the faculties, encourage multi-disciplinary problem-solving, and reduce research administrative burdens on researchers. The METU administration and senior staff believe that their pioneering approach to applied university research in Turkey (and unique insofar as most universities in developing countries are concerned) will:

- help industry to recognize the need for applied research,
- stimulate industrial utilization of research,
- help industry to identify its problems,
- create demand for research by creating a supply of technologists, and
- serve as a model for other universities.

The OAR is not intended to become a center with separate buildings and staff, but rather a plan of coordination of all of the above for better interaction between people.

Some interdisciplinary research has been underway in METU for several years. This has tended to be joint between related disciplines although programs in sociology and humanities (studies in family planning, population migration and employment patterns, and worker-manager relationships in private industry) are related closely to the activities of the Urban Planning Group of the College of Architecture. The expectation is that, under the Organization for Applied Research umbrella, closer interaction will occur between the physical sciences and engineering and the social sciences. Hopefully, research will develop around problem areas, such as transportation, sanitary engineering, communications, pollution, instead of the usual engineering and scientific disciplines. They intend to draw people from appropriate departments and assign these to specific aspects of a particular problem. The project leader will be selected on the basis of the nature of the project, need for full- or part-time participation, availability, etc.

The OAR, when fully operational, will consist of four institutes (largely based on existing research administrative units non-active within the faculties). The first two have been established: an institute representing the Faculty of Administrative Sciences; the second representing the Faculty of Science and some Engineering--called Systems Science. The third institute will derive from the Faculty of Architecture, while the fourth will be comprised of civil, chemical, mechanical, metallurgical engineering, mining and geology. The concept visualizes spinning off such institutes as separate centers if these become sufficiently large.

The OAR research committee is comprised of the Deans of each Faculty, the Assistant President for Research, and the METU President. The committee establishes policy organizational changes, program structure, etc. The prevailing philosophy is that applied research in METU should be financed by the sponsor. At the present time, however, the sponsor pays part of the costs, some funds come from TUBITAK, and some funds come from METU.

METU staff currently enjoy a number of staff incentives, rewards, and motivation including released time from teaching for research; overload payments; patent and copyright benefits; awards, prestige, honors from TUBITAK and other science organizations; and the OAR arrangement generally will not improve on this system. The principal advantages of OAR will be the ability to establish and coordinate larger and more important programs for and between the institutes and to provide administrative services necessary to assure maximum professional staff concentration on research. An individual staff member is permitted to function under OAR without being a member of one of the institutes. He will receive the same incentives as institute participants, but will be denied research services, secretarial assistance, etc. Approximately 250 of METU's 800 faculty members are expected ultimately to become active in the institutes of the OAR. There are no plans at the moment to hire full-time researchers, although these in all probability will be required if METU is to meet the demands of its increasing number of industrial sponsors within a reasonable time.

One most interesting aspect of METU's OAR philosophy involves providing facilities and opportunities for outsiders (from industry, government enterprise, or other countries) to receive training or other appropriate experience with the view to ultimate application of increased knowledge about technology to the problems of industry.

Instituto de Investigaciones Industriales (III)
Institute for Industrial Research
Monterrey Institute of Technology
Sucursal de Correos "J"
Monterrey, N. L., Mexico

Type: University research center.
Board: Independent, self-perpetuating board; members are chosen equally from developed and developing countries.
Director: Avelino Guerra García, Associate Dean of the Division of Engineering and Architecture, acts as Head of the Institute.
Staff: 1975-75: Division of Engineering and Architecture--91 full-time and part-time professors and researchers, 6 professors are studying abroad for a Ph. D.
Affiliations:
Integrated with the Division of Engineering and Architecture, Monterrey Institute of Technology.
Finances:
1974 total income US$486,590; US$19,388 from analysis and tests; US$467,202 from research and development projects. Seventy percent is spent to pay salaries, fringe benefits and project expenses; ten percent covers overhead and 20 percent goes to departments for expenses such as academic research or special courses abroad.

III is an industrial research center incorporated with the Division of Engineering and Architecture, Monterrey Institute of Technology. It was founded in 1951 by a group of industrialists, to carry out testing and analytical work for industry. It was originally affiliated with the Southwest Research Institute of San Antonio, Texas, and located at Monterrey. It remained an autonomous institute until 1970 when competition with the university and continual failures to bring the faculty into the program forced it to merge with the Monterrey Institute.

The Institute participates in a number of activities including chemical, biological and physical testing, standards and performance testing, pilot plant studies, techno-economic and productivity studies, research and technical information center. Staff capability is in the areas of applied chemistry, physics and engineering. Specialized projects in the past have included recovery and disposal of industrial wastes, design and analysis of electrical power systems, in-plant industrial surveys, industrialization of natural products, low-cost housing material development, environment and pollution problems, design of fluid distribution networks by computers.

III's primary purpose is to make industrial, agricultural and mining research available to the community. III has developed fairly close contact with industry through its testing and analytical work. Of its earned income, 76.6 percent comes from the private sector compared to 12 percent from the federal government, 6.7 percent from federal decentralized enterprises, and 2.9 percent from Monterrey Tech. III has a permanent program of visits to identify industrial problems. Several professors serve half-time as researchers in plants, contributing

further to the active interaction which has developed between III and the private sector.

In the past 22 years, III has successfully completed more than 6,500 tests and 625 projects for agriculture, industry and individuals in the United States, Mexico and Central America. In 1973, projects were conducted for about 40 industries; analyses and tests were performed for about 150 small- and medium-sized sponsors.

Asian Institute of Technology (AIT)
P. O. Box 2754
Bangkok, Thailand

Type: Private autonomous graduate technological university, recognized as an independent international organization in Thailand, reporting formally to the Thai Minister of Foreign Affairs.

Board: Consists of not less than nine and not more than 60 members who are international in character, yet serve as individuals rather than representatives of the country. The President of AIT is a member of the Board.

President: Dr. Milton E. Bender, Jr.

Staff: 1973 total of 65 faculty from 18 countries, approximately 300 students and 20 research associates, projected to increase to steady state of 750 students by 1980.

Finances:
Projected operating budget for 1974-75 is US$3,100,000. Receives support from government, industry, different countries, individuals, and tuition. The U.S., initially major contributor, now supplies only 20 percent of the budget, with plans to end support July 1975. Donors for scholarships: Governments of: Australia, Canada, Belgium, British Columbia, Denmark, Japan, Netherlands, New Zealand, Thailand, United Kingdom, United States, West Germany; Foundations: KIEDANREN (Council of Economic Organization/Japan), J. L. Marden and Family, Lee Foundation, Starr Foundation; Industry: General Telephone and Electronics International, Inc., IBM World Trade Corporation, Shell Oil International, Shell Company of Thailand, Ltd.; General Scholarship Fund: Savage Hill Foundation, General Electric, Time, Mobil Hong Kong, Ltd., Mobil Oil Malaya Sendirian Berhad.

AIT is a non-profit, non-political international organization, originally known as the SEATO Graduate School of Engineering, chartered in Thailand in 1959 to meet the needs of engineering education in Asia. A commission was formed by the Southeast Asia Treaty Organization (SEATO) in 1965 to effect a transition of the SEATO Graduate School of Engineering into a private institution. In 1967, AIT became that independent institution with approval of the charter by the eight founding members.

The Institute is involved in graduate academic programs, research directed towards regional economic problems, and the presentation of special programs, conferences and seminars. AIT's chief responsibility is the training of a select number of individuals for future service in the economic development of Asia. The academic division offers a Master of Science, Master of Engineering and Doctor of Engineering. Major fields of study are: hydraulic engineering; environmental engineering; soil engineering; transportation; construction, engineering and management; agricultural engineering; structural

engineering, structural mechanics; systems engineering; industrial engineering and management; urban and regional development; ocean engineering; and water resources engineering. Current emphasis is being placed on the growth of interdisciplinary programs.

Research is an important activity of the Institute, since it is an essential part of training future leaders and a current service provided to the community. Faculty research programs develop according to the demands of new areas in technology, gaps in knowledge and searches for improvement. Programs are selected according to their relevancy to Asia and correspondence to areas of AIT faculty expertise.

In 1973, a three-year study was begun on "Industrialization in Asia for Improved Standards of Living." The purpose is to provide development information to educators, government, business, industry and investment leaders. A new regional experimental research center has been established and is expected to increase the number of major research projects requiring large-scale models or pilot plant studies. Projects presently underway include work on algae growth in sewage, control of aquatic weeds in rivers and canals, and development of standards for water quality in rivers.

Some of this research is sponsored by engineering firms and government agencies. The amount of research contract and grant support has been increasing rapidly.

AIT has achieved considerable success in its unique position of a graduate school of technology serving a whole geographical region. Since 1959, the Institute has steadily expanded its sphere of activities, services and programs. AIT is well founded, well equipped, adequately financed and has a well qualified staff. It is entirely Asia-oriented with more than 92 percent of its graduates working in Asia--43 percent are in business and industry, 42 percent in government, and 15 percent in teaching. The Institute has been instrumental in increasing professional conferences in Asia. The new center has sponsored a number of successful seminars; a number of regional professional societies have been supported; and a major regional documentation center has been established.

With increased growth, shortage of experienced staff is a recurring problem. The Southeast Asian governments and others are pleased with results and plan to continue support. A seven-year master plan outlines an expansion program with a 1980 projected value of US$27.5 million. Ten million dollars are expected in grant research in 1980. The range of academic studies will increase and include new areas of technology and science, such as food technology, computing science, electrical and chemical engineering. Seven hundred fifty students are anticipated. Expansion plans involve new facilities, a computer, communication center, library and information center, recreation center, regional engineering and experimentation center.

GOVERNMENT CIVIL SERVICE INSTITUTES
(State and Federal)

Federal Institute of Industrial Research (FIIR)
P.M.B. 1023, Ikeja Airport
Oshodi, Nigeria

Type: Semi-autonomous institute under the Ministry of Industries
Board: Government council of nine members, including: the Permanent Secretary, Federal Ministry of Industries; the Director, FIIR; two representatives from commercial organizations; one representative from an agriculturally oriented organization; one representative from a federal university.
Director: I. A. Akinrele
Staff: 1973 total of 229; 43 professionals, 45 technical supporting, 46 administrative, 96 other.
Affiliations:
British Overseas Development Corporation, Tropical Products Institute of England, Ford Foundation.
Finances:
1970-1973 operating budget US$630,000, all government subsidy. 1972-1973 earned about US$800 from 24 contracts, mostly quality control tests.

FIIR was founded in 1955 as the Institute of Applied Technical Research by the former Federal Ministry of Commerce and Industries, for the purpose of stimulating industrialization of Nigeria through research into industrial use of local resources and development of indigenous technologies, and through providing routine services to industries. FIIR has focused its activities on bringing modern technology to bear on traditional food processing methods, and development of import substitutes in the minerals field. Operating divisions are: Food Science and Technology, Industrial Chemistry, Processing, Engineering, Industrial Analysis. Technical services include technical information, chemical analysis, chemical and biological testing, physical testing, standards and performance testing, basic and applied research, pilot plant studies, and industrial application of research results. Work has been carried on in the areas of food processing, microbiology, pulping and paper studies, ceramics, textile studies, applied organic chemistry and engineering technology.

FIIR has been successful in transferring several research projects into use by public and private sectors of Nigeria. Among these are: mechanized production of Gari, distillation of palm wine into alcoholic beverages, production of coir fiber as upholstery filling, refining of kaolin and its use in ceramic wares, manufacture of Soy-Ogi, a protein-fortified maize beverage, hot air drying of fish.

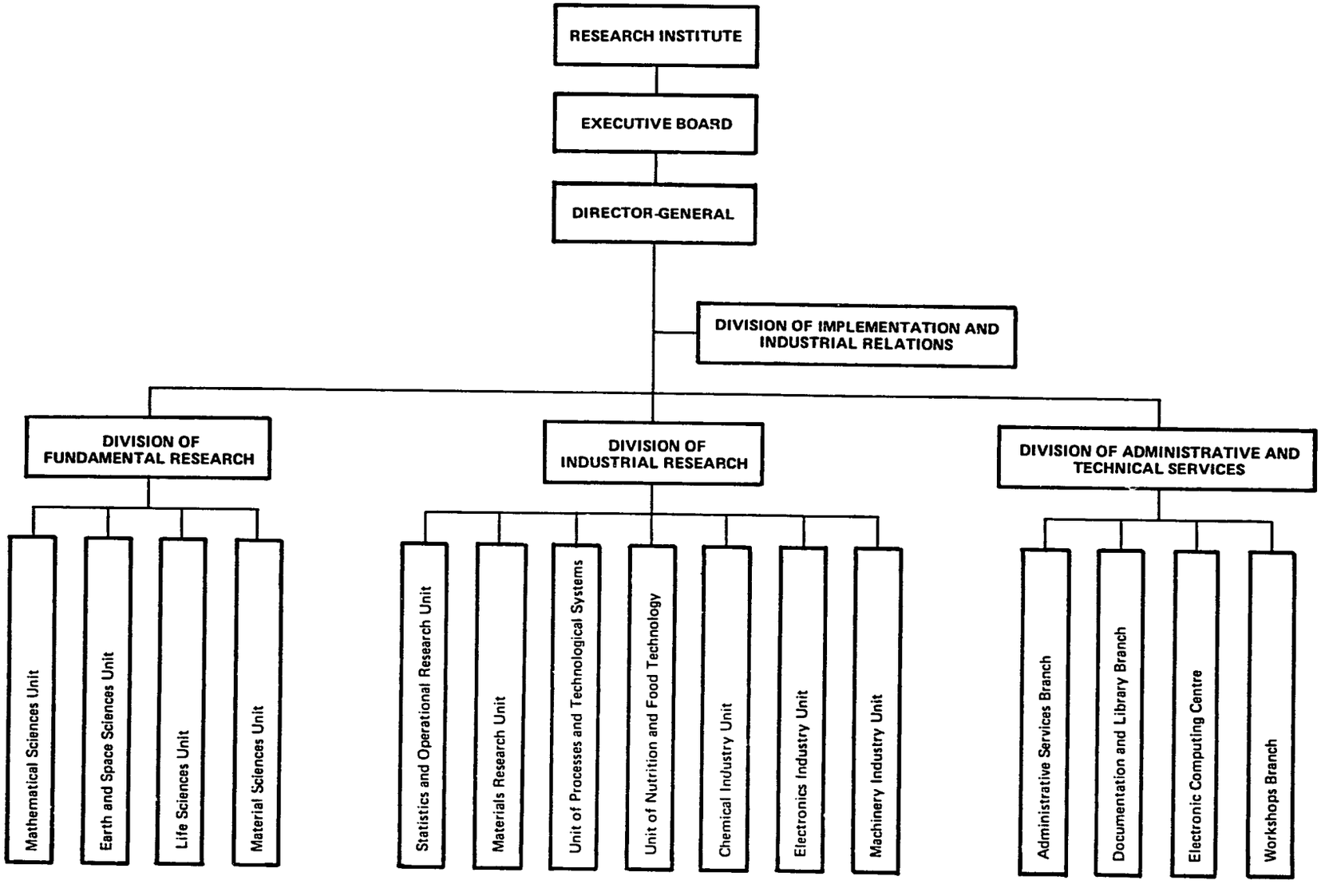
FIIR attempts to select research projects according to technological priority needs of the country. The Nigerian first five-year plan emphasized secondary (e.g., manufacturing) industrial development, even many such industries required importation of processed raw materials, but which materials were also available in Nigeria. The second five-year plan has placed some emphasis on primary industry development, so that FIIR will increasingly concentrate

on import substitution and utilization of natural resources. Even so, agri-oriented processes will continue to receive considerable attention.

