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INDUSTRIAL RESEARCH AND SCIENCE AND TECHNOLOGY FOR DEVELOPMENT

A WORKSHOP IN PREPARATION FOR THE 1979 U.N. CONFERENCE

INTERNATIONAL SCIENCE AND TECHNOLOGY INSTITUTE, INC.

INDUSTRIAL RESEARCH AND SCIENCE AND TECHNOLOGY FOR DEVELOPMENT

A WORKSHOP IN PREPARATION FOR THE 1979 U.N. CONFERENCE

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EXECUTIVE SUMMARY

The United Nations has scheduled a Conference on Science and Technology for Development in Vienna in August, 1979. In support of this Conference, the United States is undertaking a number of activities aimed toward clarifying the various agenda items and laying a firm foundation for its national role in the Conference. The Workshop reported here, on Industrial Research and Science and Technology for Development, is one of these activities.

The Workshop participants, consisting of senior research managers from 21 U.S. corporations, nationals of several countries, and representatives from five Federal agencies and several private non-profit organizations, met to discuss the fundamental issues affecting the present and potential linkages between corporate R&D organizationa and the developing countries. The action conclusions reached during the Workshop discussions can be summarized as follows:

I. It is technology that is of primary importance to development. Science at work is technology.

II. Private enterprise is the primary source and owner of industrial technology in the United States. Mutual benefit and self-interest is the only sound basis for sharing or transferring this technology.

III. U.S. industrial enterprises are a major current source of technology flow to the less developed countries. This flow should be encouraged and guided, but not impeded.

IV. Barriers exist which inhibit and impede the flow of technology from U.S. industrial firms to the developing world. The UN Conference can be a useful forum for promoting recognition of these barriers and suggesting means of reducing them. Lack in the less developed countries of appropriately trained and educated people is a specific, major example.

V. American industry is very conscious of the fact that it is "walking on the edge of the sword" when it transfers technology to a less developed country. Every technology recipient is a potential competitor. Yet, such transfer continues.

VI. American industry sees substantial opportunities in R&D related to the developing countries. Examples include exploitation of processes that may not be competitive in this country, e.g. production of commercial chemicals from agricultural by-products, which here cannot compete with petrochemicals; development of drugs aimed at health problems in the developing countries, which may include diseases we don't experience in the U.S.; development of herbicides and pesticides for tropical agriculture; agricultural field research which can be accelerated

by the availability of 3-4 growing seasons in one year; and research on quality control of raw materials that might best be done in the countries of their origin.

VII. Technologies which cannot compete in the U.S. market may be answers to problems in the developing countries. These may be either newly developing technologies, such as explosive cladding of stainless steel sheets on mild steel, or older technologies, such as the kettle process for making soap.

VIII. U.S. industry is inherently attuned to the concept of "appropriate technology." And there are problems with implementing it.

IX. Industry sees significant ways to contrubute through its R&D capabilities to the less developed countries. ITT's Fundacion Chile is a leading example.

X. U.S. industry sees virtues in an expanded Government role in this field. It particularly would appreciate help in identifying opportunities.

1. INTRODUCTION

The role of science and technology in the development of the countries of the Third World is a topic of increasing national and international interest. Internationally, the United Nations Conference on Science and Technology for Development (UNCSTD) will convene in Vienna next August. Domestically, the United States and other nations have been engaged for many months in preparation for this Conference.

One of the activities undertaken by the U S. government in preparation for UNCSTD is the Workshop on Industrial Research and Science and Technology for Development that is the subject of this report. This Workshop took place in Arlington, Virginia, on November 8-9, 1978. It was managed and hosted by the International Science and Technology Institute, Inc., under the sponsorship of the Office of Science and Technology of the U.S. Agency for International Development, with the cooperation of the Industrial Research Institute, Inc. (I.R.I.).

The first item on the Workshop agenda was provision of a background overview of the current situation in the field of science and technology for development. This was followed by discussion sessions designed to bring out from all participants the maximum possible amount of insight regarding this field. The final item was a summary reporting and discussion session to develop a sense of consensus around the results of the day. This report is similarly subdivided, with sections 2, 3, and 4 presenting the results from these three sections of the agenda. Section 5 is the overview background paper that was provided to all workshop participants. Sections 6 and 7 present the Workshop agenda and the list of participants.

The points of view contained herein are the reasoned judgements of individuals, not of corporations or agencies, who have kindly shared their opinions as a means of providing counsel to the Office of the U.S. Coordinator for the United Nations Conference on Science and Technology for Development. We owe a debt of gratitude to each and to their corporations or agencies that permitted and encouraged their attendance. In general, specific references to specific companies or other institutions have been omitted during the editing process. However, ITT and Fundacion Chile were of such central interest during the discussions that explicit reference to these two organizations seemed imperative; we are indebted to ITT for permission to make such reference.

2. BACKGROUND OVERVIEW

Highlight excerpts from the several background overview papers are presented in the subsections that follow.

2.1 Motivation for Workshop (R. C. Sangster, National Bureau of Standards).

The Workshop originated with a suggestion to the AID office of Science and Technology in June, 1978. The origin of the suggestion was the observation that the industrial research and development community of this country was a huge and very valuable source of science and technology for the industrial development of the nations of the Third World, that seemed to be relatively little involved in any formal way so far in the U.S. preparations for UNCSTD. The short-range motivation for the Workshop was to draw this community more explicitly into the U.S. preparations for UNCSTD. The longer-range motivation was to stimulate greater actual involvement by this community in contributing to development of the less devloped countries (LDCs).

2.2 The Challenge of Science and Technology for Development (Mr. Charles Dennison, Executive Director, Council on Science and Technology for International Development)

The subject of science and technology for development has come into its own. The task for your workshop is to explore the linkages between the U.S. research and development capability represented by the Industrial Research Institute and the requirements of the developing countries and to learn how to assist these countries to make the best of their technology and to improve their indigenous capability for technical advance.

I define science to mean the discovery and dissemination of new knowledge or truth for its own sake. Technology is the application of knowledge and the solving of problems, the creation of useful, valuable products and services, in effect, the creation of wealth.

In a recent review by National Security Director Brzezinski, he emphasized that the worldwide awakening of peoples who have recently entered the international system is changing the fundamental structure of international affairs. The nearly total decolonization of the last three decades has caused pressure from the released peoples for participation in the world system and for a greater share in the distribution of wealth, power, and influence. The OPEC petroleum action in late 1973, with the quadrupling of oil prices plus the embargo, constituted a sudden, unprecedented geo-political shift in power. This geo-political stroke has been accentuated by the dispersal of nuclear and

industrial capacity about the world, raising the question of nuclear proliferation with its threat of war. These developments occur in the midst of a demographic surge illustrated by two sets of figures: Between 1900 and 1950 the world population grew by 900 million. Between 1950 and 2000, it is expected that the comparable figure will be 3.5 billion. The compounding of these factors leads Dr. Brzezinski to the conclusion that these global circumstances cannot be accommodated within the existing world system or its institutions. He states that our objective is to make the United States more relevant to global change. I suggest that the charge of making the U.S. relevant to needed global change serves as the core reason why this workshop is important to the Nation's affairs and to the interests of corporations and institutions represented here. It is the key long-term reason why the U.S. should take a constructive innovative stance at the 1979 UN Conference.

In the U.S. role of peaceful management of global change, our capacity in science and technology, medicine and management are among our strongest assets. Consideration of the situation facing the industrializing nations suggests that the type of stagnation found in the industrial societies may not be merely a passing cyclical manifestation. Many hold that if this analysis is accurate, we really must reconsider the interdependence of the industrial and the developing nations The greatest untapped potential area for economic expansion obviously lies in the unsatisfied needs of the three-quarters of the world's people in the developing world. For years the developing nations as a group have sought a larger share in the international economic system. These demands culminated in the call for a New International Economic Order based on "equity, sovereign equality, common interest, and cooperation among all states."

As Albert Fishlow of Yale observes: "the private sector of the developed countries... is the most prominent means we know of transferring technical knowledge and managing capacity and diffusing modern industry.... Yet, direct foreign investment continues to be viewed with suspicion and resentment as an inadequate instrument for making available to the South the technological capacity of the North." The U.S. cannot and should not underestimate the extent and depth of developing countries' resentments and demands. Much of the concern is aimed at the availability, cost, transfer, and use of technology. An issue of signal importance in this volatile North-South relationship is how we can make more sensitive, thoughtful use of this nations' exceptional industrial research capabilities in the development process of those countries that wish to collaborate with us. This is a process of individual country negotiation, and the business of this Workshop is to see how our industrial R&D resources can be used in a mutually acceptable fashion to assist in the development process.

Some State Department data on how U S prosperity has become increasingly intertwined with the growth and stability of the less developed countries:

Trade: In 1977 the LDCs (less developed countries) bought merchandise woth $42 billion, 35% of total U S exports. The LDCs bought 40% of all U.S. exports of manufactures in 1977, more than Western Europe, Japan, and the Communist countries combined. The U S. imported goods worth $67 billion from the LDCs in 1977, 45% of this total, $31 billion, was for energy products from the OPEC countries Over the last five years, the LDCs have provided 25% of the U S. raw material imports on which our industrial machine runs. Between the early 1970's and 1977, sales of U.S. goods to the LDCs grew by 22% a year, compared with 15% growth of our sales to the industrially developed countries

Investment: Nearly one-half of total U S receipts from foreign investment and related items came from the LDCs in 1977 The stock of U.S. direct investment in LDCs amounted to $29 billion at the end of 1976, or 20% of the world total of U S foreign direct investment, but was the source of 47% of our earnings from private investment overseas.

The developing nations have a need for investment, technology, and management Imaginative proposals for mutually acceptable use of our industrial research skills in development can improve the climate for investment while assisting the countries concerned The usual role of science and technology in development is country-specific, project-specific, gradual, and builds on its successes. It can provide a lasting inbuilt capability for ensuring the nation's economic advance and participation in the international economic system The realistic progression should be Engineering, Development, and Research--E, D, and R This is a painstaking long-term process, but it does offer many opportunities for American companies to do far more than they have been doing. It is in the U S. interest, and in the interest of corporations who wish to stay in the international field, to contribute as many specific industrial research gains as possible in countries where they are wanted What we do abroad should enrich and strengthen our P&D in the U.S.

We have an opportunity in the 1979 UN Conference to take a constructive stance in a meeting devoted to fields of endeavor in which we excell The Conference and the process of scientific technological advance provide an occasion for the nation and its industry to exercise constructive leadership in the peaceful management of change

2.3 The Role of Science and Technology in Development: Needs, Opportunities, and Constraints (Mr. Henry Arnold, Director, Office of Science and Technology, Agency for International Development).

I welcome you to this Workshop and welcome the opportunity to explore with you the ways in which your Industrial Research, Development, and Engineering Laboratories can become profitably involved in improving the lot of the poor and middle income countries.

In a larger sense, almost every major problem plaguing the U.S. today involves the developing countries. The very best science and technology that the world can mobilize is essential to meet the mutual world problems which, to an ever increasing extent, will determine the future well-being of all of us. First, there is the overriding problem of *burgeoning population*. The world must use every skill available, including those of the private sector, to keep unrelenting pressure on this problem. Second, there is the problem of *global food shortage*, which, at the moment, may be largely a problem of distribution The only apparent answer is to increase local production and distribution in the developing countries. U.S. research and technology have a major role to play. Next, is *energy and natural resources*. It is obvious that developing countries, starting from a very low rate of energy usage, must find additional energy despite the relative rigidity of the world's available supply, if they are to enjoy economic growth. Nor can one doubt the need to match the skills of the U.S private sector with the resources of the developing countries in order to minimize growing world-wide competition for resources. And finally, *trade* with developing countries has brought substantial benefits to the U S.--greater than most of us realize. In a recent address, Governor Gilligan, the Administrator of A.I D., stated:

> "The development potential of markets for American products throughout the Third World almost defies description within 20 years, there will exist in developing areas of the world almost three billion people who will need nearly everything the United States can produce. Their problem--and ours--is whether or not their economies will have developed to the point at which they can afford to buy the things they want and need."

The opportunities for science and technology to contribute to the welfare of this world of growing interdependence by assisting the development process in developing countries include, from the viewpoint of your company's management (and its shareholders), opportunities *to expand the exports of products and processes* to the growing populations of the developing countries; *to enhance your access to raw materials* by sharing the concerns and supporting the countries' development efforts, *to expand exports of R&D* by improved knowledge of and greater sensitivity to the needs and

conditions of the developing countries--given the broader range and different character of these needs, it should be possible to convert more of the results of your R&D into sales--for example, processes suitable for small-scale production or those requiring considerable labor may not be profitable in the U.S. but uniquely suited to developing country needs; and *to explore the climate for cooperation* with developing countries--company sponsored research or development leading to the solution of problems peculiar to a developing country could have a dramatic beneficial impact and public relations value, so that it could be worthwhile even if no specific business potential is foreseen.

In dealing with developing countries, both sides tend to underestimate the differences between "North" and "South". Technology needs to be matched to the conditions in the developing countries, and these are not always apparent. A simple transfer of U.S. technology is unlikely to be effective and may, indeed, have an overall negative effect. Most developing countries are short on scientists and engineers and especially technicians. Often their formal training in science and even engineering is directed toward academic goals rather than problem solving in the real world. Management and entrepreneurial talents are in equally short supply. Any successful venture, whether a government project or private enterprise, must face up to this lack. The governments of developing countries often intercede in private transactions to a greater degree than in the U.S. Where the risks are too high, governments (theirs and/or ours) will need to share them.

At this Workshop and during the ten months between now and the UN Conference, we hope to explore with you the feasible roles and relationships of the private and public sectors. To that end, I warmly invite your comments.

2.4 Remarks by James Stromayer, U.S. Deputy Coordinator for the UN Conference on Science and Technology for Development, Department of State.

The UN decided to have a conference on science and technology for development, about two years ago. One motivation was that the developing countries felt that a better application of science and technology could accelerate their economic and social progress and thereby enable them to achieve greater self-reliance in fulfilling the needs of their people. Another was the feeling that better application of science and technology could contribute to a resumption of the high rates of economic growth achieved in the 1960's.

If you consider *science* as knowledge, and *technology* as the application of knowledge to the production of goods and services, these two subjects in themselves are awesome in their scope. If you then tack on the word *development*, you have three subjects

embracing virtually all the experience and knowledge of mankind. Then when you consider that at Vienna in 1979 there will be something like 150 countries to concert their thoughts on these subjects in two weeks, it is a very difficult challenge to know how to focus the discussion in a sensible way with a view to yielding beneficial results, not only to the United States, but to the world at large. This is the organizing task before us.

In recent years the dialogue between the developed and the developing countries has often been marked by rhetoric, polemics, and confrontation. An important political challenge of the Conference is to set the content and tone of the debate on a constructive, realistic course that will yield the maximum practical results with a minimum of rhetoric and acrimony. A pattern of collaboration and consultation in science and technology can have a positive influence in establishing cooperative habits that can strengthen and enrich our overall political relations with the developing countries. Another political challenge of the Conference relates to the viability and utility of the UN system itself. To show that the UN can successfully manage a world conference on science and technology and development, with beneficial results for all participants, would strengthen the UN's confidence and its ability to meet the challenges of the future.

In the economic sphere, *first*, there is the challenge *of meeting the basic human needs of over one billion people who live in conditions of abject poverty.* The goals of the Conference should, therefore, include overcoming the worst aspects of poverty by the year 2000. *Second*, it must be recognized that without self-reliant economic progress within the developing countries, and without a more equitable sharing of the fruits of economic progress among all nations, the issue of poverty cannot be addressed. Therefore, *advancing the economic growth of the developing countries* should be a major goal of the Conference. *Third*, in an interdependent world, poverty and economic underdevelopment in individual countries cannot be effectively overcome unless global measures are pursued *to deal more effectively with global pressures on food and water, energy sources, raw materials, population growth, and the environment.*

American development assistance reflects a conviction that economic rights are an integral part of human rights and that economic aid to other countries must help to restore these rights. The meeting of basic human needs can, of course, best be accomplished within economies that are themselves strong and vigorous. U. S. policy accepts the premise that one element of encouraging the growth and expansion of the economies of developing countries and of achieving greater equity involves strengthening their scientific and technological capabilities. President Carter has expressed the policy objective of making scientific and technological cooperation with developing countries a key element in our relationships. As one means to achieve this objective, the President has proposed a new Foundation for International

Technological Cooperation (FITC) as part of our development assistance and cooperation programs with developing countries. Such cooperation should provide for working with upper- and middle- income developing countries as well as low-income countries. Another area that should be an important component of our position is improved mechanisms for exchanging information on science and technology. The foreign policy objective of cooperating with other countries in these fields reflects a strong world-wide interest in dealing with problems which increasingly affect the quality of life of present and future generations.

2.5 Remarks by Clint Stone, Planning Staff, Foundation for International Technological Cooperation.

FITC is an entity which has yet to be born, and this embryonic organization does not yet have a clearly discernable shape. It has long been recognized that the application of science and technology to development has characteristics which differ from the supply of commodities and services entailed in bilateral development assistance activities. The feeling persists today that science and technology have not been fully integrated into nor achieved their full potential in bilateral and multilateral assistance activities. There is a great deal of knowledge and skills in this country which should be part of the U.S. address to development problems.