An Industrial Analysis Division within FIIR is aggressively pursuing industrial contacts with the objectives of identifying industrial problems as well as to provide technical assistance such as economic or management analysis, product surveys, etc. The Industrial Analysis Division is also beginning to internally evaluate FIIR projects to determine their market potential and economic viability.

The Lagos Chamber of Commerce and Industry has an industrial standing committee which is supposed to maintain close liaison with Nigeria's Federal Institute of Industrial Research (FIIR). The committee meets monthly to discuss current general problems of industrial growth as well as specific industrial areas such as construction, textiles, food production, pharmaceuticals, etc. Increasing interaction is taking place between FIIR and the Nigerian National Research Council, as well as with Nigerian universities and other research centers in Nigeria. FIIR is planning establishment in the immediate future of branch laboratories in key industrial areas of Nigeria in order to accelerate interaction with Nigerian public and private sectors.

FEDERAL INSTITUTE OF INDUSTRIAL RESEARCH
FIIR



National Institute for Scientific
and Industrial Research (NISIR)
Shah Alam
Selangor, Malaysia

Type: Government corporation under the Ministry of Technology, Research and Local Government.
Board: Council of 18 members and a chairman, representing the government and various private agencies; six industrialists.
Director: Teh Hock Heng.
Staff: 1974: 24 professionals, 80 technical supporting and 12 administrative.
Affiliations:
Federal Industrial Development Authority (FIDA), responsible for economic and managerial aspects of industrial utilization of technology; Council of Trust for Indigenous People (MARA), technology needs of small industries, cottage industries, and craft industries; Malaysian Industrial Development Finance (MIDF), loans for industrial ventures; the 13 Malaysian State Economic Development Corporations (SEDCs).
Finances:
1974 operating budget of US$400,000, principally supplied by a government grant; U.N. experts and other UNDP assistance (equipment, etc.). About five percent of the budget is from contracts.

NISIR, a non-profit government corporation, was inaugurated in March 1971 to promote, coordinate, and undertake scientific and industrial research which would benefit industrialization in Malaysia. Unlike many mono-purpose institutes such as the Rubber Research Institute, the Food Research Institute, the Plastics Center, Forest Research Institute, and specialized research departments in several universities, NISIR was intended to be a multi-purpose national R&D institute. However, the vested interests of the other existing centers have made it difficult for NISIR to assume, to the fullest extent, its intended role.

The consequence of this has been that NISIR, while originally intended to operate in four rather broad sections, viz, research in: physics, electronics, electrical engineering and metrology, chemistry and chemical technology, materials science and mechanical engineering, and industrial consultancy services, has found it necessary to focus more closely on six industrial subsectors. These are: metals and light engineering industries, non-metallic mineral products and building materials industries, minerals processing industries, electronics and electrical industries, chemicals and chemical industries including fermentation, textiles, fibers, leather, timber and pulp industries. What has happened is that NISIR's emphasis, as originally visualized, has changed from rather basic-oriented laboratory research to industrially oriented applied R&D.

A research committee, established in 1973, screens all suggested research projects and is responsible for preventing or

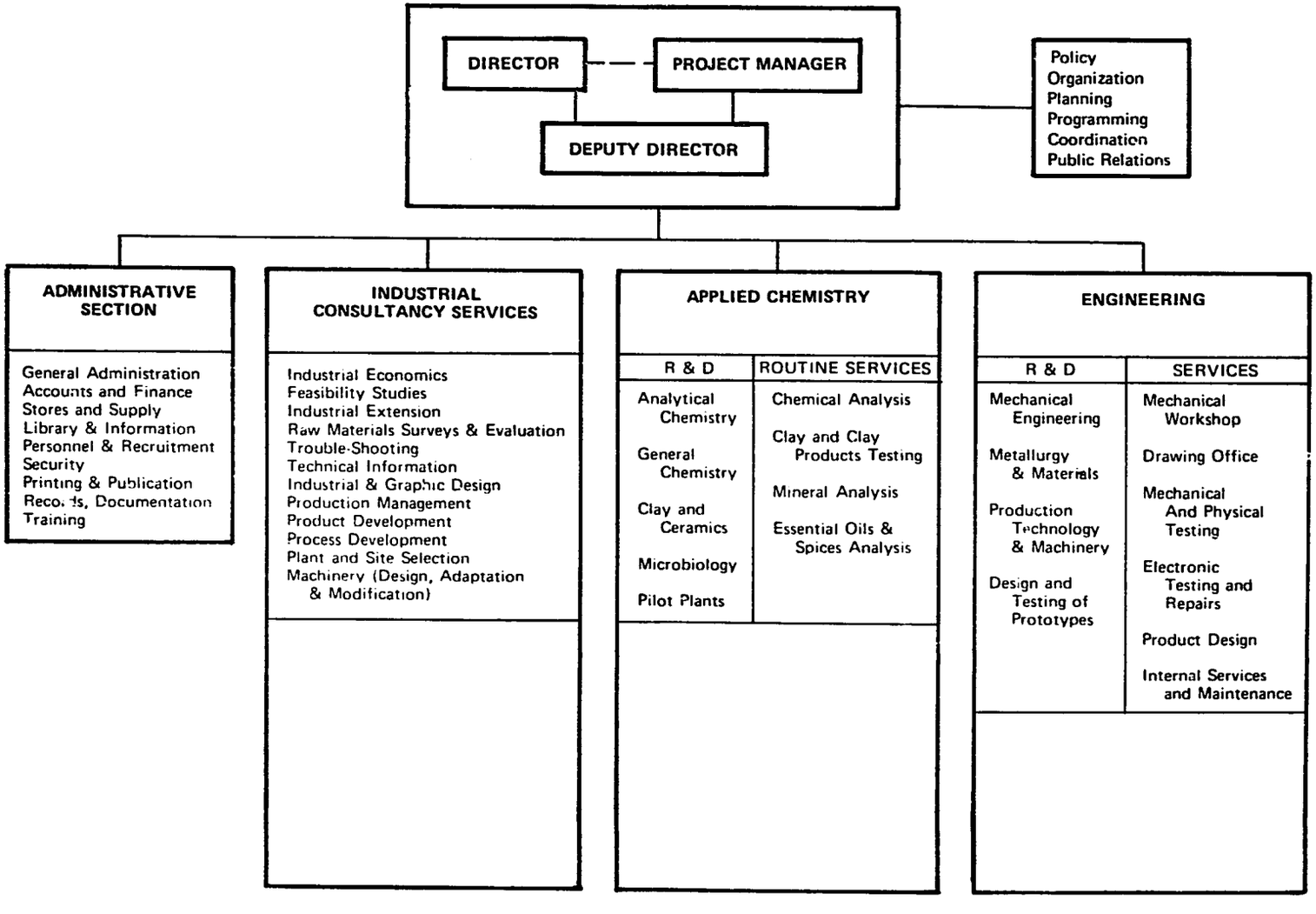
eliminating duplication of effort between NISIR and other research organizations in Malaysia, uneconomically feasible or low technological priority projects. While this control places some constraints on NISIR's programs, nonetheless, it makes it possible for NISIR management to more nearly match suggested or possible projects with NISIR facility and staff capabilities.

Industrial liaison is increasingly a part of the NISIR management plan, and is being implemented through a recently established Extension and Technical Information Services Division. The functions of the Division include maintenance of a technical library, providing technical information to private and public sector users, coordination of inquiries, and follow-up on assistance provided or requests for information, data, etc. The Division is in the process of conducting an industry-by-industry survey in each Malaysian state, in cooperation with each state SEDC in order to determine the industrial problems and needs of each state.

NISIR staff are also actively engaged in an industry exchange program. NISIR may send a staff member to a specific industry for a period of time to analyze the industry's operations and offer advice. In such cases, NISIR will pay the staff member's salary, but charge the industry a fee to partially recover costs. In some instances, NISIR is interested in gaining specific on-the-job training for its staff members. NISIR locates a cooperative industry and seconds its staff member for a period of time to gain industrial experience at no cost to the industry. The third mechanism is for NISIR to provide space and facilities to firms who wish to conduct research of their own but have no facilities available. Each of these mechanisms for NISIR-industry staff interchange provide an excellent training and learning opportunity for NISIR staff.

At the present time only a small amount (five percent) of NISIR's operating budget is recovered by contracted services. This seems to be of less importance however than the concept of assisting in the industrial development process in the most effective way available to NISIR.

INSTITIUT PENYELIDEKAN SAINS DAN PERUSAHAAN NEGARA
NISIR



Instituto Nacional de Tecnologia (INT)
National Institute of Technology
Avenida Venezuela 82
Rio de Janeiro, CEP-20.000 G.B., Brazil

Type: Federal civil service institute under the Ministry of Industry and Commerce.
Director: Paulo Mauricio Pereira
Staff: 1974 total of 203; 130 professionals, 21 administrative, 30 technical supporting and 22 others. There are 236 part-time employees, of which 39 are professionals, 19 administrative, 160 technical supporting and 18 others.
Finances:
1971 operating budget of US$1,896,000; US$1,330,000 provided by the government and US$566,000 earned in contracts.

INT has its origin in the Federal Experimental Station for Fuels and Minerals established in 1921. In 1933 the Station became the Institute of Technology; in 1934, it was renamed the National Institute of Technology (INT).

Since 1961, INT has been constituted of administrative and auxiliary services, and twelve technical divisions. These are: Industrial Inorganic Chemistry; Industrial Organic Chemistry; Metallurgy; Building Technology; Sugar and Fermentation; Textiles and Paper; Fuels, Lubricants, and Combustion Engines; Electricity; Ceramics, Refractory Materials and Glass; Rubber and Plastics; Industrial Physics; Training and Documentation. A Technological Information Center was established in 1968. The Institute participates in a number of activities, including the provision of technical information, techno-economic studies, productivity studies, standards and performance testing, pilot plant studies and research. The staff today is involved in the areas of applied chemistry and physics and engineering. Areas of specialized expertise are metallurgy; building technology; sugars and fermentation; textiles and paper; fuels, lubricants, and combustion engines; electricity; ceramics, refractory materials, glass; rubber and plastics. Fees are collected from industrial clients although these cover only a fraction of actual out-of-pocket costs for providing services.

Until recently, one of INT's most successful innovations has been the establishment of a Center for Information and Field Services, a combined operation for disseminating technological information, know-how and technical extension activities. The Center had 48 people at the end of 1973, a mix of engineers, economists, sociologists, journalists, and technical information specialists.

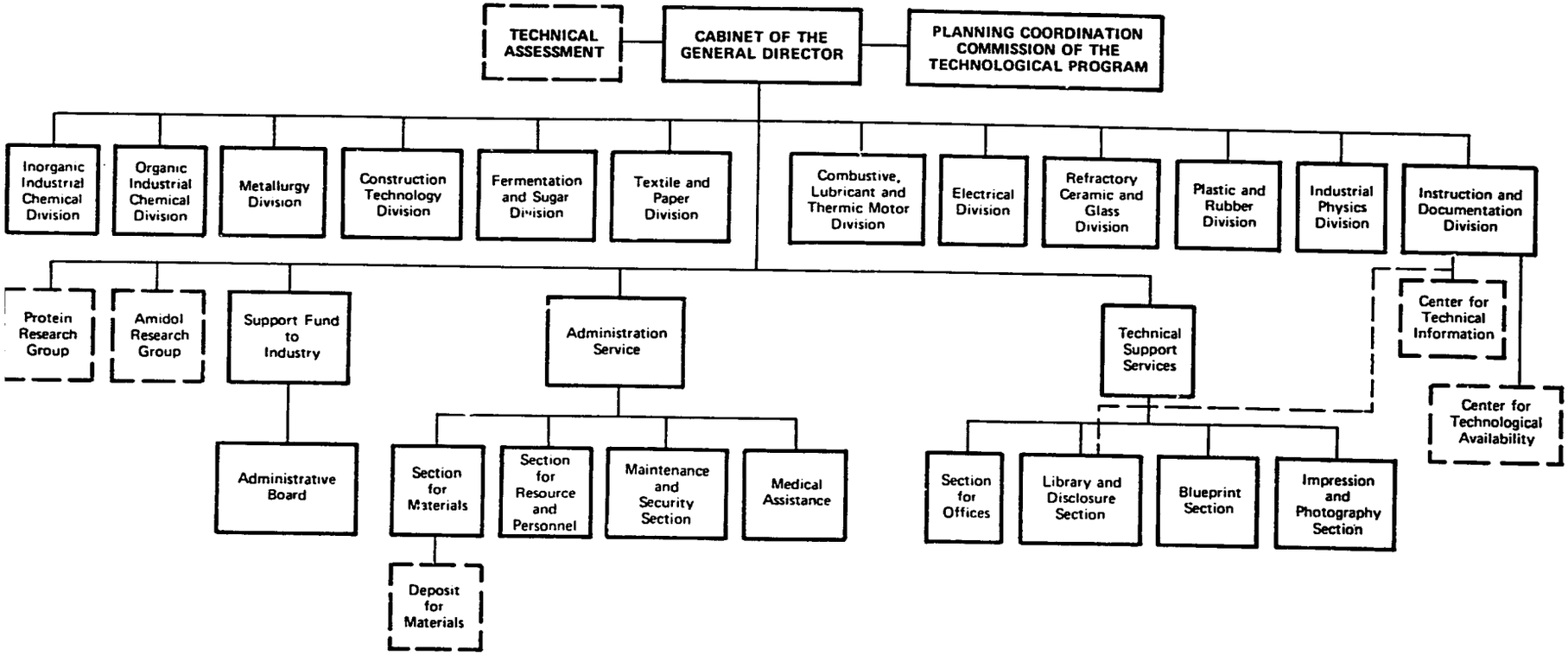
During 1973, 10,000 Brazilian industries were contacted by the Center to identify information needs, seek industrial problems and bring these to INT for solutions. The general approach has been to solve the technical problem on the spot for no fee if only a short time is involved. Otherwise, the industrialist with the problem is expected to pay at least a part of INT's services.

The Center, in 1973, was receiving approximately 400 inquiries for information per year on a no-fee basis; the number was expected to increase when a small handling charge was instituted. Some 4,000 industries were on a regular mailing list to receive appropriate technical articles, while abstracts were sent to 10,000 Brazilian industries.

Field stations were located in four other Brazilian states, and INT has instituted a program of interaction through other existing institutes (such as CETEC, CEPED, ITEP, etc.) if the institutes were capable of handling the technical extension needs encountered.

The Center was abruptly shut down in mid-1974.