The President announced the intent to establish a Foundation for International Technological Cooperation in a March, 1978 speech to the Venezuelan Parliament. The Planning Office for FITC came into being in August of this year. It was incumbent upon this office to provide an initial document by October 13, 1978, with sufficient specifics to enable budgetary review. The Office of Management and Budget is currently reviewing the concept and budget. This will be followed by White House decisions on the larger matter of the reorganization of U.S. foreign assistance.

Science and technology in this country is a rather complex system involving universities, industry, government, the media, and the public. Our society has many interactive linkages which result in the application of science and technology to societal needs and activities. Imperfect as this system is, its equivalent is not often present in developing countries in any significant way. Efforts to improve and increase the application of science and technology to development must recognize the context in which they will take place.

It is intended that FITC be responsive to the goal of increasing developing country capabilities to carry out research and analysis as well as to establish systems for application of the results to economic development. Both in the planning stage and in the ultimate search for problem solutions, FITC will seek

major involvement by developing country individuals, institutions, and governments. The broad topics which we judge as important to the developing countries and which appear amenable to science and technology inputs are:

- Increased rural productivity.
- Diseases of developing areas
- Reducing population growth rates.
- Improvement in developing countries' technological skills.
- Information and communications.
- Non-agricultural employment.
- Environmental planning and natural resource management.
- Energy planning and new energy supplies.
- Nutritional improvement in poor families.

2.6 The Realities of Joint R&D in Developing Countries (Mr. James P. Blackledge, Associate Director, Denver Research Institute, University of Denver, Denver, Colorado)

The more than 200 research institutes in the developing countries are the logical linkage for joint R&D. The majority of these institutes are government organizations and receive principal financing from the governments. The institutes have been in existence anywhere from 10 to 20 years, are usually well-equipped, and the people are well trained. These institutes were created by their governments with the principal objective of assisting in their nation's industrial and economic development. It appears, however, that in a large number of instances, such desired interaction has not taken place. The research institutes find themselves often without appropriate guidance.

In a number of countries industry has a very suspicious attitude regarding involvement with the research institutes because of the institute-government relationship. Since it is infrequent that research institute staff will have prior industrial experience, these staff members seldom know how to communicate with industry. Industry in turn tends to regard the research institutes as "ivory towers" and feels that is often more appropriate, where possible, to acquire technical assistance or proven technology from abroad, rather than to utilize the services of their indigenous research institutes.

One of the ways that USAID has been attempting, over the past ten years, to ameliorate this situation, is to establish linkages between research institutes in developing countries and those in the developed countries. The approach that we have used is one of trying to teach the people in the institutions how they can conduct contract research for clients. We have to teach them how to write a proposal, we have to teach them how to manage research, we have to teach them how to write a report that their client will understand and to provide results that the client will be able to use. We have helped them to establish technical information

centers. We have guided them in methodologies to transfer and adapt technology. We have provided opportunities for training, both in their own countries and in the United States, in the laboratories of the Denver Research Institute and in industry and government laboratories. We frequently use experts from industry in these training and joint research programs. We have made a point of insisting that the expert and his counterpart from the research institute visit industries and meet with industry officials to explain the nature of the problem, to attempt to ascertain the actual demand on the part of industry, and to solicit, to the extent possible, involvement by industry in the proposed project.

I think there are several possible mechanisms to help the industrial research institutes in the developing countries which I would like to present for your consideration. First, there are many opportunities to train LDC research institute people in the U.S. industrial laboratories to a much greater extent than has been practiced in the past. The other mechanism is to send people from your research laboratories to the developing countries for varying periods of time to work with people there on joint research projects. I would not be at all surprised to learn that your research people would return to their laboratories in the United States with new and different ideas acquired while undergoing their experience in the developing country. I think that you will find that people in the developing country, with the proper direction, can be pretty good researchers. You will find that they know how to do laboratory research, although they do not yet know how to manage it. Therefore, I would recommend that you consider very carefully establishing linkages with institutes in the country where your particular industry has a permanent or potential or current interest. The one thing that the U.S. industrial infrastructure can contribute to, in a measurable way, is to help these institutions increase their ability to impact on industrialization, thus in turn having an impact on employment and increasing the quality of life.

2.7 Real Problems in Technology Transfer for Development (Dr. George S. Hammond, University of California).

I have formulated the following list of problems encountered in the transfer of technology to assist implementation of changes in the less developed countries of the world, because I know that the problems are real and because they are the ones on my mind at this time.

1. Understanding the meaning of the subject
2. The relationship between science and technology.
3. Technical problems in transfer with adaptation.
4. Suitable manpower to implement programs.
5. Other resource problems.
6. Recognition of goals of involved parties.

7. Financing.
8. Time scales.
9. Variations in laws, government positions, and common local practices.

Understanding. The only words in the phrase "transfer of technology for development" that do not have very different meanings to different people are "of" and "for". Some people use the term *technology* to refer only to industrial manufacturing. To me this seems a grievous restriction in terminology because it ignores or denies large technical contributions to such areas as the evolution of medical care, improved agricultural practices, and communication and transportation systems. One unfortunate consequence of this misunderstanding of technology is the fact that opportunities for effective and beneficial transfer of technology in the areas where it is easiest are often ignored because consideration of the entire subject is preoccupied with debate about the toughest parts of it. The term *development* is just as confusing as the others. About the only thing that people's notions have in common is that the term implies some kind of change. The confusion and emotional conflict concerning what should be implied by the term *development* are a source of frustration to a technical person working to do a job in a development program. He or she can usually rest assured that some people will consider the work to be useless or even malevolent.

Science and Technology. A particularly egregious area of misunderstanding is the relationship between the two. *Science* is the study of the behavior of things, living and nonliving, in the universe and the accumulated knowledge and understanding derived from that study. *Technology* relates to the practices that people develop in dealing with the universe. Modern technology is heavily influenced by scientific knowledge. It is not simple to draw a dividing line between science and technology, because there is none. However, in the extremes, they are very different kettles of fish. Unfortunately, the phrase "science and technology" has been used so often that people begin to treat the phrase as a single substantive with unfortunate consequences.

Technical Problems in Transfer. The notion that a specific technological operation can be successfully transported *in toto* from country A to country B has been explored many times over. In brief, a transplanted technology even under foreign management must couple to the local society. This changes the ground rules for successful operation in many ways, even including change in the characteristic properties of the output products.

Manpower. Politicians can make all sorts of agreements to exchange science and technology, but it will not work unless there are people who are willing to cross national borders, work under unfamiliar circumstances, and undertake high risk ventures. The staying power of volunteer workers is usually poor. Most governments do not attract many professional technical people to

their foreign services. Transnational corporations are unable to enter into many important fields of international technological activity and are currently under strong attack for their performance in the fields where they are prepared to function best. I conclude that there is a manpower vacuum which no one is prepared to fill.

Resources. It is little more than a truism to say that a country must find some indigenous resources to contribute to its own technological development. The truism becomes a thorny problem when examined in detail.

Goals. All kinds of cooperative human activity run into trouble because the participants have hidden agendas which keep them ill at ease and functioning with reduced efficiency. The fact is that all people force themselves into corners where they appear hypocritical if they do not make some careful inventory of their goals when setting up large and complex programs. Discussion of all goals, more or less noble, will help people to keep minds on the real problems when the going gets rough rather than leading to an ascerbic exchange about hypocrisy. The gathering of status symbols may be a harmless activity, but can be destructive if the symbols consist of expensive equipment that sits idle. One of the motivational mistakes is based on the common behavior of small companies in the past which were often preoccupied with the drive to get in and out fast with a profit. The same image has been transferred to corporations with large foreign installations but doesn't fit. In reality the future of major foreign enterprise is so tied to the growth of a developing country that the multinational has a real stake in national growth.

Financing. A reasonable supply of money is required to make significant progress in international development programs. Simple analysis of economics indicates that there never will be enough money from the developed nations to provide what some from the developing countries want, that is, instant parity. It also takes no genius to see that there will be some reluctance of the richer countries to invest much in countries where population growth is so rapid that failure *seems* almost inevitable. It is likewise easy to see that a country such as the U.S., which is in trouble because of adverse balance in payments, is not going to be eager to increase concessional foreign aid. A logical substitute for concessional aid would be formulation of plans whereby the donor country can recover its investment from successful joint operations in some kind of profit sharing plan. Such plans are hard to negotiate in ways that are fair to all parties. Two contributing factors to our relatively poor performance are: (1) our traditional pose as philanthropists, and (2) the fact that our government by tradition and law leaves most of the negotiations to private firms.

Time Scales. A perpetual problem in development is the urgency of the matter. Unsolved problems of disparity in balance of payments, increasing poverty, and the technology gap worsen at alarming rates. Unfortunately, the sense of urgency stimulates hasty action that increases the incidence of failure and wastes resources. The present state of affairs in technically advanced nations has evolved over periods ranging from several decades to a couple of centuries and has involved periods of grinding poverty along the way in most, or all, cases. The present explosive situation in much of the Third World seems to demand an alternative to the historical process of development that has not yet been conceived.

Variations in Conditions and Ground Rules. The people of the world play by many different rules. Laws and cultural dictates vary enormously. Fundamentally sound technology may be rejected by a culture and the successful introduction of new technology inevitably changes the culture in which it is introduced. Poverty itself produces some cultural features which most would agree should and will change if poverty is abated. The cultural by-products of affluence are not all desirable, but most poor people seem willing to take their chances with them. Behavior which is accepted as ordinary in one society is unacceptable or misunderstood in another. In the course of reaching a state of rapprochement with a few counterparts in another country we may pollute them in the eyes of their compatriots and ourselves in the eyes of our own countrymen, an insecure basis for seminal activity An example often cited at this time is the prohibition by law of what we call bribery in international activity However, in some countries very low pay of public officials is expected to be augmented by "commissions" which our businessmen are forbidden to pay. My sense of right and wrong is consequently subject to some strain.

3. HIGHLIGHTS OF WORKSHOP DISCUSSIONS

The essence of this report is contained in this section, in the quotations from the Workshop discussions. These quotations are often exact, but sometimes paraphrased slightly to improve the English or to omit explicit references to specific companies or countries.

The Workshop discussion sessions employed the "cybernetic session" technique developed by Hall and Dixon of the National Bureau of Standards. The essence of this technique is a "mix and mingle" process, whereby periodically during the discussion, half of the participants at any given discussion center get up and leave that center, dispersing pseudo-randomly to the other discussion centers. All participants have the opportunity to discuss all of the defined discussion topics, and none stay for an extended time at any one discussion center. Everyone has a chance to interact with everyone else in the group, at one time or another. The technique is explicitly designed to draw forth all possible points of view and differences of opinion. In the present case, four discussion centers were used, focussed on:

A. *Opportunities* for U.S. companies in R&D for LDCs.
B. Potential *Contributions* to LDCs of U.S. industrial R&D.
C. *Mechanisms* to link U.S. industrial R&D with LDC needs.
D. *Obstacles/problems/solutions* to U.S. industrial R&D for international development.

A discussion facilitator and rapporteur was assigned to each discussion center. Also, tape recorders were used to capture the discussion verbatim. During the coffee break following the discussions, the rapporteurs arranged their notes and their thoughts. In the final summary session of the Workshop, they made brief presentations to the total group, summarizing the results of the discussions at their centers. In the following total group discussion, a sense emerged of general consensus and agreement concerning the results of the days proceedings.

Following the Workshop, the tape recordings were transcribed. These transcriptions were then dissected into segments dealing with specific, relatively narrow subjects. These segments were then sorted and arranged, to get all of the discussions on a given subject together and to present the different subjects in orderly groupings and an orderly sequence. It is characteristic of the cybernetic session technique that, no matter how the different discussion centers and topics have been defined, everybody ends up discussing much the same thing at each center. Therefore, the major groupings of the subjects actually discussed are best determined empirically, and they often bear little resemblance to the topics assigned to the different discussion centers.

The rearranged, ordered transcription of the discussions was then studied to determine the action conclusions that were either explicit or implicit in the discussions. The text that follows presents these action conclusions, followed by selected quotations from the discussions that serve to support or amplify the given conclusions, and which display the vitality and sparkle that was present during the Workshop discussions The facts, opinions, and points of view presented should enhance and contribute to both the development of the U.S. positions for the U.N. Conference on Science and Technology for Development and the planning of the proposed U.S. Foundation for International Technological Cooperation.

I. It is technology that is of primary importance in development. Science is of limited intellectual value in development unless it is applied. Science at work is technology. Science at work in the production of useful goods and services is industrial technology.

"Knowledge is not sufficient. It has to be applied. And the way you apply it is through industry. So if there is no industry, and nobody starts an industry, nothing happens. A product or service has to fall out."

II. Private enterprise is the primary source and owner of industrial technology in the United States. Governments can encourage or discourage flow of this technology to the LDCs, but cannot compel it. Industrial technology is a major national and private resource, not lightly to be given away. Mutual benefit and self-interest is the only sound basis for sharing or transferring this technology. For private enterprise, profit in one form or another is the prime motivator.

"I get the impression that Government thinks that technology is theirs, to be given or bartered away. Generally, they don't have the rights to the technology. Private enterprise does. In general, access by the LDCs to this technology has been by a bilateral agreement by a specific company in this country and a specific organization in another one. It is not something that you can talk about in the generality of transferring our technology."

"Highly placed people in the I.R.I. community are concerned about the U.S. government passing on technology of some value, forgetting that one of our great resources is science and technology. The companies are oversensitized by regulations of all kinds, to the point that they are afraid that they are going to be forced to give away some of this know-how, to uplift the LDCs."

"The basic incentive for industry has to be profit. We tend to talk around this and hide it in the noise. In fact, if you portray it the other way, you get in a lot of trouble. If it necessary to identify up front the fact that profitability has to be there."

"U.S. companies will not be in the LDCs strictly for current profit. They are also there is develop a market place, and there is an awful lot of that being done right now."

"An industrial firm transfers whatever makes sense, that for which it gets an economic payback If that is old technology, it does it. If it is modern technology, it does it. If it is R&D, it does it. You have to have a willing recipient and a willing donor If there isn't an incentive for both parties to get together, they don't."

III. U.S. industrial enterprises are a major current source of technology flow to the LDCs. They are effective. They are motivated. Their diversity is a major factor promoting the flow of technology. This flow should be encouraged and guided, but not impeded.

"I suspect that the government people really have no idea of how much private industry is doing around the world. The bulk of the technology transferred does not go through government channels. Such transfer of technology is abundant in comparison with current government activity. It is probably considered insufficient compared with the goals of the less-developed countries."

"Nearly every international company is looking hard for opportunities around the world. Nobody has to push my company to look for opportunities."

"The best linkage is a highly motivated industrial organization that wants to make profitable contact within an individual nation and just pursues that."

"We must be doing something right, because despite the rhetoric in the UN, practically every manufacturer that I know has had a steady stream of people at least looking to see what technology he might have to offer. I hope that whatever action the government might decide to take in this field will not interrrupt the momentum of day-to-day contacts that the private sector goes out and makes and the things that it tries to accomplish. It may not be as fast as those in political power would like, but the private sector approach by U.S. firms to transferring technology to underdeveloped countries leaves all of the rest of the world in the dust. To destroy that momentum

would not benefit either the U.S. or the LDCs. The UN rhetoric on a practical level is almost a non-existent impediment to making private deals."

"Given the diversity of U.S. industry, there is no such thing as a U.S. position One man's competition is another man's market. One really has to deal with companies, not 'the industry'."

IV. Barriers exist which inhibit and impede the flow of technology from U.S. industrial firms to the developing world. The UN Conference can be a useful forum for promoting recognition of these barriers and suggesting means to reduce them. They are of many varieties, and exist in both the U.S. and the LDCs. Lack in the LDCs of appropriately trained and educated people is a specific, major example.

"Countries should recognize that within American industry to some extent they (the countries) are going to be rated as investment opportunities on a scale against other countries. Communicating some of that reality of the private enterprise system may help. We need a mechanism to say to a particular country that you are never going to qualify. In all honesty, that has to be said. You can't say it as a company, it is too touchy."

"There are countries which need help that American industry can provide, but which have set up obstacles within their own countries to prevent it. This is a message that ought to go back to these LDCs at the Vienna Conference. It is also a lesson to us, to try to understand why a country that needs help so desperately will shun it."

"There are some countries in which there is no R&D capability with which to link. It doesn't mean that the U.S. cannot contribute to such countries. I just don't think that industrial R&D in this country is a very good vehicle to look to. In the less developed countries with weak technological bases, industry can play an R&D role only if something is done, either U.S. government aid or UN aid, or something, to provide the company the incentive, or profit, that it is going to have to have, in order to go in there, in the absence of a clearly identifiable market opportunity."

"Policies of these governments, limitations on royalties and on license fees, and on your ability to exploit the resulting technology, are a problem to us."

"In every case where we have seen more than one department involved in a foreign government in the application

of a technology such as satellite remote sensing, the thing fell apart from a lack of means to integrate any multi-department effort."

"Again, it has become bogged down in domestic politics."

"Government that changes every two years raises havoc in any kind of planning along these lines."

"About two years ago, the government was establishing a brand new research institute to compete with the existing one. The old one, which had been the brainchild of the former government, was now *persona non grata* with the new government, in this LDC."

"One of the prime obstacles is the tax structure that makes it more expensive, if you are an American firm, to operate and do R&D abroad, because it could be taxed both there and here."