INSTITUTO NACIONAL DE TECNOLOGIA
INT



Instituto de Pesquisas Tecnológicas (IPT)
Institute for Technological Research
Caixa Postal 7141
São Paulo, Brazil

Type: State Government institute responsible to the Governor through the President of the Council of Administration.

Board: Council of Administration consists of two representatives from the College of Engineering, University of São Paulo; two representatives of the State Council of Technology (CET); one representative of the Federation of Industries; one representative from the Engineering Institute; the Superintendent of IPT; and one observer from the State Secretariat of Finance.

Superintendent: Dr. Alberto Pereira de Castro

Staff: 1974: total of 1,388; 393 professionais, 440 technical supporting, 228 administrative, 327 others.

Affiliations:

University of São Paulo, Development Bank of São Paulo; National Bank for Development (BNDE); Science and Technology Program (CET) of State of São Paulo; sectoral system of Science and Technology, Ministry of Industry and Commerce; Brazilian National Research Council; Brazilian Association of Standards and Tests; involvement in a variety of commissions, councils, societies in Brazil; linkages through CET with the U. S. National Bureau of Standards (NBS), and the Denver Research Institute (DRI); working agreements with nearly all research centers in Brazil such as CETEC, CEPED, CIENTEC, INT, ITAL, ITEP.

Finances:

1974 operating budget US$14.7 million; US$7.8 million for personnel, US$5.6 million for facilities development, US$1.3 million for other expenditures. Thirty-six percent of the operating budget is earned income from contracts. IPT is unable to accumulate or carry over surplus funds, but has discretionary control over expenditure of earned income, including payment of bonus and incentive payments to researchers working on contracts. Funding support for external technical assistance (NBS and DRI) received from Science and Technology Program of State of São Paulo via a technical assistance loan from the U. S. Agency for International Development.

IPT originated as a State testing laboratory in 1936, and was reorganized into a multi-purpose technological institute in 1944. The Institute's salary schedules, management of expenditures, and other operational policies are still influenced by State civil service regulations. IPT is currently attempting to achieve the status of a state-owned autonomous corporation, hopefully during 1975. This corporate status, while still permitting IPT to receive state and federal funds, will provide the IPT management greater flexibility in recruiting, training, and retaining staff, in greater discretionary control and utilization of income and other funds, and in more effective

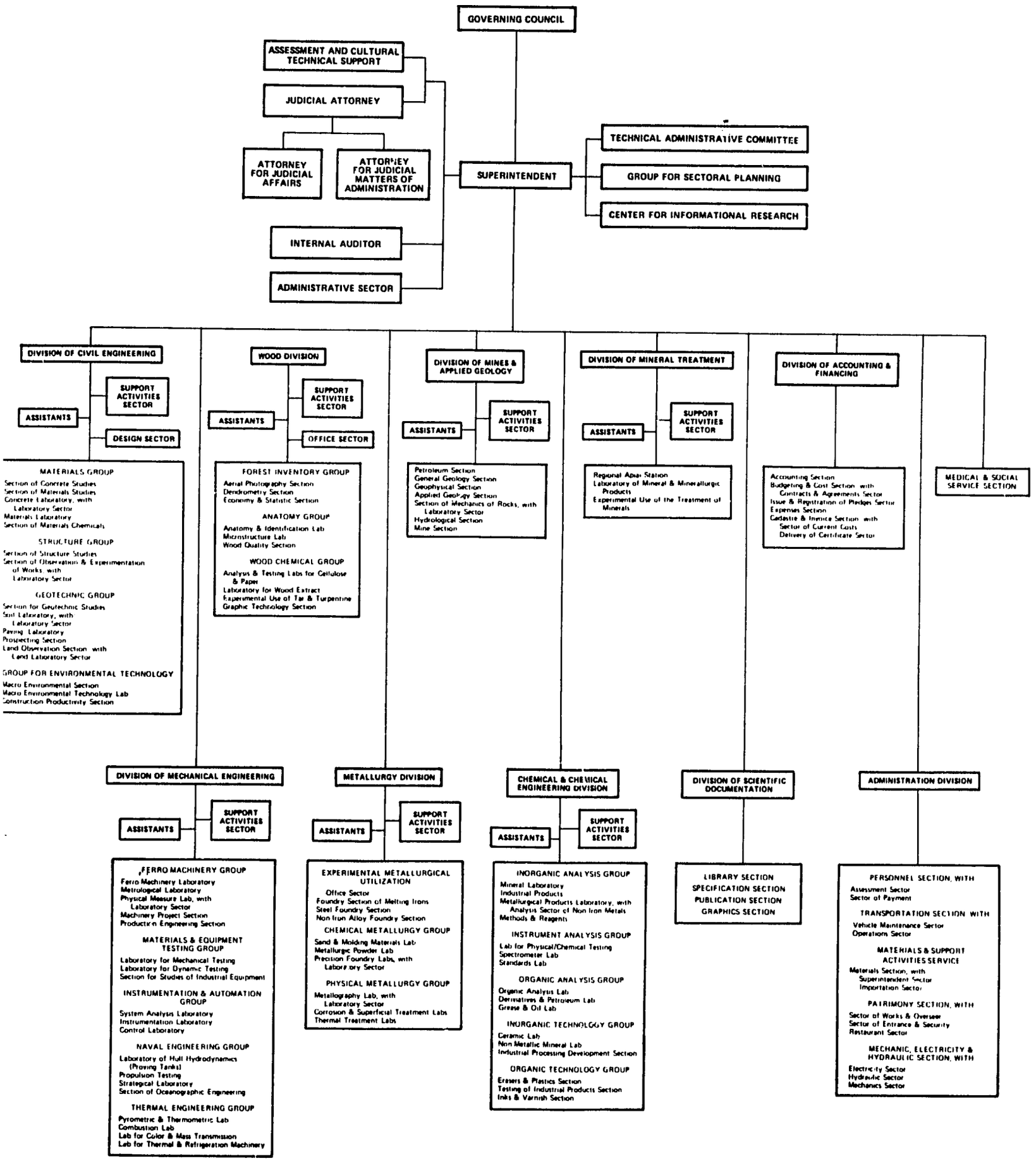
working relationships with clients.

IPT's functions include applied research, standards and performance testing, chemical, biological, and physical testing, technical information services, pilot plant operations, and training of both professional and non-professional people, for IPT as well as for industry. Technical divisions are: Civil Engineering, Chemistry and Chemical Engineering, Forestry and Wood Products, Mechanical Engineering, Metallurgy, Mineral Treatment, Mining and Applied Geology, Naval Engineering, and Technical Information. New buildings completed or nearing completion during 1974 included: Center for Instrumental Chemical Analysis, Technological Information Center (3,000 m^2), Mining and Applied Geology Building (2,200 m^2), a ceramic laboratory, Physical Metallurgy Laboratories (6,000 m^2), Paper and Cellulose Laboratories (4,000 m^2), Geotechnical Laboratory (2,600 m^2), the Naval Engineering Experimental Tank.

IPT has consistently increased its contracts and service agreements with industry and public enterprise. In 1970, some 17,000 certificates of testing were issued; in 1971, the number was 25,300; in 1972, the number was over 30,000 certificates. The number of contracts has increased from 38 in 1971 to 188 in 1974. Of the 188 contracts operative in 1974, 39 provided technical support to government-owned companies and/or agencies, 69 provided technical assistance to Brazilian industry and multinational corporations, 25 contracts resulted from industry requests for specific research, and ten agreements provided consulting services in engineering.

IPT as yet has no capability in industrial economic analysis and market feasibility studies, although staff are being trained to undertake such activities. Liaison with industry and government is excellent, and is expected to improve. A current major problem relates to difficulty in retaining competent staff. Salary schedules are considerably lower than industrial levels and IPT staff turnover rate is around 15 percent. Due to Brazil's current rapid rate of growth, availability of technological personnel is extremely limited.

INSTITUTO DE PESQUISAS TECNOLÓGICAS
IPT



Laboratório de Ensayo de Materiales e Investigaciones
Tecnológicas de la Provincia de Buenos Aires (LEMIT)
Laboratory for Materials Testing and Technological Research
Rivadavia 1917
Buenos Aires, Argentina

Type: Civil service institute under the Department of Public Works of the Ministry of the Province of Buenos Aires.
Director: P. J. Carriquiriborde
Staff: 1967: 74 professionals, 166 technical, 27 administrative, 54 workers, and 25 service.
Finances:
Government provides over 90 percent of the operating funds; 50 percent is returned through services and no fees are requested from work done for government departments.

LEMIT was established in 1941 as a laboratory for the Province of Buenos Aires to conduct materials testing, quality control and standardization. Some R&D activities have been undertaken in the utilization of minerals and other materials in the Province.

LEMIT's activities today include research on natural resources, methods, industrial products, techno-economic studies, testing, quality control and standardization. Special projects have involved studies for Public Works and the Navy, systems for painting ship hulls, anti-corrosion and anti-fouling. Applied research is conducted principally for province agencies with some additional work done for private industries and other provinces. LEMIT has been undertaking a geological-economic survey of the province with the objective of identifying possible industrial utilization of resources and materials. A systematic analysis of industry is also being undertaken to determine base levels and changes in industrialization which can be brought about through R&D and technical assistance services. Such studies have enabled LEMIT to advise industry on ways to improve quantity or quality of production. LEMIT will provide confidential reports to industry on the quality of their products and compare these (on an unidentified basis) with similar products of other manufacturers.

LEMIT has, however, limited authority to insist on product improvement unless controls or standards for a particular product have been established by the government or unless industry is willing to cooperate voluntarily.

From the Provincial Government's point of view, LEMIT's activities have been extremely successful, since LEMIT assistance to industry has resulted in more than 20 times the value of government costs to support LEMIT in the form of improvements to the province in new or improved processes or products.

Instituto de Tecnologia de Alimentos (ITAL)
Institute of Food Technology
Caixa Postal 139
Campinas, S. P., Brazil

Type: Civil service institute under the Coordinator of Agriculture and Animal Research of the Agricultural Secretariat of the State of São Paulo

Board: Council of four members

Director: Agide Gorgatti Netto

Staff: 1974: total of 392; 90 professionals, 164 administrative, 138 technical supporting

Affiliations:

Cooperation with the Universidade de Agronomico in offering intensive courses in food technology for degree credits. Linkage, through State Science and Technology Program (CET), with Consortium on the Development of Technology (CODOT) (The Universities of California, Michigan State, Rhode Island, Wisconsin and Washington).

Finances:

1974 operating budget of US$3,041,300, derived as follows:

State of São Paulo	US$1,648,600
Federal Government	693,800
Service Charges to Industry	459,000
Sale of Pilot Plant Products	166,700
FAO Grant	58,300
OAS Grant	4,900.

Twenty-one percent of ITAL's income results from contracted services and pilot plant operations.

ITAL is charged with responsibility to promote and contribute to the development of the Brazilian food industry. ITAL first originated as a laboratory of food technology in the Instituto Agronómico in 1963, and in 1964 was reorganized under the State Secretariat of Agriculture with the assistance of FAO. In July 1969, ITAL became a full technological institute with three technical divisions plus administration and maintenance divisions. Occupying 20 buildings which include 13 pilot plants, 20 highly specialized laboratories, support services, etc., the space occupied totals 22,600 square meters. A number of services are made available especially to the food industry. These include chemical and biological testing, standards and performance testing, quality control, industrial troubleshooting and problem-solving, manufacture of special new projects for market testing, techno-economic studies, productivity studies, pilot plant studies, the provision of technical information, and research. Government, university and private industries from São Paulo and other areas of Brazil send people to ITAL for training in food technology and allied fields through short courses and seminars, and, in collaboration with universities, offersintensive courses in food technology for degree credits. Expertise is offered in the fields of applied biology, chemistry, physics and engineering. Research and development is primarily related to preparing, processing, packaging, storing, distribution and utilization of food.

Specialized projects have involved fruit and vegetable processing, grain and cereal storage, food dehydration, fermentation and wine production, industrialization of fish and marine products, freeze drying of meat and fish, and marketing.

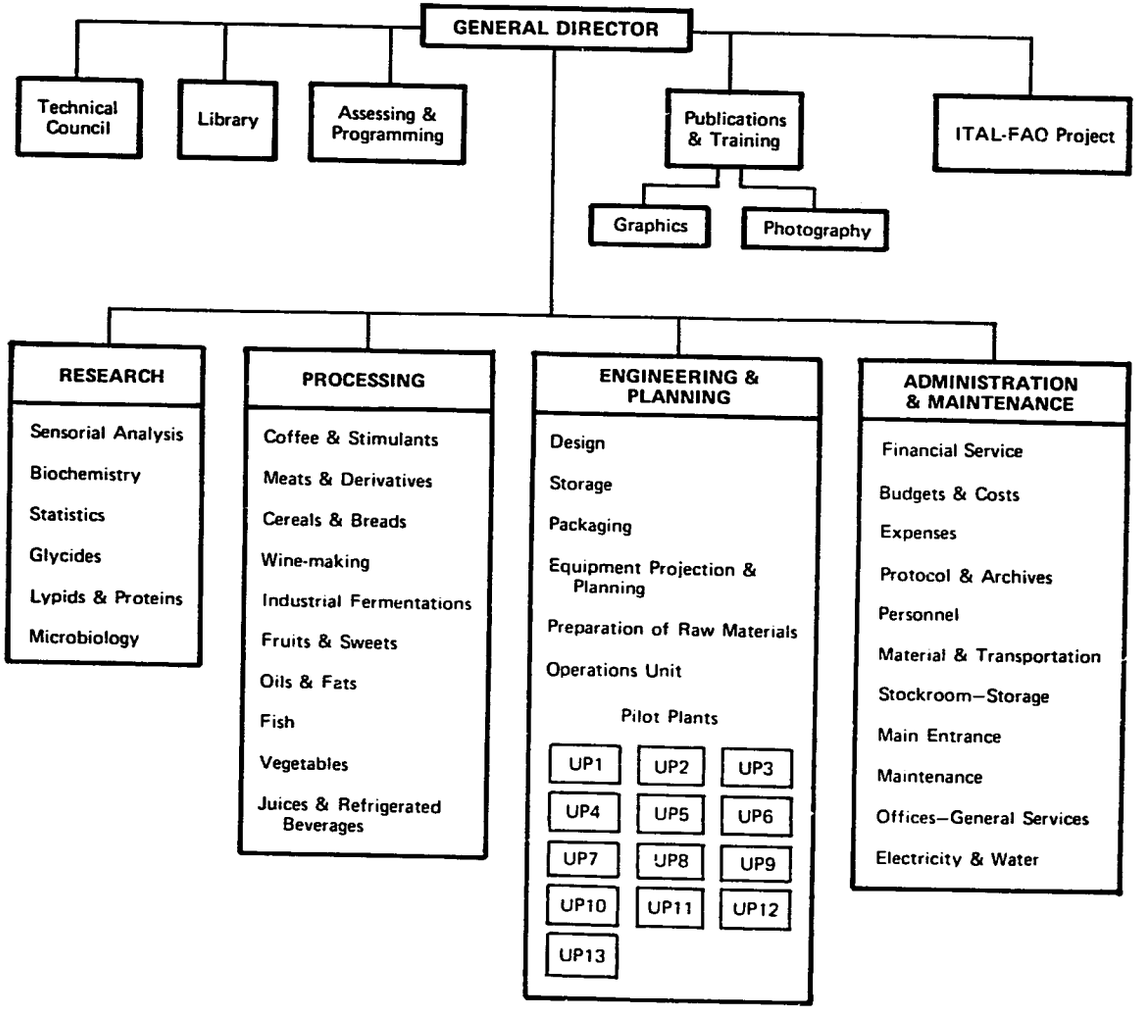
ITAL serves as an advisor to government (state and federal) organizations on all projects related to the food industry. Contacts with industrial food processors have increased markedly since 1969. ITAL reaches food industry sectors (such as meat processing, fish products, preservation of tropical fruits, etc.) both through direct personal contact between industry and ITAL staff and through special topic seminars. In the course of these seminars, for which an attendance fee is charged, industry has an opportunity to learn about ITAL's capabilities and facilities, and ITAL is provided an excellent opportunity to learn about sectoral problems and needs and to use such information both for initiating R&D activities, and for future facilities and staff development planning.