"One of the things that we are struggling with within I.R.I. is that basic research is disappearing in this country, simply because R&D is now being forced to come up with ideas and approaches that have very short term solutions, and with that as a background, cooperation between R&D organizations in this country and other countries doesn't look that atractive to the R&D organizations in this country."

"Unless you are prepared to talk metric measurements, you have a hard time dealing with LDCs in many cases. You can't even begin to sell anything unless you are prepared to talk metric languane."

"There has to be a clear statement of policy about what kinds of R&D can be exported, a blanket policy, uniformly applied, so that all countries will have the same opportunity for development."

"There is no equivalent of the A & M University system in other parts of the world, and certainly no equivalent of the business school system. So that the LDCs are missing the graduates of these educational infrastructures. The LDC upper educational system is based on a model such as Heidelberg or Oxford or Harvard. You get great scientists, but you rarely get good engineers, and you almost never get good managers. It would be a good government initiative to start something equivalent to the land-grant colleges, scattered around the world, ensuring that courses in pragmatic subjects were taught in viable programs at the universities, in industrial engineering schools, in business schools, in on-the-job training schools or institutions similar to the GM and RCA Institutes in this country."

"Many of the people who are trained in the advanced countries do not go back. They will go back for a price, which includes both money and an opportunity to do meaningful work."

"Most of the technology in this world is only intelligible to someone skilled in the art. If you don't have people skilled in the art, you can't practice the technology. The key to it is to train appropriately to the skill of the art as part of the technology transfer, to impart these skills to the local people. That is a very hard thing to recognize, that there is a human component here in that technology transfer."

V. American industry is very conscious of the fact that it is "walking on the edge of the sword" when it transfers technology to an LDC. Every technology recipient is a potential competitor. Yet, such transfer continues.

"This is higly debated in my own company. There is a school of thought that says that you don't seem to realize that they will become our prime competitors. The alternative is that they will simply buy the technology they want from the Germans or the Japanese. Once committed to industrialize, they are going to do it. I think that it is in our best interest to find a way to convert this situation to an opportunity, because otherwise they will indeed become our competitors, rather than our partners. I think it is an exceedingly dangerous situation, and we argue, I can tell you, violently, in our company, and it happens every day."

"There is the expressed commitment of a lot of these LDCs to create domestic industries. They are actively seeking foreign partners to do it. Technology is a viable product to sell. So while we are producing competitors, we are simultaneously producing additional business opportunities."

"We don't have a choice. The technology is available in one form or another, either from our industry domestically, or from some other country."

"You start with the assumption that they are not going to import. Then you can begin to think about how I can share in their industrial development, with the smarts that I have. They are all committed to becoming self-sufficient in the long run, and the best that you can hope for it to share in that development.

"But it is more than just becoming self-sufficient; it is gaining access to the export markets. There is nothing

wrong with that. They are going to do that with or without your help. We are competing with other nations, all of whom are only too anxious to help these people industrialize."

"It wasn't until we sent quality control people to Argentina that we began importing good shoes. A U S shoe company recognized the writing on the wall that they were going to be importing shoes, but they had better be good shoes. They therefore took advantage of the situation and said, let's turn it around and make it a joint venture, so we aren't going to lose all of it, we will only lose half of it."

"It is difficult politically in the United States or in any industrial country, because it is widely viewed as exporting jobs, which may or may not be true, but is perceived that way."

"The skill level filters down. Cheap clothes used to come out of Japan, then Hong Kong, now the Philippines. The local people must be learning something. They get more competitive, their labor rates move up, they join the world economy--that's the objective of the exercise. As a lesser-developed nation becomes a moderately developed nation, moves up some mysterious spectrum, clearly they begin a self-generation process, whereby they bring a second or third generation of people or countries along. It is a very positive thing, not unlike the experience that we have had in the United States in the South, 30-40 years ago, bringing skills down from the North to an essentially agricultural, Southern community. There is a strange similarity between the situation in the United States 30-40 years ago and the current situation with the LDCs."

VI. American industry sees substantial opportunities in R&D related to the LDCs.

"There are a lot of R&D opportunities in developing countries. The biggest opportunities are doing kinds of R&D which for one reason or another are not profitable or sensible or logistically appropriate to do in this country."

"The opportunities we are talking about have to be very specific. Each company has specific opportunities, and each country presents specific opportunities. You have to focus on those countries that are ready for tou, that want you, that have specific opportunities, and then you go into action if you can work out a satisfactory deal."

"The opportunities here are long-range and should be focussed on the economic well-being of the globe.

Helping an LDC to become more prosperous cannot help but help your business there."

"An example of a relevant area can be seen in the fact that in this country 30-40 years ago a good many processes were developed for the production of commercial chemicals from agricultural byproducts. These were good processes. They were rejected in competition with petrochemicals. This is an area where sensible R&D can be done in an LDC that would not make sense here."

"The drug field is another one. There is a real need in world commerce for development of drugs to be cheap, without as much premium placed on performance."

"In the drug field you can actually have a greater incentive or interest in a country where the problem exists. It hits home there where it doesn't here."

"We have an active agricultural herbicide program down in Brazil, manned by Brazilians, the results of which will be for Brazil, as the first stage. The second stage is going to be research in Brazil on agricultural herbicides for all tropical countries, Brazil being the choice of the places to be for all tropical countries."

"The smaller U.S. companies have things that would be useful. Some specialize in growing seeds. They can show a developing nation how to do this. There is quite a bit of R&D involved, and it can be mutually helpful."

"My company has established research facilities in South America, because they go through 3-4 growing seasons in one year, and that really accelerates research on crops."

"Put research into countries with new foods, particularly fresh foods from tropical countries."

"Problems of the quality of imported raw materials provide the opportunity either to go there or to bring people in to train."

"One thing I would like to see is to take advantage of some of the unusual climatic situations, say in Chile, and do things with solar energy we don't do here."

"What can the industrial research laboratories in this country do to cooperate with LDCs that would be mutually rewarding? Just re-examining this question, in the light of this dynamically increasing market and the changing political environment in the LDCs, from our point of view of self-interest, to evolve new mechanisms, see new opportunities, and so on, is a useful thing. It is really going

to produce some results for future work with the developing countries."

"Many of our companies do have in the LDCs some act businesses. Perhaps in the past we haven't been smart enough to use that as a start to encourage some local R&D which would expand our opportunities."

"The industrial research laboratory of a U.S corporation can look at the situation in developing countries as a spear-head for expanding the markets of its parent corporation in these countries "

"On the balance, we find the opportunities and the solutions overtaking the problems at such a rate that this is going to be an expanding market, and thus, this will be an expanding area for our own attention and planning for the future."

VII. Technology which cannot compete in the U.S. markets may be answers to problems in the LDCs.

"Many of the U.S -developed R&D projects, processes, or even products are not really terribly relevant in practice, because some other system or process or product is more effective *in the U.S.* It doesn't necessarily follow that it is more effective for use in another country. The company that has developed the second or third process which has lost out has a loss on the development project, and might be very interested in transplanting it to a less developed country where it might be able to compete. American industry may have a real self-interest here, in looking at the industrial needs of less developed countries, to see to what extent its second process or product is relevant to that country and saleable there "

"In Brazil we established a relationship around a specific project, to transfer to Brazilians the capabilities to explosively clad thin sheets of stainless on a mild steel base. Brazil imports all of the stainless they use, and conservation of stainless is significant. Here in the U.S. we don't have a need for this particular technology."

VIII. U.S. industry is inherently attuned to the concept of "appropriate technology". And there are problems with implementing it.

"We have spent a lot of money and made a lot of errors in trying to help people out, or in trying to do business in a country that wasn't ready to accept our degree of technology sophistication. They lack simple things like

refrigeration and clean water. I have seen our company wrestle with this problem and pull back on most frontiers, because it is too hard to solve. So I think that the "appropriate" philsophy is a good philosophy."

"In most of these countries there is a high interest in the prestige value attached to high technology. The perception of the government is that it is not going to be around unless it can have national pride, and that nowadays is linked with high technology."

"It was totally rejected, precisely because it was a hand-me-down. Absolutely insulted, at your partner's level."

"He accepted advice to use a mothballed paper plant lying around in England, from the U.S. Academy of Sciences. He obviously would not have accepted such advice from a private business venture."

"The need for labor-saving should not be underestimated as being wrong-headed. There are several different levels of labor. Skilled technicians and professionals are very, very expensive. They are in high demand. They are being stolen."

"Our whole base of technology has been labor saving, almost all of it. And this has been brought into the LDCs which are in exactly the opposite situation. And we are not about to go back and scale down, or go back 50 years in our technology files. It takes an awful lot of work to redesign a process to use more labor and less capital, so you can lose your economics."

"The soap kettle process is a 200-300 year old process for the manufacture of soap, which our company abandoned about 1940 when the hydrolyzer process came along. Yet, when you go to a small country like an LDC, the kettle process is exactly what they want to do, because the capacity and the process and the capital investment is perfectly on target for their needs and labor-intensiveness. And we don't have anyone in our company that knows how to do the soap kettle process any more. They have retired, most of them in the last five years.... You can't ship soap very far, it costs too much."

"If the government is going to do it, they want the latest process. If it is some private individual or group of individuals, they really don't care, they simply want to make money."

"I frankly think that it is more difficult to transfer technology than to transfer scientific knowledge. It is the inability to perceive these technological relationships that is at the root of the problem "

IX. Industry sees significant ways to contribute through its R&D capabilities to the LDCs. ITT's Fundacion Chile is a leading example.

"Fundacion Chile is an experiment in technology transfer that ITT is doing in Chile. It is a joint effort to improve the nutrition and food situation and also the telecommunications system in the country If you want to get science and technology used, you should do it in some sort of business. That is the sort of thing that we are working with The other thing we hope to teach them is some of our techniques in research management. It has been quite an education for us to learn how many extremely well qualified people there are and how little they have had an opportunity of putting their capabilities to work. Marketing was not in our original plan for Chile, we had to add it We have had to rediscover some of the things we take for granted, such as the importance of teamwork between scientifically trained people, and an easy exchange of information "

"We have had some selfish motives in Fundacion Chile. In the first place, we got into it through a rather brilliant Chilean initiative, during the negotiations about settlement for our expropriated telephone properties. However, if we can learn how to go into a developing nation and help it thrive economically, if we are in that country doing business, it can't help but improve our chances if we improve the economy. Further, if we can learn how to do this in Chile, we ought to be able to do it for pay somewhere else. We also think that if we are good enough at this--we are just beginning--we ought to uncover opportunities for growth that we otherwise would not have found. One final selfish thing is that we recognize that if we don't have friends in the LDCs, we are liable to suffer terribly."

"We could speed up what we want to do with the various countries if we could have some, however small, American-managed Institutes to get across some of these ideas and also show by example how to do teamwork in research aimed at commercial end results. You can't always get a corporation to fund that, but it is someting that maybe a new governmental initiative could look at. A small corps of capable, proven industrial technologists and scientists working closely with governments, a lot of training, and simple cooperative things that could be done

which build up a feeling of success which gets some momentum going. We think we see this with our Fundacion Chile. We hope we have proven that if we have good will, we can try it somewhere else."

"Chile often feeds problems up here for assistance, and not necessarily only to us, but also to other food concerns with which we have some arrangements."

"The school lunch program is 11 cents per child per day. Two essential solutions to supplementing it were devised, based on the available materials and dietary needs. One was a very prosaic item called the "bouillon cube". The second was the oatmeal cookie. No Chilean in his right mind ever ate oats before. Those were for horses."

"From this point forward I think that what one is dealing with in working with developing countries is cooperative relationships, and cooperation *only* where there is mutual self-interest."

"American companies are much more flexible and much more willing to deal in organizing R&D where it is appropriate and economically viable in an underdeveloped country, than companies from certain other highly developed nations."

"We could make a real contribution in using American knowledge in quality control, to our advantage and to theirs. And if you don't want to buy anything from anybody, you aren't going to have world peace."

"Almost every company working overseas has a certain number of local people that they are developing into the work force. If you have a turnover of 2-3% a month, you are feeding a lot of local industries."

"American corporations who have people overseas could encourage their own employees to put maybe 6-10 days a year into helping some other local industry or into teaching at the local universities. That is a big resource that somebody ought to study and that we ought to tap. Companies are on the search for ideas or new mechanisms like this. They would see them as increasingly important as the price they pay for their operations within these countries. One approach would be to work through the American Chambers of Commerce, which exist in every country of the world."

"I think industry's biggest contribution is in the management of technology. One of the biggest contributions we can make is simply to teach them how to manage. Make them focus on what their needs really are, what they want to get, and how you go about getting it."

"In many developing countries there are plans, but there is absolutely no relationship between the plans as articulated by the planning authorities and the R&D infrastructures that are supposed to do things to make the plans come about. If there is anything the U.S. can bring to the ball game, it is indoctrination in the philosophy to have our R&D, our technology, correspond to the long term needs of our business."

"I have never ceased to be amazed at how effective the International Executive Service Corps has been in most of the LDCs I have visited and lived in. It seems to me that a program akin to that would be easily implemented, and very cheaply, where you could take a man that has spent his career in R&D and use him as a source point within the country or within an Institute where he can impart 30-some years of experience."

"A guy in late career has some 30-40 years of manufacturing practice. He can go back to a less capital-intensive environment and relate to it. He has advantage in knowing how things were done in the "good old days", which may be in fact what he is transplanting to in an LDC."

"Pre-retirment people, perhaps with some company support, under a government paid plan, or in a government-funded market place, under an AID-type activity, could be very useful. I think that you would find motivated people for these "industrial fellowships", or whatever they might be called. This is better than the International Executive Service Corps, where they give a guy three months and he works for travel and expenses. Someone like this could stay a year or two or more."

"There is source of people from industry that you might want to call upon. I.R.I. has a group of 'emeriti', who are highly motivated and competent."

X. U.S. industry sees virtues in an expanded government role in this field. It particularly would appreciate help in identifying opportunities.

"You really don't know what your opportunities might be, unless you get into a country to make a first-hand assessment, or pay somebody to do it for you. We have offices in most every LDC in the world. The opportunities reveal themselves through our people who are working there. A lot of this stems from the man who was president of our company when all of this started. He was convinced that there were opportunities. For a company that doesn't have an office or a local presence, you need the government or somebody to help you."

"An LDC is not an LDC is not an LDC. They are going to have to be put into categories. Those that can afford certain things, those that cannot. Those that allow private enterprise, those that do not."

"The U.S. government in particular and the local government are going to have to start making noises like they really want this to happen--tax incentives or other financial ways of responding. Without that, I don't think we are interested."

"I see an organization like the proposed U.S. Foundation for International Technological Cooperation acting as an intermediary in this process. Somebody has to find out what the developing countries are interested in. You people have to interpret what is needed overseas, you place the contract, and then the firm in the United States goes to work."

"If a company in the United States had sufficient expertise, they would take it on as a business entity to provide product development or research management or whatever on a contract basis for profit. I see a trend that is beginning to develop in some companies, where the companies have no reasons for being there other than to make money."

"Does Government really want industry in this field? I think the answer is very much *yes*. I would hope so, on two counts. One, we cannot pursue this thing forever and ever, and so we have to find other resources than the Government that ultimately would see that this is in their own interests. Second, I think that Government fully recognizes that much of the technology that is being talked about is vested in industry, and that it is not the property of the Government. So that is where the action is, and we have to figure out some way to make it work."

4. SUMMARY PLENARY SESSION

Dr. J. E. Goldman of Xerox was requested by the workshop organizers, on very short notice, to summarize the results of the day, from an I.R.I. point of view. He very graciously consented, and a lightly edited version of his extemporaneous remarks follows:

Had I been here earlier, I probably would have established myself as the seminar curmudgeon. Every seminar, you know, needs a curmudgeon, somebody who "is from Missouri", who has to be convinced of everything, who will question every assumption and quarrel with every conclusion. I am sure that in your own organizations, particularly those of you who have research organizations, you know that your seminars are made by having somebody sitting in the front row who is always asking questions of the speaker.

I have a little bit troubled by some of the conclusions and encouraged by others, that were formulated at this meeting. Let me tell you where I was a bit troubled.

In assessing the opportunities for R&D or science and technology to help the economies of the developing countries, the comment was made that we have to give the LDC's the wherewithal, the science and technology capabilities to solve some of the critical problems; mentioned specifically were health, food, energy, and education, and of course you can add others. I wonder sometimes whether we are leading from strength when we talk about the ability of science and technology to solve these kinds of problems. We have been somewhat less than successful in our own country. It is true that over a half-century or so we have mastered the problem of using chemistry and pharmacology in the solution of health problems, and, certainly, in the U.S. we have mastered the science of agriculture as have some of the other countries in assisting toward the solution of the food problem. But if we go on from there, to such subjects as energy, education, and then urban blight, and transportation, and all the social problems that we encounter, I think the history of certainly the past few decades has demonstrated almost unequivocally that we have not learned how to use science and technology to master these problems. The final returns on whether we can are yet to be written.

We know in our own industrial organizations we have problems in coupling R&D to the needs of the company. And there is now a domestic policy review initiated by the White House as to why innovation within our own country is lagging and what we can do to use R&D to stimulate a little more economic output from the huge input of R&D resources. So we have our own problems before we come and try to tell LDCs how to use science and technology for economic gain.