ITAL is slowly recovering some of its direct and indirect costs from contracts with industry (in 1974, 21 percent of ITAL's income was derived from contracted services and pilot plant operations). ITAL has found that industry generally is unwilling to pay for the results of research until these can be further verified in ITAL-operated demonstration plants. Thus, the ITAL concept is to make limited production runs for a fee, and with raw material provided by the industry. Subsequently, if the client is satisfied ITAL will provide assistance in training, plant design, process development or improvement, operational assistance, etc. Once the plant becomes operational, ITAL will continue to provide technical assistance, through in-plant assignments of ITAL staff, analysis and testing, on a full-cost recovery basis. This ITAL attitude has resulted in clients returning with requests for further assistance, development of new products, new processes, etc.

ITAL marketing assistance has been an essential element in the above process, particularly for small- or medium-size industries who do not have the internal capability to identify domestic or export market potential, customer preference or satisfaction, and similar trends. ITAL has completed 33 such projects since 1969, an additional 31 similar projects are underway.

ITAL is attempting to achieve status as a state-owned autonomous corporation, which would provide greatly improved discretionary operational control to the ITAL Director.

INSTITUTO DE TECNOLOGIA DE ALIMENTOS
ITAL



Institute of Standards and Industrial Research of Iran (ISIRI)
Karadj, Iran

Type: Department of the government under the Ministry of Economy.
Board: Council of seven members.
Director: Mohsen Sorody
Staff: 1974 total of about 750; 250 professionals.
Affiliations:
Active interaction with universities in Iran; professional help is attained from the universities. Active member of the International Standards Organization; cooperation with the Ministry of Agriculture, Ministry of Post, Telegraph, and Telephone, Ministry of Science and Higher Education, and the Army of Iran.
Finances:
1974 operating budget of US$4,000,000, largely supplied by the government.

ISIRI originated as the "Standards Organization of Iran" and was then combined with the Industrial Research Establishment at Karadj in the 1960s. In 1965, the present institute was formally founded. The main divisions of the Institute describe its capabilities: Standardization Bureau, Testing Laboratory, Industrial Research Laboratory, Hallmarking or Certification Organization, Weights and Measures, Bureau to Provide Safe Delivery of Export Goods, Leather and Hides Laboratory and Metrology Center. Activities include technical information, chemical analysis, chemical and biological testing, physical testing, standards and performance testing, productivity studies and techno-economic studies.

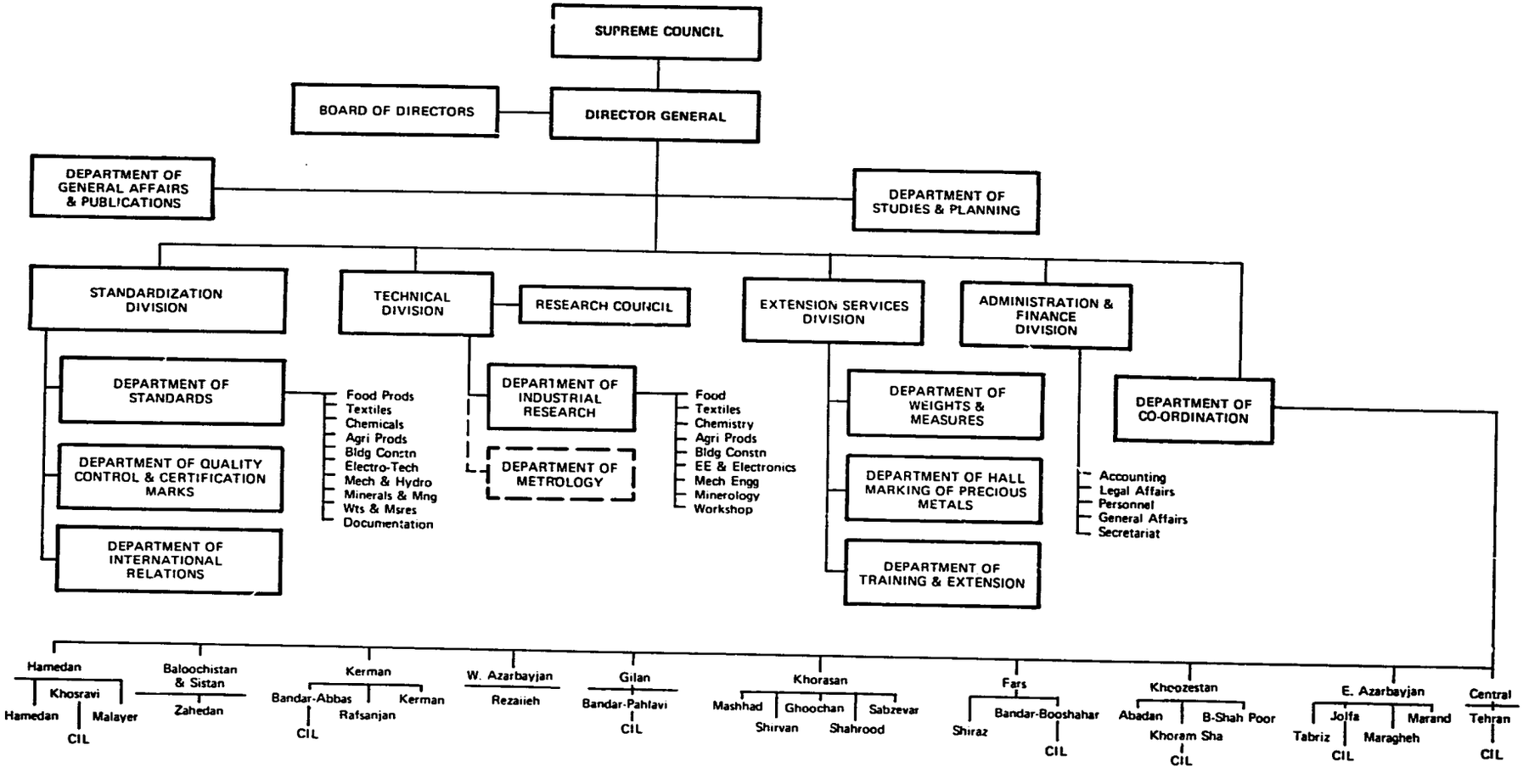
At the present time, ISIRI is focusing its efforts almost entirely on standards,quality control and testing. While an attempt was made to coordinate research activities with standards and certifications, the process was found to be largely unsuccessful. Industrialists distrusted an arrangement whereby a certification division of ISIRI might require the support of research or product development in a research division of ISIRI prior to issuance of a certificate. The implications, even though unfounded, largely contributed to the demise of ISIRI research. Only a few research projects, not connected to standards or certification, were undertaken (about 40 in four years) and practically none of these produced results that went into industrial production. In 1970, ISIRI research activities were suspended, in order to develop a satisfactory approach to R&D which would be in consonance and not conflict with ISIRI's primary objectives. In the interim, major Iranian universities have established applied research centers which are being used by industry. Examples are: the Center for Applied Research and Consultancy Services (CARCS) of the University of Tehran, the Biochemical and Bioenvironmental Research Center, and the Industrial Liaison Office for the Arya-Mehr University of Technology; the Industrial Liaison Division of the College of Engineering of Shiraz University. It is easier for ISIRI to utilize the

staff and facilities of the universities for research which is needed; well trained people are available, and laboratories are better equipped. Also the potential for criticism of possible collusion between certification and research is eliminated.

ISIRI has a network of some 36 stations throughout Iran which are qualified to issue hallmarks, certificates, conduct analyses and tests, etc. Since ISIRI guarantees the quality or performance of products it certifies, it is also liable for claims resulting from failures, non-performance, sub-standard quality, etc. ISIRI has the authority, under government mandate, to close down an industry which is non-compliant with required standards, either for domestic use or export, or which is producing a sub-standard product.

In the majority of instances, ISIRI will conduct an economic analysis of the situation before applying compulsory quality control or standardization, or closing down an industry. If too many people might suffer from unemployment, ISIRI usually will put the company on notice (up to three months) to make changes necessary to meet the required standards. If the extent of unemployment is small, the industry is usually closed down until it can meet the required standards.

INSTITUTE OF STANDARDS AND INDUSTRIAL RESEARCH OF IRAN
ISIRI



RESEARCH INSTITUTE SYSTEM

Council of Scientific Industrial Research (CSIR)
Rafi Marg, New Delhi, India

Type: Civil service type administrative body for a number of national and regional laboratories and related organizations; under Ministry of Planning.

Governing Body: President (Prime Minister); Vice President (Union Minister in charge of the Departments of Scientific and Industrial Research and Electronics); plus one representative of the Administrative Ministry under which the Council is included; one representative of the Minister of Finance; the Director-General, CSIR (ex-officio); two members of the Board of Scientific and Industrial Research; all private donors of a sum of not less than US$50,000; a nominee of a firm or an institution which has donated a sum of not less than US$250,000; and one or more members appointed by the Government of India.

Director-General: Y. Nayudamma

Staff: 1974: 10,912 scientific and technical, 2,880 administrative.

Administrative Body For: CSIR is the administrative body for thirty research establishments including national laboratories, institutes, organizations, and regional laboratories, with 65 field stations attached to them.

Affiliations:

Linkages in Poland, United Arab Republic, Hungary, Great Britain, Yugoslavia, East and West Germany, United States, Bulgaria, Rumania and the Union of Soviet Socialist Republic.

Finances:

1973-74 operating budget was US$28,540,000. 1942-1967: total grants from the government equalled US$58 million in recurring expenses and US$32 million in capital expenditures. Total expenses of that period were 113.71 crores. Industry usually pays half and asks government to provide the rest for particular projects. Any income generated from periodicals, patents processes testing or industry returns to general budget.

The CSIR was founded in 1942 with the objective of promoting science and its application for national development. In 1971 CSIR was attached to the Department of Science and Technology of the Ministry of Planning in a move designed to more closely interweave science and technology into national economic planning and to encourage CSIR to function more effectively in achieving economic and industrial growth, self-reliance and social justice.

Under this new mandate the CSIR has become increasingly dedicated to industrial/applied R&D projects, although with concommitant fundamental research as required for these programs. Laboratories and industrial research associations have been organized into six groups: Chemical Sciences, Physical and Earth Sciences, Engineering Sciences, Biological Sciences, Fibers, and Scientific Information. Activities include technical information, chemical analysis, chemical and biological testing, physical testing, industrial troubleshooting and research.

Thirty separate research units--national laboratories, institutes, regional laboratories--along with 65 field stations, operate under the CSIR umbrella and are located at various sites throughout India. In addition, 14 research association laboratories have been established. The national laboratories are engaged in research which is basic to industrial development. The regional laboratories are multi-purpose in character and are concerned with problems of industrial development in their respective geographic areas. Some of these laboratories are concerned with general needs of the nation, such as food, fuel, buildings, highways. Others devote their efforts to research in engineering, public health, geophysics, oceanography, experimental medicine and toxicology. Laboratories have been established to deal with problems of interest to specific segments of industry--electronics, ceramics and glass, leather, minerals and metals, marine chemicals, drugs, scientific instruments. These research units are largely subsidized by the Indian Government.

A key element of the CSIR system is the ability to create special-purpose research units outside of the normal organizational hierarchy and to dissolve these units when these have fulfilled their purpose or are no longer required. Such research units are created on the basis of requests for assistance by particular segments of industry, by industrial associations, etc., and who, as a condition, pay 50 to 75 percent of the operating costs of the unit. Since the units are designed to meet specific needs, staff assignments can be made on a multidisciplinary basis and altered easily to meet changing needs. The CSIR permanent laboratories and staff provide backstopping, management advice and direction, use of specialized facilities, etc.

As a general rule, bench- or laboratory-scale research is thoroughly evaluated prior to entry into pilot plant or scale-up projects. This includes techno-economic surveys and market surveys to provide the necessary data required for assessing the size and nature of the operation.

CSIR is paying increasing attention to the solution of applied research problems. Over 1,800 (about 88 percent) out of 2,055 projects undertaken in 1971 were applied in nature. At the end of 1971, 229 out of a total of 491 processes released were in production as compared to 192 out of 416 processes in 1970. During the 25-year period between CSIR's founding in 1942 and 1967, over 8,000 technical papers were published; approximately 800 papers have been published each year (1,049 in 1971). During the same period, some 1,291 patents were processed (163 patents were processed in 1971). CSIR processes and products are being increasingly utilized by industry with the assistance of the National Research Development Corporation of India.

Pakistan Council of Scientific and Industrial Research (PCSIR)
Press Center, Shahrah-E-Iraq
Karachi 1, Pakistan

Type: Statutory, autonomous organization under the Minister for Science and Technology.

Board: Council of 21 members nominated from the federal government, four provincial governments and public and private industries. The Governing Body of the Council consists of the Chairman, a member (technology), a member (science) and a member (finance). The Governing Body is responsible for general administration and supervision of affairs of the Council.

Director: Acting Chairman, M. M. Qurashi; Karachi Director, Mohamed Aslam; Lahore Director, Yusuf Ahmed; Peshawar Director, Riaz Ali Shah; FULREC Head, Abdul Hameed Chotani

Staff: 1974: 538 professional, 46 administrative, 1,319 general services and support.

Administrative Body For: Four laboratories (the labs together consist of 13 mono-purpose divisions which are to be developed into 12 semi-autonomous institutes in the future; see organization chart), the Pakistan-Swiss Training Center and the National Standard Laboratory.

Affiliations:
CENTO, universities in Lahore and Karachi, linkage with the Denver Research Institute, Atomic Energy Commission, Lahore and the Ministry of Science and Technology (controlling authority).

Finances:
1973-74: government funds--recurring expenditure and projects US$2,144,000, expansion of laboratories US$235,000. Revenue from research and development contracts and extension services: US$64,000.

PCSIR is the largest technological organization in Pakistan, established, controlled and financed by the government. The need for a research and development organization in Pakistan was felt in 1951. A Department of Scientific and Industrial Research was established within the Ministry of Industries to pursue research and development aimed at greater utilization of indigenous raw materials. The Department was converted in 1953 to semi-autonomous status and renamed PCSIR. In 1973, PCSIR derived its present statutory status and increased autonomy from the PCSIR Act passed by the National Assembly.