My own personal contact with this kind of problem started in the early 1960's. In 1964 I was asked by the U.S. State Department to head a delegation to CENTO, the Central Asian Treaty Organization--Turkey, Iran, Pakistan, UK, and the U.S. I learned some very interesting things in the course of that experience. This was shortly after NATO had initiated what is now referred to as the NATO Science Program--technical interchanges among the NATO countries--and CENTO was asking, "Why can't we, too, have such technical interchanges with the more developed countries, the UK and the U.S.?" In addressing this problem, it occurred to me, and I actually articulated this chain of thought:

I was then with the Ford Motor Company. The annual turnover of the Ford Motor Company was somewhat larger than the gross national product of Pakistan, which is where is Conference was being held. As you can well imagine, each of the countries was sporting their outstanding contributions to science and technology, trotting out those scientists from their countries who had outstanding reputations, few of whom, by the way, spent much time in their countries.

But back to the thought process that said that the Ford Motor Company was larger than Pakistan, and in many ways as diversified: you know, we were very big in glass, and steel; we mined in northern Michigan, and transported our own ores; paints, plating, and so on. And within the Ford Motor Company we had a very healthy and intrinsic exercise, which was the way I made my living, of trying to plan and administer R&D to interface with these needs and these plans. We looked to the future to see what our glass-making facilities were likely to be, and what kinds of technology would we use, and we were therefore the first to install the float glass process in our glass-making operations, to the economic benefit of the Corporation. And so on down the line.

Whereas, if you looked at a country like Pakistan, you sort of threw your arms up there. There really was no relationship between the planning exercises that the governmental authorities were doing as to what the future of the GNP of Pakistan would be, where they expected to enhance their economy, and what the R&D people were doing. And so it occurs to me now as it occurred to me then, what it is that we of the U.S. can really give to countries like that, using Pakistan of that period as symbolic of what we are talking about today as we discuss the LDCs.

The concept of industrial research and development is a uniquely American concept. It was really invented and perfected in the United States. Certainly there are notable exceptions--Philips in Holland, Royal Dutch Shell, and so on, but basically this is a concept that we have advanced in the U.S., and in fact perfected. And it is the concept and the management of the concept that is what I believe we have to export. And if we are to

export this properly, I think we should not get lost in the morass of the detail and the professional sophistication of a given field of research or technology or science, or need, but try to help countries of the world emulate this concept as best they can It is, therefore, as we had occasion to discuss at one or two of the discussion sessions, it is this management concept of how you implement R&D, how you introduce an infrastructure, and then how you manage it and match it to the respective needs of the country, that has to precede any real attempt to polish up the sophistication of that entity called science and technology, and utilize it.

Within the American corporation, I think we have learned to do that rather effectively. And this is what I.R.I. in effect really stands for. We have agglomerated that capability into an organization and try to help make available the experiences of companies within that organization, which countries, which are the equivalent of companies, can look to and try to understand.

I certainly don't believe we have all the answers I know that we have heard a few answers today, certainly during the discussion sessions. Some of the speakers this morning had answers that I.R.I. members probably had not thought about, or on occasion have not polished up. But, in principle, I would like to suggest that we should put up front and center the need to understand the practice of science and technology as it relates to economic growth, rather than the specific examples as they may apply to one country or another. And out of that process it is quite possible that there may come a few celebrated examples, from which in the long run we as a country will realize profit, in the fact that any great innovation that takes place, wherever it may be in the world, ultimately inures to our benefit.

DISCUSSION:

Mr. Lu Rudel (Office of the U.S. Coordinator for UNCSTD, Department of State):

I would like to ask Dr. Goldman how you bottle that. If you are going to be going to a Conference and offer that package, how do you gain access to that kind of skills and capabilities. I don't want to ask who pays for it, because that takes us....

Dr. Goldman:

That is a good question, Lu.

A sign of the maturity of a field is that it becomes the subject of discussion at a business school. First, you know, it grows up as a field of scholarship, and it is given discipline, and when finally it is mature, the business schools catch on. And one of the things I have been observing for the last two decades, having been in this whole field of R&D management, is

that more and more of the better schools are offering specialization in the management of R&D. Sometimes it is very good, and they draw upon the experiences of industry, and they do good research. Sometimes it is hackwork, because the people who do it have never had any experience in R&D, but this is like any other field. This means that there is a process, once it becomes a discipline in a school, it is an on-going process of bottling up. If you ask how would I bottle it up, I would say, I would think, side by side with the kinds of discussions that were taking place here today, which I think are very helpful and very stimulating, we should have an equivalent kind of discussion on the principles of R&D management as they may apply to a country, as they may be transferred from a company to a country. And if I had made the speech of mine this morning, we might have diverted some of the discussion to examining that. I think that here and there I heard people speaking about these things at our discussion sessions. But I believe there is opportunity to try to formalize the bottling-up process, as you put it.

Dr. Sangster (National Bureau of Standards):

The Industrial Research Institute was founded in 1938 under the auspices of the National Research Council, the operating arm of the National Academies of Science and of Engineering. Dr. Goldman has already alluded to the fact that one of the reasons it exists is so that companies in the U.S. can share, can educate each other. Membership is limited to research organizations affiliated with manufacturing companies. I would like somehow to see a package whereby KIST in Korea or IPT in Brazil, and so forth, could become some sort of affiliate members in the Industrial Research Institute. That is one way to package an opportunity for these people to have a chance to learn from American R&D organizations.

Mr. Blackledge (Denver Research Institute):

Dr. Goldman, you were talking about the great expertise in management of research systems in this country, and the potential for transferring this technique to the developing countries. I certainly agree with what you said. However, I would like to caution the group, based on our own experience over the past seven years during which we have put on probably 20 workshops in various regions of the world for research institute directors, in the Middle East, Latin America, Southeast Asia, and so on. What we have learned is that it is an agonizingly slow process. We have held these meetings three different times in several regions. We have gone back a year later, we have said "OK, what did you learn the first time?" We find people's assignments change, policies change, governmental politics change. We find that it is a very, very slow process. I recognize that there are all kinds of mechanisms to transfer the know-how, but I think it is a slow process. You can't go in and just say, "Here is how you do it!", turn your back, and walk out. It will take a lot more time.

Dr. Cotton (ITT):

I wonder if it might be worthy of a minute's thought to conceive of having the FITC approach a lesser developed country, perhaps on a pilot basis, to say that we would like to sit down with them and try to define what their principle needs are and try to find areas where they think technology could help them meet those needs, and then to define very specific research objectives, and then to loan a resident group of American practicing researchers to team up with the local people, and just solve one problem, or attempt to solve one problem. And then by doing things together, you teach a lot better than you ever can with a school. I think that would take a piece of money and imagination, but I think it might be worth trying.

Mr. Copeland (ISTI):

I like that idea, and I would like to expand on that just a moment. One, because it has been done in one arena, and that particular arena is the universities here in the United States. And in the one case I am familiar with, it has proven to be successful, namely in the U.S.-Brazil chemistry program But why not try the same thing with industries? Instead of grouping the academics into a consortium, why not group several industries into a consortium, and try the same thing? I think that is a good idea.

Dr. Sangster:

That has been done in the agricultural field by LAAD--Latin American Agribusiness Development--for example. This and other examples came out in a workshop similar to this one last August, in the agribusiness area. I am not aware of any of them in the manufacturing areas. But prototypes do exist.

Unknown:

Yes, I think there is a lot of chance to accentuate the positive in the things that have been done. This Latin American Agribusiness Development thing is very worthy of expansion It is an invention of AID, I understand, plus American agribusiness corporations, and it is providing something that all day long we have found is the need. Once you have done some research, you need some money to put it to work. They make loans, and so far they have been successful. They have made money, too. With the American skill of taking technology and marketing people and economists and business venture analysts and putting them together as a team to solve a problem, it is part of our belief that we are the best packagers in the world.

Dr. Goldman:

In response to Mr. Blackledge, basically the less developed the country is the more bureaucracy it normally has, and bureaucracy is the mortal enemy of progress. But then, so is it in this country. A new idea that germinates in Washington will often take quite a few years to surface and get organized. But there are many counter-examples of success in achieving what I was talking about. I think that Dr. Holloman, at MIT, who has had some industrial experience and has been working with various countries, has had some very salutary examples of successes in guiding the country toward marshalling its R&D forces in the proper direction. I have had one or two experiences of my own. At a meeting at General Electric about two months ago, I met an individual that I first met in Pakistan some 14 years ago and had not seen since. And he told me, "You know, I remember that meeting we had in Lahore very, very vividly, and, you know, it had a great effect on how we organized. Within a year of the time the meeting took place, we saw changes in the entire program of what Pakistan was doing." The nuclear research reactor they were thinking of buying suddenly took second place, and suddenly they were doing some research on building materials, and on utilization of hemp, which was one of their main products

I have had my own personal experience in this area. Xerox has a policy of sabbatical leaves for officers. I took four months off three years ago and went off to Israel. I was a guest of the government, and I was asked by the Ministry of Commerce and the President, who was himself at that time a physical chemist, to see what could be done about reorganizing the research capability of the country. My report was circulated and read at the highest levels, and led to a major reorganization of the way the country organized its research. Not that they were as glaring as Pakistan was with respect to the lack of correlation between the design of the research program and the long range plans of the country. I saw with my own eyes the change taking place.