The PCSIR directorate is located in Karachi and controls planning, development, training, budget, accounts, audit, patent coverage, publications, press information and personnel management. The research and development operations are carried out through four subsidiary laboratories which have delegated authority for their areas and are located in Karachi, Lahore and Peshawar. In addition, PCSIR operates a diploma-granting, Pakistan-Swiss

Training Center in Karachi for precision mechanics and instrumentation.

The PCSIR laboratories conduct pure and applied R&D, with emphasis on industrial science and technology for national development. Laboratory staff undertake a variety of activities, including chemical analysis, chemical and biological testing, mechanical testing, technical information dissemination, techno-economic studies, industrial troubleshooting, pilot plant studies and research. Research programs have included food and fruit technology, leather technology, glass and ceramics, biological fermentation, oils and fats, natural drugs from medicinal plants, ore dressing and metallurgy, mineralogy, wool technology, pesticides, polymers, coatings, building materials and chemical engineering process design.

PCSIR performs an advisory function to both provincial and federal governments. Recently the laboratories have developed a good relationship with industry through their efforts to promote utilization of research results. During its formative years, PCSIR was organized, staffed and managed primarily by basic researchers and enjoyed almost absolute freedom in choice of research projects. Applied research and development was carried out on a few projects stressed by the government. In 1965, however, the government demanded increased applied research and development activities along with increased services to industries. An Industrial Liaison Branch was established in the directorate to expand contact between PCSIR and industries. The function was later decentralized and the Karachi and Lahore Laboratories established branches to facilitate contact.

Today, senior scientists make every attempt to develop personal industrial contacts and to encourage industry to bring its problems to PCSIR. Multidisciplinary teams go to firms to solve specific problems. Seminars to stimulate industrial development have brought individuals together on a cooperative basis. At the present time, market surveys for sponsored projects are left to the sponsor. A fixed fee is usually charged industrial clients, on a non-guarantee basis, for preliminary laboratory investigations. If results are good, then industry is urged to pay more through process royalties or increased contributions. Thus far, however, industry is still paying very little of the total cost.

The PCSIR laboratories are continuing their search for additional contracted services support, and at present are reviewing fee schedules for the private sector, semi-government and government organizations. The government is pressing PCSIR to further expand its extension services to industries and to increase its revenue from the results of research and development.

The reorganization and promotional activities have improved PCSIR's image and status in Pakistan. PCSIR staff and industry representatives are collaborating on several projects to successfully use R&D results. PCSIR is becoming known for its ability to provide technical know-how in pre-production and demonstration pilot plant operations.

The PCSIR salary scale is lower than that of the private sector, so that frequently the most talented staff members are lured away, often leaving an imbalance in the ratio of technologists to scientists. Criteria for promotion is seniority in service and cadre, number of papers published, patents obtained and processes developed. A percentage of premiums and fees is paid to the research or extension service teams as a bonus which partially offsets salary differential.

Lahore Laboratory (550 staff)

Lahore Laboratory has a comparatively higher ratio of technologists to scientists, thus the work there is concentrated primarily on industrial technical problems. Recently, Lahore staff have initiated feasibility studies and technical extension work, particularly in glass and ceramics. They have been working to establish closer contact with industry and have jointly established committees with industry to evaluate excess or wasted industrial production. A good pilot plant operation exists. Textiles, metal-mechanical, chemical, sugar and petroleum industries are approaching Lahore Laboratory for technical assistance. Sponsored research is fairly well accepted as of now, and industry no longer expects totally free service, although fees are low.

Some success and increased contact with industry are indicated by the growth taking place within this laboratory. Out of 418 projects initiated since 1967, 87 have been completed and leased out, 28 have been completed and are ready for commercial exploitation, eight have been completed and have facilities existing for initiation of production, 20 have been completed with published results, 114 discontinued with possibility of revision, and 50 abandoned. Over 1,000 papers have been published and about 200 processes have been patented.

Karachi Laboratory (725 staff)

Karachi Laboratory is the oldest and largest unit of PCSIR. The Karachi Laboratory is responsible for a number of activities, including research, economic feasibility reports, preparation and supply of samples for industry, technical reports and information dissemination, advisory service, pilot plant studies and scientific liaison. Preliminary feasibility studies of processes developed have been carried out in this unit since 1968. The Karachi Laboratory was the first unit to establish close contact and liaison with industries, render extension services, and form functional committees relating to and collaborating with various industries. Besides offering a number of services, the Karachi Laboratory sends teams to industries to identify in-plant problems and suggest solutions to be investigated by the Laboratory. Industry is slowly beginning to respond and some major sponsored projects are now underway. Paints, plastics, paper, board, wood, food, fish, textile, pharmaceutical, chemical, electronics and petroleum processing industries are using the Karachi Laboratory for scientific and technical assistance and sponsored research. The unit has, so far, developed and leased out 90 processes out of which

about 30 are in commercial production. More than 100 technical/ operational problems have been solved. About 1,200 papers have been published and 200 patents obtained.

Peshawar Laboratory (250 staff)

Peshawar Laboratory is smaller than both the Karachi and the Lahore units. It does not yet have an industrial liaison service. The directors and the senior staff of the unit have, however, been approaching local industry with some success. The unit has rendered services to the mineral, wool, textile and food and fruit-based industries.

FULREC-Karachi (100 staff)

FULREC, the Fuels and Leather Research Center (formerly the Pilot Plant Research Station), is the smallest unit of PCSIR. It does not have an industrial liaison service, but like Peshawar, its director and senior staff have been pursuing this function. Considerable success has been achieved with respect to extension work in the leather industry. Success with fuel and fuel-utilizing industries has been limited to date but is increasing.

Pakistan-Swiss Training Center

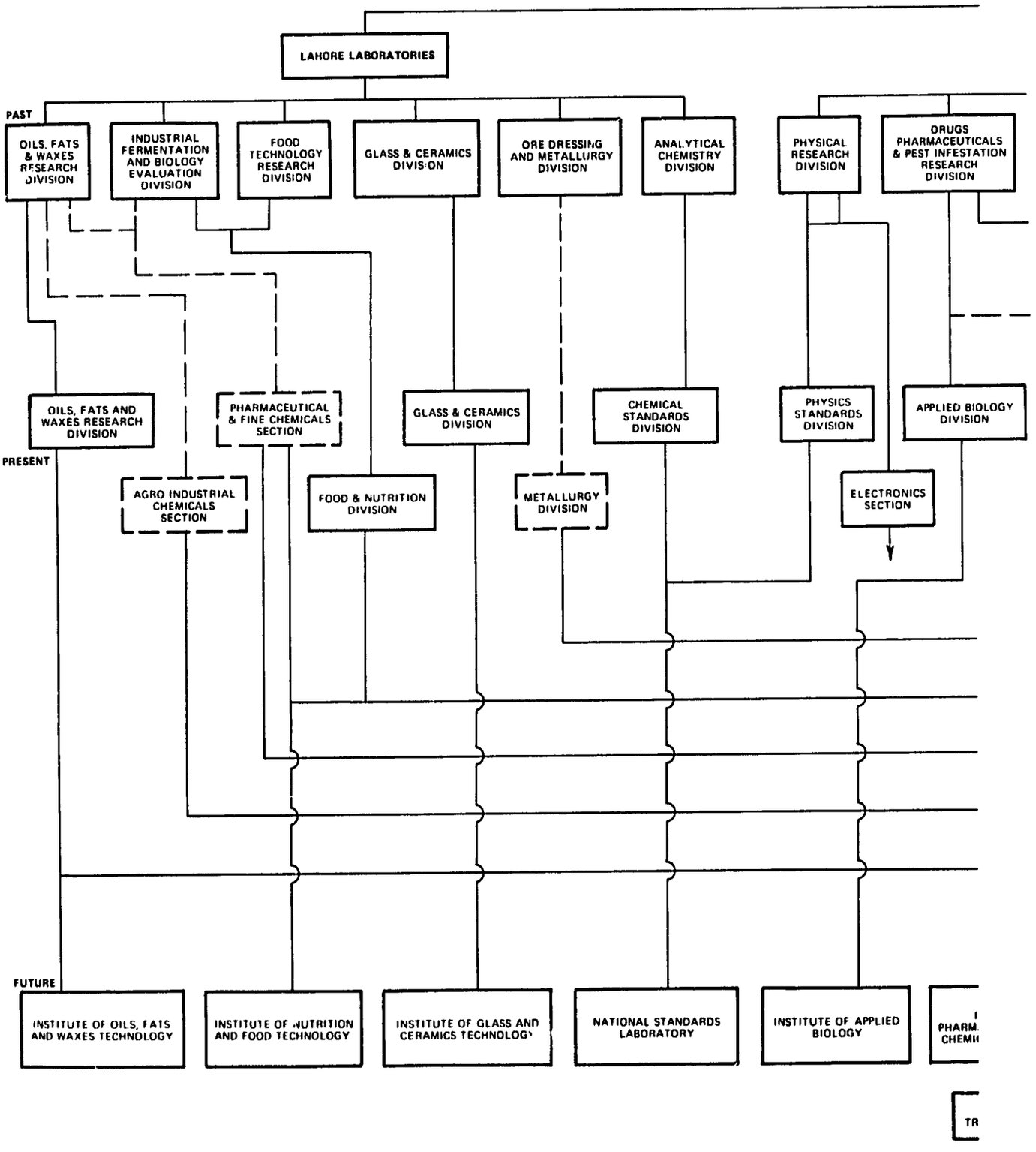
The Pakistan-Swiss Precision Mechanics and Instrumentation Training Center was set up by the PCSIR with the help of the Swiss Foundation for Technical Assistance. The Center provides training in precision mechanics and instrumentation and offers advanced courses in electronics and optical instrument technology. The Instrument Division provides electronic instruments, electrical instruments, industrial and process instruments including pressure gauges, optical instruments, precision balances, etc. The Production Unit of the Center renders service to the country by designing and manufacturing intricate types of tools, dies, punches, gauges, jigs, fixtures, gears and precision machine components, thus saving valuable foreign exchange by eliminating imports of such items from abroad. In 1973-74, the income from this activity amounted to US$23,750.

The Pakistan-Swiss Training Center is projected to be incorporated into the National Engineering Laboratory.

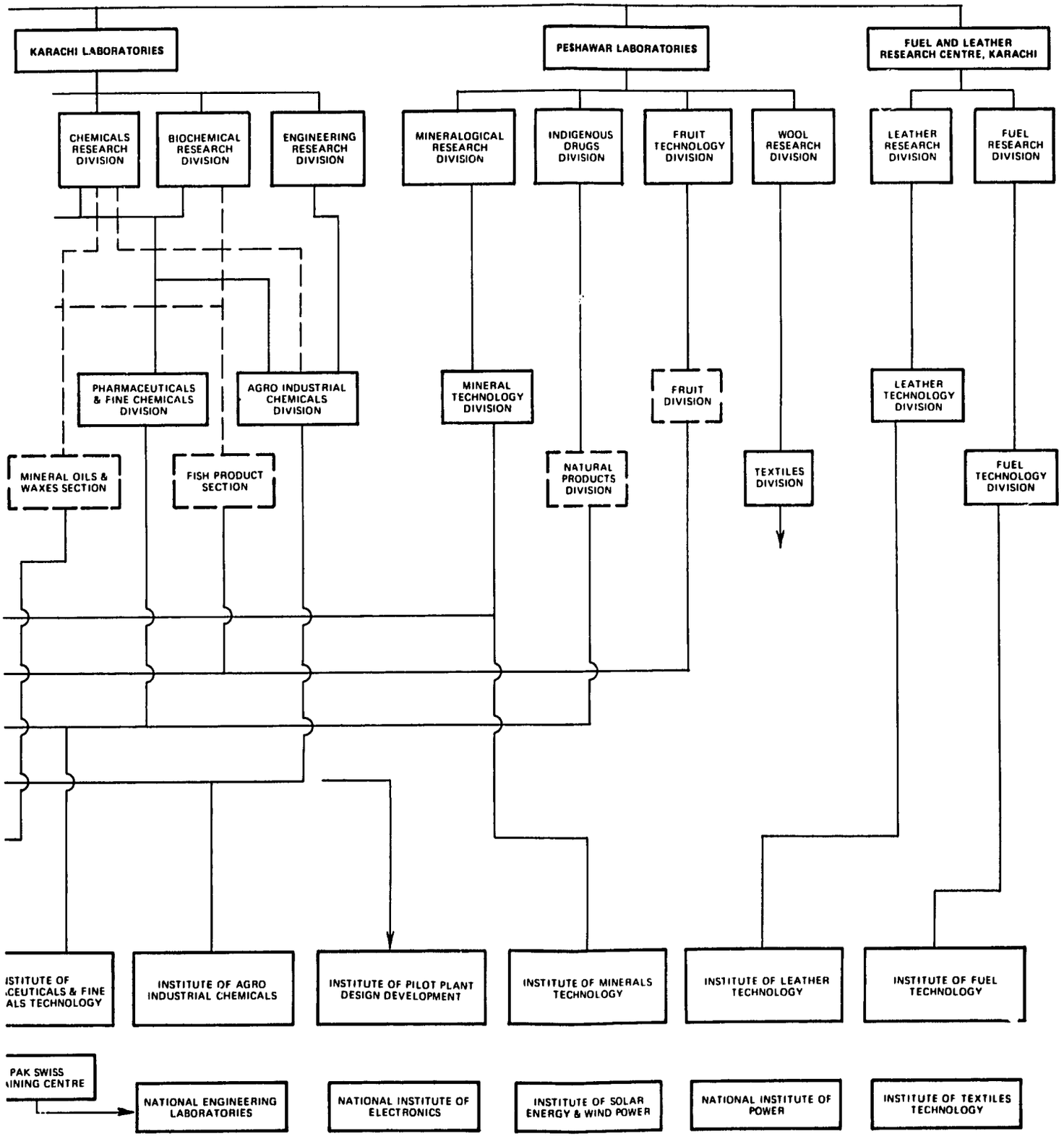
Pakistan National Scientific and Technical Documentation Center (PANSDOC)

PANSDOC was originally included in the PCSIR organization; however, in 1973 the Pakistan Science Foundation established the Pakistan Scientific and Technological Information Center (PASTIC) and PANSDOC was incorporated into the Center and will continue to function in Karachi as a regional center.

PROPOSED REORGANIZATION OF PAKISTAN COUNCIL OF SCIENTIFIC &
PCSIR



INDUSTRIAL RESEARCH LABORATORIES



Instituto Nacional de Tecnología Industrial (INTI)
National Institute of Industrial Technology
Libertad 1235
Buenos Aires, Argentina

Type: Autonomous institute system operating within the area of the Department of Industrial Resources.
Board: Executive Board with nine members appointed by the President consisting of four who represent private industry, four who represent government entities, and a president who is appointed by the Minister of Industry and Mining.
President: Jorge Luís Albertoni
Staff: 1974 total of 784; 189 professionals, 211 administrative, 276 technical supporting, 108 others.
Administrative Body For: A group of central laboratories plus 20 research centers in various areas of Argentina.
Finances:
1973 operating budget US$5,310,000 of which 80 percent provided by the government, 20 percent from earned fees and contracts.

INTI was established in 1957 as an autonomous entity under the Department of Industrial Resources. Within the framework of government-formulated national policy, INTI has the responsibility to assist industry in solving technological, training, and management problems by providing R&D, prototype development, materials testing, courses, lectures, symposia, and by operating a center for technological information.

INTI is a consultant to the Federal Government on the feasibility of new industrial projects proposed by local and foreign investors, and screens suggested foreign technology in terms of appropriateness, relevance, duplication of existing national technology, costs, and constraints. INTI operates the Foreign Industrial License, Patents, and Contracts Registry, which analyzes commitments of local enterprises and authorizes remittance of corresponding royalties abroad.

The INTI laboratories undertake a number of activities including: technical information dissemination, chemical analyses, chemical and biological testing, physical testing, standards and performance testing, industrial troubleshooting, fundamental and applied research, development, pilot plant studies, and industrial application of research results.

Specialized fields of competence include: food technology (meat, dairy, fruit and vegetable canning, fats and oils), natural resources (mining, metallurgy, pulp and paper, leather, rubber and plastics, seaweed processing), industrial metrology and primary standards, materials behavior and testing (creep, fatigue, fracture, structural strength), hygrothermal, acoustic, and lighting designs for buildings, environmental pollution, and industrial waste treatment.

INTI central laboratories include Departments of Chemistry, Physics, Metallurgy, Non-Destructive Testing, Building Materials, Structures, Rubber, and Metrology. In addition, a network of research

centers are located throughout Argentina.

The key element to the INTI system is the tactic which has been devised to create special-purpose research units outside of the normal organizational hierarchy of INTI and to dissolve these units when these have fulfilled their purpose or are no longer required. These research units are created on the basis of requests for assistance by particular segments of industry, by industrial associations, etc., and who, as a condition, pay 50 to 75 percent of the operating costs of the unit. Since the units are designed to meet specific needs, staff assignments can be made on a multidisciplinary basis and altered easily to meet changing needs. In each instance the INTI permanent laboratories and staff provide backstopping, management advice and direction, use of specialized facilities, etc. In each case, executive committees review problem areas, recommend action to be taken and review the results. If INTI attempts to contract directly with industry or industrial associations, the funds would revert to the government. However, INTI can establish, by law, research centers which can conduct research programs and services with the participation of industrial enterprises, universities, and government enterprises. Contract funds made available through such arrangements can be used to pay higher salaries to research center employees and for other developmental and institution building activities.

When an industrial group or association recognizes a need for technical assistance to a specific category of problems, arrangements can be made with INTI to establish a research center to investigate those problems. Generally, the industrial association agrees to provide 75 percent of the cost of such a center, while INTI will provide up to 25 percent of the cost in terms of capital, use of facilities, equipment or people. In several instances, the industry contribution approximates 90 percent of the total costs involved.

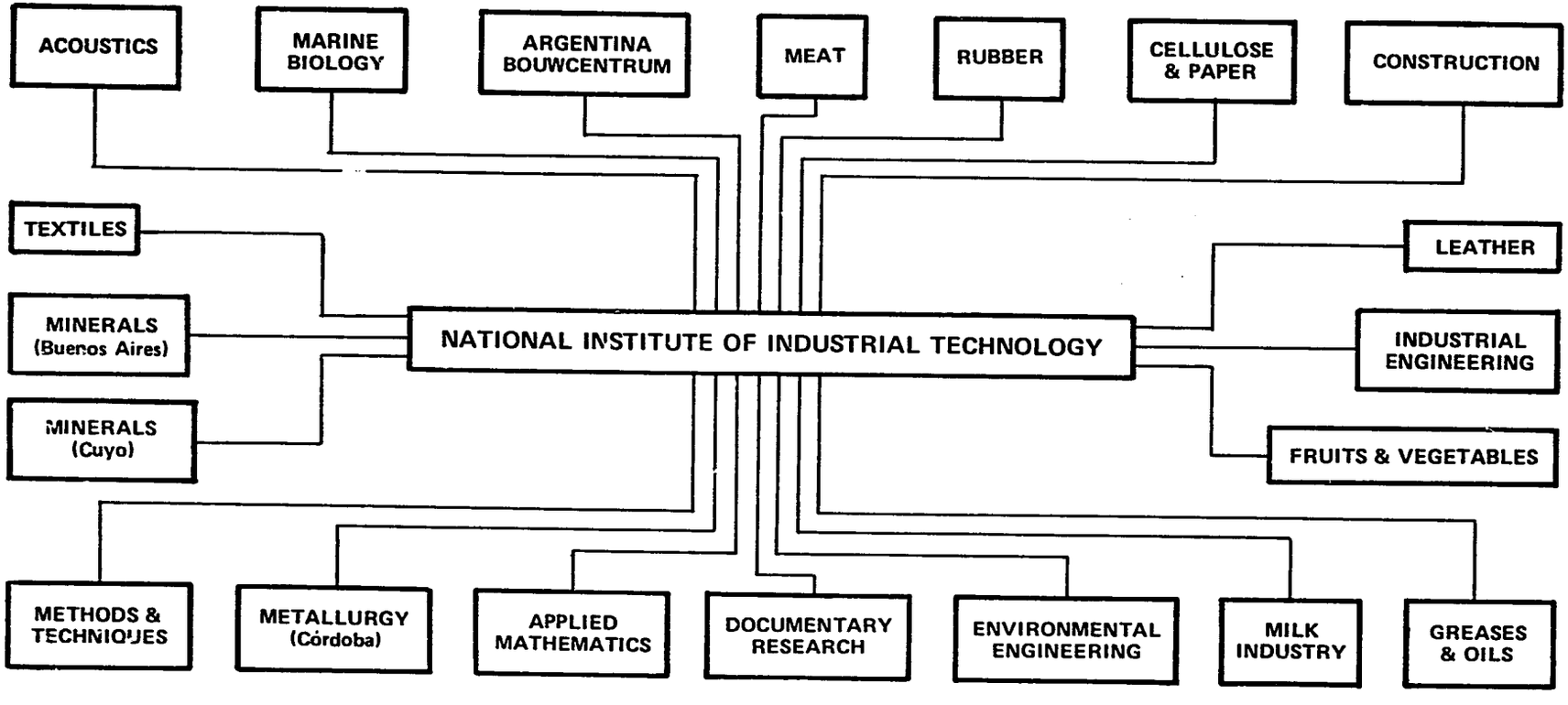
INTI research centers have little overlapping of research interests. INTI classifies its research centers as follows:

- Technology of construction and the human habitat.
  Research centers in building technology, building and housing (Bowcentrum Argentina), acoustical and illumination engineering, ambient engineering;
- Productivity, work methodology and training, management and industrial design.
  Research centers for techniques and methods in small- and medium-sized industry, industrial design, mathematical techniques applied to management;
- Natural products and food.
  Research centers in fats and oils, fruits and vegetables, leather technology, marine biology, cellulose and paper;
- Mining industries and metallurgy.
  Research centers in minerals, mineral industries, metallurgy;
- Research center in technology of elastomers and plastics;
- Research center in combustion technology;
- Research center in textiles;

- Research center in documentation.

The INTI research centers have faired somewhat better than similar centers under the CSIR in India. These have been formed at the request of existing associations or government enterprises which are already working together and have identified common problems. It should be understood that a large amount of effort of these centers is directed towards analysis and tests, quality control, and other services. But, increasingly, the amount of adaptive research is increasing as industry gains confidence in the ability of these centers to solve their development problems.

INSTITUTO NACIONAL DE TECNOLOGIA INDUSTRIAL
INTI



National Institute of Science and Technology (NIST)
Herran Street, Corner Taft Avenue
P. O. Box 774
Manila, Philippines

Type: Government civil service institute under National Science Development Board administered by a chairman with cabinet rank.

Board: National Science Development Board members, referred to as the Board of Governors; eight positions of which five are presently filled.

Commissioner: Jose R. Velasco

Staff: 1974 total of 492; 225 professional, 74 administrative, 193 technical supporting and other.

Administrative Body For: four service centers and two research centers; Agricultural Research Council, Biology Research Council, Food and Nutrition Research Council, Medical Research Council, Tests and Standards Laboratory, Scientific Instrumentation Division and Industrial Research Council.

Affiliations:
NIST is one of six implementing agencies of the National Science Development Board (NSDB).

Finances:
1974 operating budget of US$1,630,000, all provided by government. Special fund of US$13,359 (Philippine agencies or international organizations); general fund of US$369,990 (comes to NIST from their central budget through the NSDB); fiduciary fund of US$257,914 (held by Treasury Department); special science fund of US$1,825,105 (derived from a tax on motorists); small amount earned in most years for tests, analyses and research results (money turned over to Treasury); total of US$2,466,370.

NIST is one of six implementing agencies of the National Science Board of Development responsible for research and information dissemination directed toward the development of economic growth in the Philippines. The history of this institute is quite long and involved since it first originated as the Bureau of Government Laboratories in 1901. In 1905, it was converted into the Bureau of Science and expanded by inclusion of the Bureau of Mines and the Ethnological Survey Unit of the Bureau of Education. In 1933, some units were transferred, and in 1947 the name was changed to the Institute of Science. In 1950 changes were again made, and for a time the name was Institute for Science and Technology, only to be changed again to the National Science and Industrial Research Institute. In 1958 the Science Act gave it the present name and placed it under the National Science Development Board (NSDB).

Until 1972, NIST research and service areas were: agricultural, biological, medical, industrial, chemical R&D, food and nutrition, tests and standards, scientific instrumentation, techno-economics, documentation,

and laboratory training program. In 1973, however, NIST was again reorganized. The Food and Nutrition Research Center (except for the Food Technology Section), was transferred to the NSDB an an entity at the same level as NIST. The Agricultural Research Center, Medical Research Center, and Biological Research Center were incorporated into a Biological Research Center. A Microbiological Research Department was established. The Industrial Research Center absorbed the Departments of: Chemical Research, Ceramics Research, Engineering R&D. Techno-economic staff was merged into a new Planning and Programming Division. The Documentation Division was reduced in scope and became a Library Services Division.

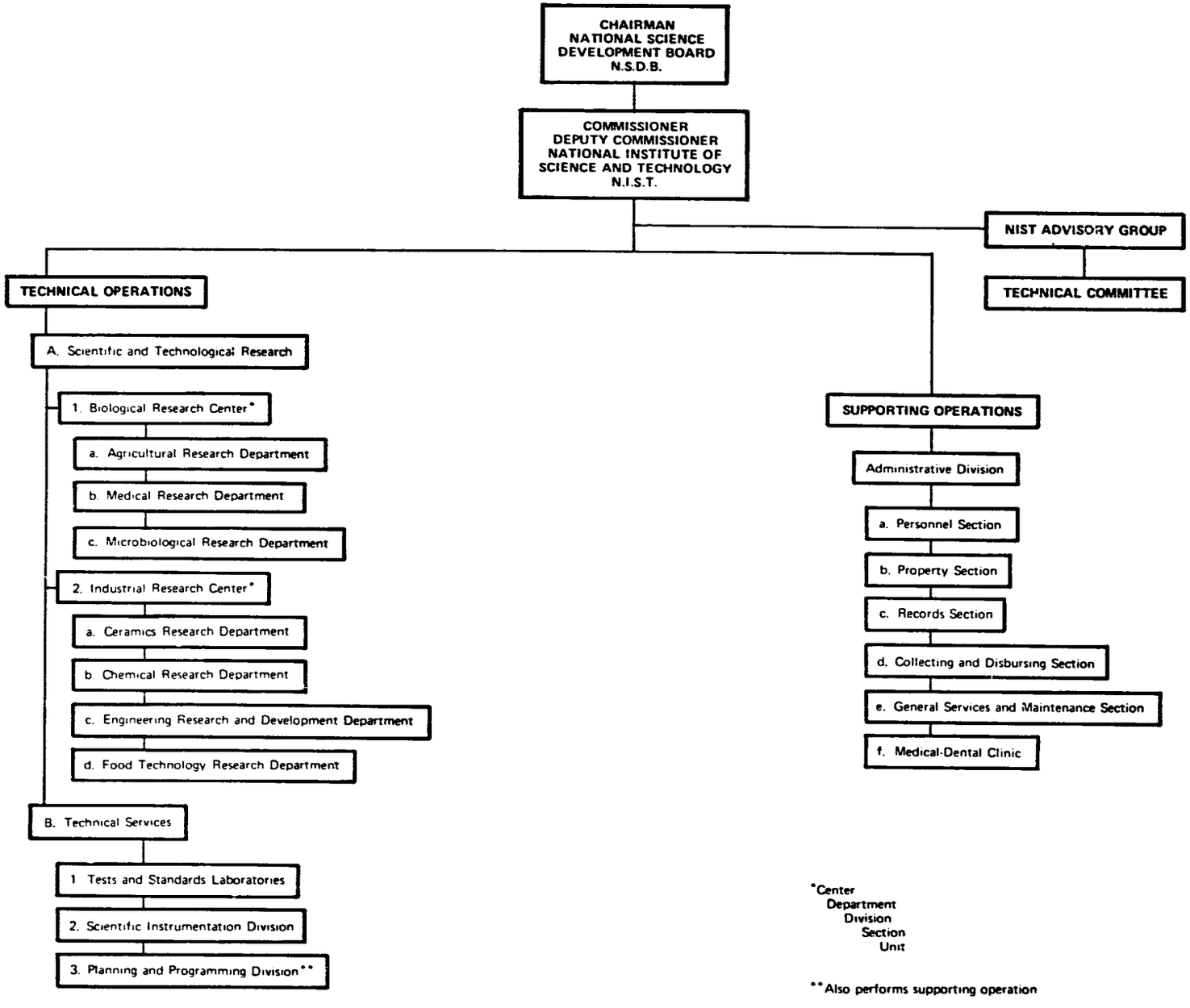
At the present time NIST is seeking to become an autonomous body, with separate corporate status.

NIST program emphasis has changed as its organization and mandate has been altered. At the present time, emphasis is directed toward research and services which will provide developmental assistance to the government and the industrial sector. The Institute participates in a number of activities including the collection of technical information, chemical analysis, chemical and biological testing, physical testing, standards and performance testing, techno-economic studies and research. Work is conducted in the areas of applied physics, applied chemistry and engineering. Specialized research has centered on drugs from plants, industrial fermented products, coconut, fruit products, oil derivatives, by-product utilization, and erosion control.

In 1974 NIST was asked to assume responsibility for the nation's fuel and energy and electronics R&D. The Ceramics Department of NIST is providing services to cottage level industries. NIST and an Agriculture Cooperative are joint-venturing on the operation of a NIST-developed coconut processing plant on a commercial basis.

The NIST Scientific Training Division conducts three-year training programs in electronics, fine mechanics, precision optics, and scientific glass-blowing.

NIST's industrial services to industry are generally limited to standards, calibrations, measurements, analyses, etc., for which small fees are collected. Medium and large industry distrust of a government technological institute makes it difficult for NIST to contract for R&D services. Thus, much of NIST's efforts are directed toward technical extension activities to those small industries who lack sufficient capital but nonetheless require technical assistance. It is quite likely that in the long run such technical extension activities will contribute more to Philippine economic development and improvement in the quality of life than will attempts to conduct sophisticated R&D for larger industry.


CHAIRMAN
NATIONAL SCIENCE
DEVELOPMENT BOARD
N.S.D.B.
COMMISSIONER
DEPUTY COMMISSIONER
NATIONAL INSTITUTE OF
SCIENCE AND TECHNOLOGY
N.I.S.T.
NIST ADVISORY GROUP
TECHNICAL COMMITTEE
TECHNICAL OPERATIONS
A. Scientific and Technological Research
1. Biological Research Center*
a. Agricultural Research Department
b. Medical Research Department
c. Microbiological Research Department
2. Industrial Research Center*
a. Ceramics Research Department
b. Chemical Research Department
c. Engineering Research and Development Department
d. Food Technology Research Department
B. Technical Services
1. Tests and Standards Laboratories
2. Scientific Instrumentation Division
3. Planning and Programming Division**
SUPPORTING OPERATIONS
Administrative Division
a. Personnel Section
b. Property Section
c. Records Section
d. Collecting and Disbursing Section
e. General Services and Maintenance Section
f. Medical-Dental Clinic
*Center
Department
Division
Section
Unit
**Also performs supporting operation

Lembaga Ilmu Pengetahuan Indonesia (LIPI)
Indonesian Institute of Sciences
Djl. Teuku Tjhik Ditiro 43
Jakarta, Indonesia

Type: LIPI is a government body which provides guidance in the field of scientific research. LIPI is administrator for a network of institutes; directly responsible to the President of the Republic of Indonesia.

Board: Chairman, Executive Secretary, three Deputy Chairmen, one for Natural Sciences, one for Technology, one for Social Sciences and Humanities.

Chairman: Dr. H. Tb. Bachtiar Rifai

Staff: 1974 total of 1,697; 218 professionals, 221 administrative, 268 technical supporting, 990 others; of these, 38 professional staff and 41 administrative staff are part-time.

Administrative Body For: National Biology Institute, National Institute for Geology and Mining, National Institute for Oceanology, National Institute for Physics, National Institute for Chemistry, National Institute for Metallurgy, National Institute for Electro Techniques, National Institute for Instrumentation, National Institute for Economic Studies, National Institute for Cultural Studies and National Scientific Documentation Center. LIPI also coordinates several national committees such as: Scientific Committee on Marine Research, Scientific Committee on International Biological Program, Coordinating Committee on Hydrological Research, National Committee on Earth Sciences. LIPI represents Indonesia in conducting relations and cooperation with several international organizations and scientific bodies of other countries, such as: International Council of Scientific Unions (ICSU), International Union of Geodesy and Geophysics (UGGI), International Geographical Union (IGU), Special Committee on Oceanic Research (SCOR), Committee on Space Research (COSPAR), Special Committe on International Biological Programme (SCIBP), International Federation for Documentation (FID), Pacific Science Association (PSA), International Organization for Standardization (ISO), International Electrotechnical Commission (IEC).

Finances:

1974-75 operating budget of US$3,520,000, including routine budget of US$1,352,000 and government development budget of US$2,168,000.

LIPI first originated as the Council for Sciences (MIPI) in 1956, which was an autonomous advisory organization under the Ministry of Education. In 1962, MIPI became responsible for establishing and administering a number of research institutes as well as transferring scientific and technological knowledge. Later, under the Ministry of National Research, MIPI lost status and became known as the Institute for National Research, LEMRENAS. In 1967, the

government created LIPI which took over the original tasks of both LEMRENAS and MIPI.

LIPI's chief responsibilities are "to promote the development of science and technology in Indonesia, to search for scientific truth while maintaining academic and scientific freedom, and to prepare for the establishment of the Indonesian Academy of Sciences." LIPI administers a number of activities which contribute to this mission. These include: conduct of basic and applied research within LIPI institutes, advice and counsel to the government in the formulation of science policy, service as an advisory body for government agencies in matters related to science, coordination, integration and synchronization of activities in the field of science and technology at the national and regional level, implementation of science and technology to national development, increasing public understanding of the role of science and technology in national development.

LIPI's ten national research institutes are located in Jakarta, Bogor, and Bandung, and these conduct research in the natural, technological, and social sciences and humanities. Brief descriptions of each institute's activities are provided in the sections which follow.

In 1972, LIPI developed plans for a multidisciplinary technology research center, the National Technological Research Center (NTRC), which would become an autonomous corporation, released from civil service regulations, with authority to manage its own funds and develop a closer working relationship with industry. The NTRC was visualized as being a non-profit organization with continuing dependence on government funds but able to accept research and technical services contracts from government enterprise, the industrial sectors, and international technical assistance agencies. As the result of a subsequent U. N. evaluation, however, some questions have been raised about the usefulness of the NTRC concept. Accordingly, the concept has been revised to simply merge existing institutes, where possible, in order to provide better management and administrative direction, while non-merged institutes will continue under the overall LIPI administration as before. To date, five such institutes in Bandung have been merged together under a deputy chairman as the National Research Center. These are the National Institute for Chemistry, National Institute for Physics, National Institute for Metallurgy, National Institute for Electro-Techniques, and National Institute for Instrumentation. As a result of this grouping, administrative affairs are shared and the laboratories are thus able to concentrate their attention on scientific tasks. The merger greatly encourages the possibility of interaction between institutes, better utilization of scarce human resources, equipment, facilities, etc.

For example, where programs are related to the development of the metals industry, the National Institute of Chemistry can be assigned the study of the chemical characteristics of metals, the National Institute for Physics will study their physical properties, the National Institute for Electro-Techniques can investigate the use of the materials in the field of electricity, and the National Institute for Instrumentation will consider repair, calibration, and development of instruments needed either for the research or for production by industry.

The Indonesian Minister of State for Research is attempting to obtain greater cooperation and interaction between the LIPI research centers and technological institutes under other Indonesian ministries. The objectives are of course to optimize use of limited facilities and skilled human resources, provide stronger programs of science and technology directed toward Indonesia's development and to make available to government enterprise and private sectors appropriate technology, which is required by these entities in the development process.

Following are brief summaries of the research institutes under LIPI. The first five are institutes grouped in Bandung and are part of the first National Research Center. Each institute performs tasks supplementary to tasks performed by the others.

National Institute for Physics, Bandung

The National Institute for Physics conducts both basic and applied research on the physical properties of materials. The Institute, jointly with the Air Force, is investigating various properties of ferromagnetic materials. In cooperation with the Government Electric Company and a French manufacturing concern, the Institute is investigating the production of transformers in Indonesia.

The Institute is conducting neutron diffraction experiments, making resistance measurements of diodes, and other electronic components at liquid air temperatures, with the objective of developing indigenous very low temperature-measuring devices, conducting a variety of geophysical measurements, and is studying transition ions in solids using an EPR as a spectrometer.

National Institute for Metallurgy
Djl. Sangkuriang, Bandung

The Institute was established by the Indonesian Council for Sciences (MIPI) in 1964 to conduct research on the utilization of minerals. In 1965, the program was cancelled and then re-established in 1969 under LIPI. The Institute consists of three divisions: Mineral Processing, Metal Processing, Analytical.

The basic interests of the Institute continue to be mineral processing, extractive metallurgy, and hydrometallurgy. Their work thus far has involved treatment of laterite iron, nickel ore, inventory of technical data on foundry sand, the upgrading of low-grade nickel ore and manganese ore, use of NDT equipment in detection of welding flaws, magnetic separation of tjilatjap iron beach sand, and determination of concression factor on manganese ore.

The Institute is responsible for working with other laboratories on joint projects in order to avoid overlap. There is no work for private industry, as all mining is controlled by government enterprise. The Institute is refraining from promoting the large number of foreign companies now beginning to emerge in Indonesia until it has attained more experience.

National Institute for Instrumentation
Djl. Sangkuriang, Bandung

LIN is an instrumentation institute originally established in 1961 under MIPI. In 1965, it was awarded US$800,000 by the

Netherlands Government, which was extended in 1969 by an increase of US$140,000 in the grant. There are four divisions of LIN: Glass Blowing, Fine Mechanics Division, Electronic Division, and Education Division. Since 1967, LIN has been responsible for the repair, testing, design, maintenance and construction of instruments, standardization, documentation and promotion of the instrument industry. The Institute offers a six-month training course to technicians in industry and works to upgrade both equipment and technicians. LIN, as well, conducts seminars to disseminate instrumentation information. LIN has recently set up a calibration laboratory and has plans for a metrology laboratory. Some contracted services are in effect with industry.

National Institute for Electronics
14 Djl. Souringgaling, Bandung

The Institute is concerned not only with the use and maintenance of old equipment and systems but also the design and development of new equipment and systems. Presently, most attention is given to communication, extension networks to the villages, and equipment development. A continuous survey is conducted in order that the Institute may keep informed of the needs of various regions and any problems surrounding maintenance and supply that might have developed.

The Institute has had some offers to buy equipment designs by the government. Greatest interest and demand has been concentrated on communication systems between large cities and villages. Industry does not manufacture components, so that to date there have been few contracts for R&D. There is no appropriate patent mechanism to avoid illegal exploitation of the Institute's developments.

National Institute for Chemistry (LKN)

LKN was established by MIPI in 1962 and, through presidential decree, continued its existence under LIPI in 1967. It has three divisions: Division of Food Research, Division of Chemical Natural Resources and Division of Chemical Engineering. These are set up to carry out both basic and applied research, with emphasis given to work on raw materials and their utilization. The Institute conducts analyses for oil and sugar companies, and some testing for the glass and cement industries.

National Institute for Geology and Mining
Djl. Sankuriang, Bandung

The Institute operates within the framework of research and surveys ore mineral resources. Activities are largely mission-oriented in geology and mining. Some contracted services are undertaken, principally for government enterprises. Major problems related to development are identified through these activities and become the basis for further research.

The Institute is charged with responsibility for gathering, systematizing, and preserving the tremendous amount of scientific data on mineral resources that have been produced since 1967 by government as well as foreign companies. Other responsibilities include conducting studies on Indonesian mineral economics, forecast analyses of mineral exports in terms of time, existing resources,

discoveries of new mineral deposits, and development of substitutes (e.g., energy) that could threaten Indonesia's exports.

The Institute does not compete with the Indonesian Geological Survey which conducts testing and service. The Institute cooperates with the Oil and Gas Institute on a subcontract basis.

National Institute for Economic and Social Research
39 Djl. Gondangdia Lama, Jakarta

The Institute for Economic and Social Research is responsible for work in the areas of economic and population development. They obtain and provide data and materials needed for planning and are occasionally called upon for advice on specific problems.

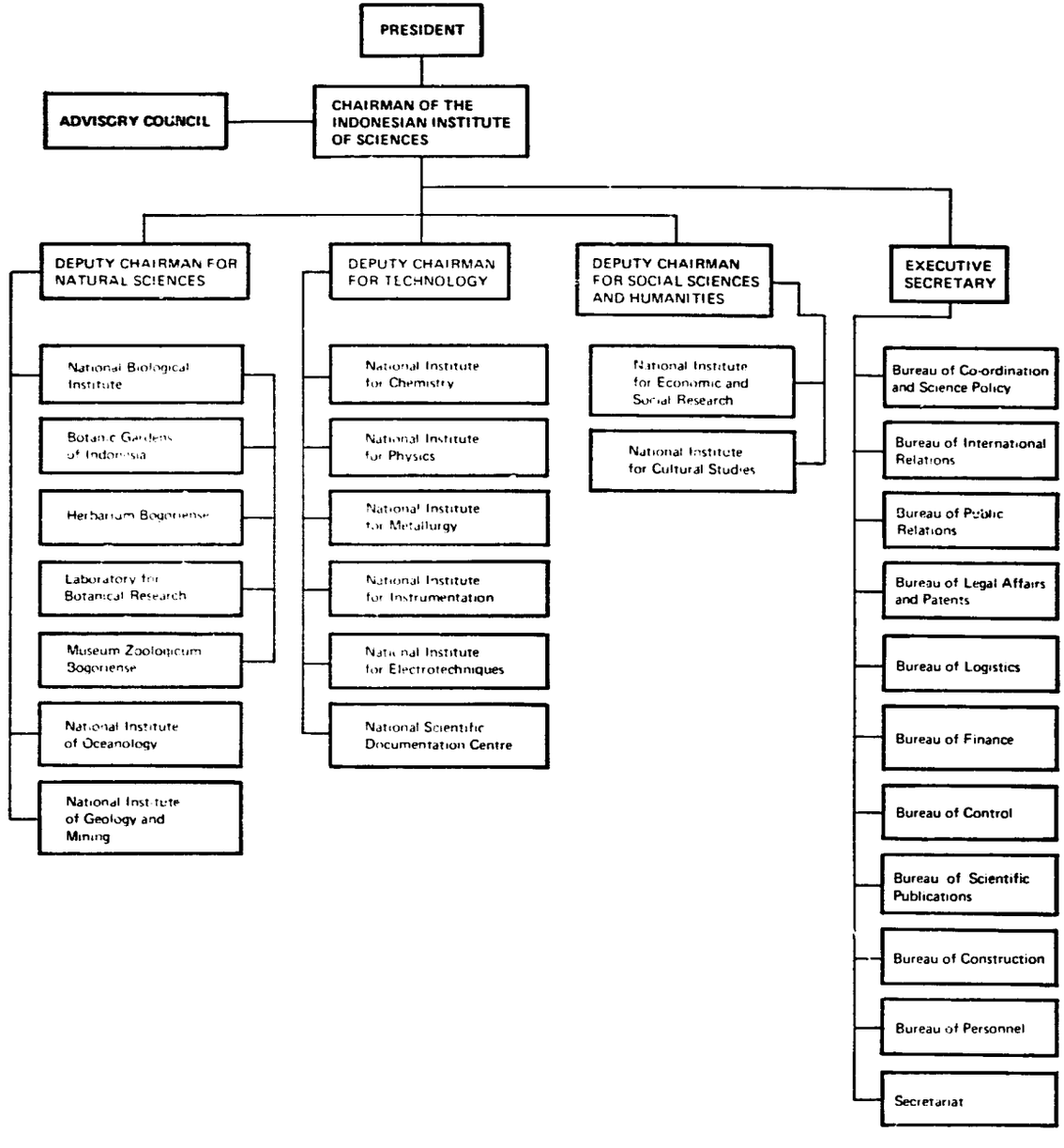
National Biological Institute
Djl. Ir. H. Djuanda, Bogor

The Institute consists of four affiliated centers which conduct research on a wide range of biological subjects including plants, trees, shrubs, herbs and animals. The centers are divided accordingly: Hortus Botanicus, Herbarium Bogoriense, Laboratory for Botanical Research, and Museum Zoologicum.

National Institute for Cultural Studies
3 Taman Pedjambon, Jakarta

The Institute for Cultural Studies works in close cooperation with the university conducting research on cultural aspects. Part of the research is directed toward providing a view of the life and values of national ethnic groups. Other research concentrates on the cultural traits of other nations, especially neighboring and developing ones, in hopes of contributing to a closer relationship with them.

INDONESIAN INSTITUTE OF SCIENCES
LIPI



Lembaga Penelitian Dan Pendidikan Industri (LPPI)
Institute for Industrial Research and Training
Jl. Tulodong Bawah 11/14, Blok. R.
Kabayoran Baru
P. O. Box 2802
Jakarta, Indonesia

Type: Under Ministry of Industry
Board: An internal board composed of Directorate Generals of the Ministry of Industry, e.g., textile industries, chemical industries, basic industries, light industries and handicrafts.
Director: Benito Kodijat
Staff: 1974: 800 administrative and technical personnel in all LPPI institutes.
Administrative Body For: 15 institutes and 26 educational institutions covering the areas of ceramics, leather, batik and handicraft, building materials, cellulose, metals, textiles and industry in general. LPPI also administers analytical laboratories to serve industry in Medan, Semarang, Surabaya, Ujung Pandang, Menado, Banjartaru.
Affiliations:
Linkages with various industrial associations in attempt to develop research associations.
Finances:
Funds come from international sources, government and industry. 1974-1975 development budget US$1,205,000; routine budget US$241,000.

LPPI consists of several single purpose institutes created to plan, establish and coordinate research programs needed for national development. LPPI, through its administrative structure and close working relationships with the Ministry of Industry Directorate Generals, provides linkage between institutes and regional industry. The original emphasis was on testing and some quality control for industry. Just before World War II, LPPI expanded its activities to include developmental research, dissemination of information, and training activities. After World War II, industrial and governmental interest was such that testing and information gathering became the only active services. With initiation of the first Five-Year Plan 1968-1974, LPPI again received pressure to expand its activities. Financial support was given in order to regain and improve LPPI research and development capabilities along with technical information service, testing and training programs. During the same period Indonesian industry experienced considerable growth, assisted by foreign investments (727 projects, US$3.4 billion) and domestic capital(1,963 projects, US$3.28 billion).

LPPI is responsible for standardization, quality control, process and product improvements, and technology transfer, particularly for industries under the purview of the Ministry of Industry. Large industries, financially able to do so, may seek technical assistance outside of Indonesia. The greater number of Indonesian industries however (80 percent) still must rely on indigenous sources of R&D to

strengthen their efforts for survival and growth. Research is conducted in the areas of sociology, economics and industrial technology. The institutes are presently more oriented toward practical problem-solving and troubleshooting for small- and medium-sized industries.

LPPI has established good rapport with industry by sending representatives out to promote industrial research, and provide technical assistance, either on a short- or long-term basis. Annual seminars are conducted to identify and discuss current problems of industries. Management development courses are offered by the institutes in various locations outside of Jakarta.

LPPI has been quite successful in seconding its technical staff members to industry for periods of time ranging from a few weeks to more than one year. Industry pays the staff member's salary plus institutional costs. The institute staff gain practical experience, are usually able to solve industrial problems, and continuing cooperation between the LPPI institute and industry is engendered.

LPPI's goals for the future are centered primarily on increased interaction with industry. Emphasis is being placed on industrial feedback and monitoring, while continuing and strengthening quality control, product and process development, and training programs. As a member of TECHNONET, LPPI is attempting to establish an Indonesian technical information network to serve industrial needs. LPPI is seeking to promote appropriate technology and technology alternatives for small-scale industries and for potential labor-intensive industries.

LPPI utilizes a salary incentive plan for institute staff in an attempt to at least partially offset the high rate of personnel loss to industry. LPPI personnel working on contracts (either industry or government), receive additional salary up to a maximum of $500 per month, and with a limit of assignment to no more than two contracts at any one time.

LPPI is presently undergoing reorganization as indicated on the revised LPPI organogram. Currently there is no plan to establish an office of coordination for the reorganized system, so that the current inter-institute relationships may be weakened or disappear.

Following are brief summaries of the institutes which comprise the LPPI system.

Cellulose Research Institute
Jl. Moch. Toha Km. 7, 4 Bandung

The Cellulose Research Institute is presently under the Director General of Chemical Industries.

The Cellulose Research Institute evolved from the rayon institute established with the assistance of the Federal Republic of Germany. The Institute conducts long-term research on the use of raw materials for newsprint and industrial papers, paper standards, rayon technology, and paper microbiology. Research is conducted at the bench level and carried through the demonstration plant phase, either in the Institute's pilot plants or in cooperation with industry. Specialized studies include work on brightness reversion, flocculation, deflocculation, drainage problems, refining and beating problems, and relationship between pulp composition and paper strength.

The Institute has developed a very high quality paper from non-productive rubber trees. The Institute cooperates with seven paper mills in Indonesia including technical assistance, seconding of staff to industry and undertaking industrial development projects. The Cellulose Research Institute is attempting to establish itself as the Regional Southeast Asian Center for Pulp and Paper, with pilot plants made available to industry and institute staff in other countries.

Chemical Research Institute
Jl. Ir. H. Juanda 5, Bogor

The Chemical Research Institute was established in Bogor in 1908 to test agriculture and forestry products utilized by industry and to monitor standards for export. The Institute is attempting to establish norms for compulsory product quality control, especially for agricultural products to be exported. Current research on agricultural products is focused on the national problem surrounding food and nutrition. Emphasis is concentrated in the areas of food technology and chemurgy of foods (carbohydrates, fats and oils, agricultural wastes), testing of food products, quality control, etc. The Institute is responsible for analysis and certification of essential oils. A separate pharmaceutical division conducts tests on cosmetics and pharmaceutical goods other than drugs, shampoos, soap, tobacco and cigarettes, to ascertain that these are non-deleterious.

Ceramic Research Institute
Jl. Jendral A. Yani 322, Bandung

The Ceramic Research Institute is responsible for transferring technology to industry, testing products, and disseminating information to consumers of ceramic products. Special studies have been undertaken on glass, vitreous enamel, refractories, clay products, lime, white ware and electric insulators. The Institute has successfully used industry-consumer workshops for identification of problems and needs which assists the Institute in planning R&D projects, and assists industry in achieving better understanding of marketing, financing, raw materials technology, and future product prospects. The Institute has been instrumental in formation of a Ceramic Industry Producers Association.

The Institute operates several demonstration plants, both to show process technology to potential users, and to adapt foreign ceramic technology to Indonesian raw materials, needs, labor and capitalization conditions, etc. Such services are usually provided to industry on a non-fee basis, although a schedule is being developed to provide such services and information on a licensing or fee basis.

The Institute attempts to coordinate and disseminate technical ceramic information to users, and cooperates with the laboratories of the Ministry of Geology and Mining in exploitation of Indonesian raw materials.

Batik and Handicraft Institute
Jl. Kusumanegara 2, Jogyakarta

The Batik Institute is responsible for conducting research in batik, silk, wood and bamboo technology. Their work has led to the modernization of production technology in handicraft of timber, silver

and bamboo. Under the sponsorship of the Batik Cooperative Association, emphasis is given to research on batik print and materials. The Institute also provides training courses to cottage industries on the batik process.

Industrial Research Institute
Jl. Karanganyar 55, Jakarta

The Industrial Research Institute carries on research dealing with chemical technology in the areas of agricultural products and others. It is responsible for having initiated and established compulsory product quality control within the region of Jakarta. The Institute also works on development of designs for simple production equipment, such as essential oil extractors and distillation units, adapted to rural area use outside the island of Java.

Leather Research Institute
Jl. Sokonandi 3, Jogyakarta

The Leather Research Institute works closely with industry on leather products and provides quality control and standards for exporting factories. They work through the Federation of Leather Association as well as directly with many leather factories. Transfer of leather technology is expanding as a result of a good institute marketing program. The Institute sends its staff into industry which pays the staff members salaries and living expenses. The government adjusts the Institute's budget accordingly. At present, 11 people are seconded for periods from a few months up to four years, depending on industry needs. Demonstration plants and simulation facilities on the factory level are capable of dealing with management and production problems as well as technical needs. The user-industry pays the processing fee for raw hides from small producers. In all other cases, the Institute provides the service for a fee until the producer is able to obtain equipment and operate a plant.

Institute of Textile Technology
Jl. Jendral A. Liani 318, Bandung

The Institute of Textile Technology is under the Director General of Textile Industry.

The Institute of Textile Technology was established in 1966 to carry on research and development of textiles, establish standards and quality control procedures, and conduct education and training. In applied research, emphasis has been given to practical experience and demonstration processes. Research has been conducted on spinning, weaving, knitting, and finishing, using natural fibers, half synthetic fibers, or synthetic fibers. Work has primarily centered around changing 100 percent cotton to blends of synthetics.

The Institute has developed contact with industry through its assistance and training programs as well as through its research projects. Institute staff members are assigned to textile factories to provide technical assistance. Since most texti factories are very small, difficulties are often encountered in transferring technology, particularly where change in use of fibers is concerned. The Institute conducts a cotton grading course, offers a five-year M.S. level course in textiles, and a one-year course for technicians (machine operators, graders, etc.). Factories request and pay for special classes in textile technology.

The Institute operates a pilot plant of 30 looms, 8,000 spindles, knitting workshop and spinning lab. These demonstration plant facilities are particularly useful for training personnel of small-scale industries. The Institute produces yarns and some textiles to sell. They have developed a hand loom and a power loom which is now being manufactured by a local industry.

Materials Research Institute
Jl. Sangkuriang 10, Bandung

MRI was created in 1912 to conduct testing and applied materials research. The laboratories undertake tests for mechanical, physical and chemical properties of metals, alloys, and many classes of building materials. The majority of such testing is currently for industry, although government entities such as the Air Force, Maritime Service, etc., also make extensive use of MRI's services. The Institute is contracting with cement and fertilizer industries, tire manufacturers and others to provide QC services in order to meet quality production standards adopted by the Industrial Associations (and drafted by MRI).

Applied research has been conducted on the technical characteristics of Indonesian cast iron foundry industries, on the comparison of Indonesian and foreign maritime paints, composition of concrete aggregates, use of Indonesian woods in maritime construction, etc.

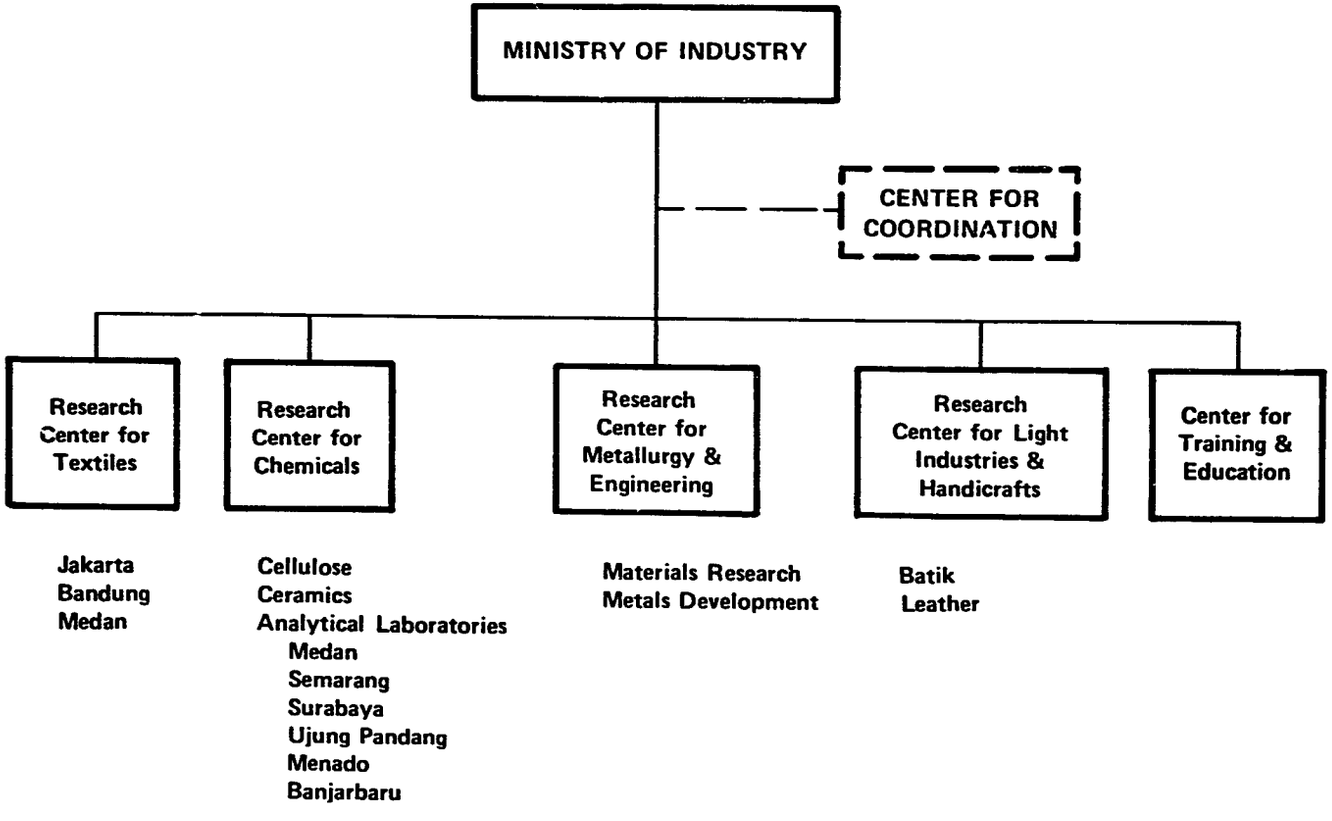
MRI works closely with LPPI's Metals Industrial Development Center, MIDC being concerned with processing of materials while MRI is concerned with the testing of materials. MRI is in the process of extending its activities to become the materials testing and standards development center for Indonesia, with branches in industrial centers other than Bandung.

Metals Industrial Development Center
Jl. Sangkuriang 10, Bandung

The Metals Industrial Development Center is under the Director General of Basic Industry.

MIDC works in the area of metal processing technology and operates as a development service to industry. Activities of the Institute include consulting, problem-solving, training, in-house research (industry-wide), and contract research applied to specific problems. Initially, concentration was placed on building construction. Now expertise is offered in the areas of casting, plastic forming, machining, welding, heat treatment and electroplating. MIDC works in cooperation with MRI, the Materials Research Institute. MIDC will develop the process, such as production of steel rods, and MRI will test the product, establish necessary standards, and advise industry.

Technical evaluations have been conducted on the galvanized steel industry, capability of machine tool industry, and rehabilitation of foundry parts for textile machines. MIDC has conducted X-ray inspection of welded components in cooperation with the Air Force. MIDC conducts a variety of industrial seminars on topics such as foundry, agricultural machines, machine tools, metrology, welding, metal forming, manufacturing techniques, etc.

The Institute plans to subcontract work from industry to produce commercial quantities of products such as pumps, with the objective of improving the quality of the product and demonstrating process parameters, quality control (with MRI), etc.

REVISED ORGANIZATION OF
LEMBAGA PENELITIAN DAN PENDIDIKAN INDUSTRI (LPPI)
INSTITUTE FOR INDUSTRIAL RESEARCH AND TRAINING