I believe that companies like those gathered here in this room, might be induced to adopt a similar sabbatical program. I think people like ourselves going out to one of these countries, which is a wonderful experience, can have a profound impact on the lives of those countries.

Mr. Seth Neugroschl (IBM):

We discussed in several panels the possibility of pre-retirement movement of people, many of them presumably with lots of management experience, perhaps looking forward to the possibility of moving into a post-retirement active role. If there were a market established by the Federal Government for this kind of activity, they could then go as individuals, and you could really tap a large number of people who would be both willing to go, highly motivated to go, and at the same time deal with a problem that our own R&D organizations face with the 70 retirement age.

Mr. Copeland:

What do you think would be necessary from the U.S. Government in the way of incentives to industry?

Mr. Neugroschl:

One possibility is that people are on the point of retirement and do retire and need supplementary income from the Government, with the result that they would be "sanitized" from the direct association with their companies, and would then be representing not companies but their own individual commitment to helping the developing country, and the developing country sensitivity to possible dual motivations might thereby be reduced. People as individuals might be more easily accepted in that kind of role, rather than as employees of their own companies.

Mr. Copeland:

Essentially you are saying that the Government would only have to pick up their salaries, and have a program for them to go into.

Mr. Neugroschl:

Or supplement their retirement income.

Mr. Henry Arnold (AID):

Would you see this as different in principle from the IESC operation? (International Executive Service Corps.) Suppose the person who has retired were put on the rolls of IESC, which is, after all, a marketing organization. Would that accomplish the same purpose that you are talking about here, if we expanded the IESC activity?

ITT representative:

We have used some of the IESC people. They are very good for a three-month shot, they will come down and give you good expertise in some area where you have a gap. But they are not anywhere near ready to come down and work for a year or two.

Mr. Arnold:

But now we are postulating the possibility that there are people who would be willing to go for a year or two, or more. And I think that is true, there are people like that. I was just wondering whether it could be handled through the IESC mechanism?

Unidentified:

My guess is that it might be. However, if it were under FITC, and if FITC did its homework first, in which it had jointly worked with a country to define its needs, and delineate specific goals, then they could select the right people with the right training and motivation, I think you would get a more effective mobilization of forces. I think that the IESC is a good *ad hoc* sort of thing to plug holes, but it isn't a cohesive plan to get from A to B, in a country.

Also Unidentified:

IESC has a stated policy that they will only send people for three months, based on the belief that longer assignments lead to the "crutch" syndrome.

Mr. Kramer (I.R.I. Staff):

On behalf of the I.R.I., I would like to thank Wes Copeland and Ray Sangster for organizing this meeting. It has served a very useful purpose.

Mr. Arnold:

I want to thank the members of the I.R.I. and other organizations for participating. We badly need this kind of discussion, and we appreciate it very much. I repeat what I said this morning, that as far as I am concerned, I would like for this to be the beginning of a series of conversations, individual conversations. If any of you are interested in giving me a call, or if you would like for me to arrange a conversation with FITC, or anybody else, please call me. Thank you.

Mr. Copeland:

And on behalf of my organization, I thank you kindly.

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5. U.S. INDUSTRIAL R & D FOR INTERNATIONAL DEVELOPMENT

(Background position paper by Raymond C. Sangster, National Bureau of Standards, Boulder, Colorado, August 1978)

5.1 Introduction

A major challenge of our time is the economic development of the poor nations of the world. As Abraham Lincoln said over a century ago, "'A house divided against itself cannot stand.' I believe this government cannot endure permanently, half slave, half free." The issue for our time may well be, "How long can the world endure, half poor, half rich?"

It is the thesis of this paper that the industrial research laboratories of the United States represent a major resource that is presently relatively untapped by, and that can be of great value in the development of, the poor nations of the world, to the mutual benefit of the laboratories themselves, their staff members, their parent organizations, and the poor countries. The problem is establishment of effective mechanisms to link these R&D resources with the development needs of the less developed countries (LDCs) so that all parties benefit optimally

It is timely to consider these matters now. First, there will occur in Vienna in August of 1979 the United Nations Conference on Science and Technology for Development It is urgent that inputs be provided now for the preparation of the U.S position at the Conference. Second, President Carter has recently ordered the creation of a U.S. Foundation for International Technological Cooperation, and planning for the establishment of the Foundation is currently under way Input from the private industrial research and development community is timely for both of these new initiatives, and both could have results that would be supportive of any new U.S. private sector initiatives in supplying science and technology for development of the LDCs

5.2 Nature of the Needs for Science and Technology for Development

The main purpose of the UN Conference is not to discuss science and technology as such, but to explore the whole complex of policy considerations concerned with the accelerated application of science and technology to development at the national level and with increased international cooperation. It is now generally accepted that development is not synonymous with mere growth but encompasses many other considerations concerned, essentially, with the welfare of man: cultural and spiritual, as well as material. The process of material growth must be made to benefit the population at large, not a few privileged sectors. Development must take increasing account of environmental aspects in the broad sense of the optimum use and economy of resources, and of factors that will enhance national and individual self-reliance and

interdependence rather than dependence. (Slightly adapted excerpts from the UN document "Guidelines for Preparation of National Papers.")

The primary need of the LDCs is for *technology* appropriate to their developmental situations. *Technology* is defined in Webster's New Collegiate Dictionary as "Applied science; a technical method of achieving a practical purpose; the totality of the means employed to provide objects necessary for human sustenance and comfort." *Science* is defined in Webster's New World Dictionary as "Systematized knowledge derived from observation, study, and experimentation carried on in order to determine the nature or principles of what is being studied; the systematized knowledge of nature and the physical world."

Some kind of technological change *must* accompany any form of material development. In contrast, new scientific knowledge is needed only when development occurs in directions or circumstances for which existing knowledge and technology are inadequate. Properly speaking, we should talk of technology and science for development, to be sure that we are always clear about our priorities.

A similar point was made in a report by the U.S. National Academy of Sciences in 1973, entitled "U.S. International Firms and R, D and E in Developing Countries":

> "The experience of developing countries at the individual enterprise level suggests that the R, D and E sequence is usually reversed; acquisition of capabilities proceeds from E to D to R.... Industry must go through certain evolutionary phases before it is ready to make commercial use of R&D efforts. As in the United States, so in the LDCs, the development of certain basic engineering capabilities--the ability to manage quality-control systems, introduce material specifications and standards, maintain tool shops, and establish other production-support activities--normally must precede more ambitious developmental and applied research on product design, new materials, equipment design, and other changes in production or processing techniques. In other words, the logical and chronological sequence is E, D & R, rather than R, D & E."

Factors necessary for material development in addition to the use of new technology include entrepreneurship (the willingness and ability to organize and manage an economic undertaking, assuming the risks for the sake of the rewards), the accumulation of capital, and increased or new skills for the labor force. While these additional factors will not be dwelt on at any length in this paper, it must never be forgotten that technology alone can accomplish nothing--technology must be employed in an organized undertaking by people who have the necessary tools and equipment and know-how to use them.

Industrialization is the most effective method so far found for economic material development Indeed, the pres[illegible] ross disparities in material welfare between the rich and poo[illegible] tions (differences in per capita annual income in the range [illegible] factors of 10-100) are a direct result of the industrial revolution. The industrialized nations are rich, the preindustrial nations are poor (except for the OPEC and certain other nations that are suppliers of key industrial raw materials), and the currently rapidly industrializing nations are becoming rich

The industrial revolution was founded on a revolution in technology and was accompanied by the rise of modern science

When the poor countries set out to industrialize their economies as a route to national development, they early concluded that this could be done most rapidly by exploiting the technological capabilities currently in use in the already industrialized countries. Hence, they pursued a path of "technology transfer" In some developmental areas such an approach is clearly essential, or at least strongly justified, e g , in the establishment of a modern jet-age air transportation system, or in the adoption by Indonesia of a satellite communications system to link its widely scattered islands. However, adverse consequences of the simple technology transfer approach also rapidly made their appearance

One major adverse consequence was further enhancement in these countries of their "dual economy" characteristics, the side-by-side existence of two populations with entirely different patterns of living·

> "In these nations a small portion of the society is urban, industrial, and modern; the remainder of the population is either rural, existing according to traditional agricultural patterns, or urban poor, subsisting on scraps from the industrial and commercial segment. Attempts to modernize a nation's economy usually widen the internal gap between the rich and poor." (W H Harman, *An [illegible] Guide to the Future*, San Francisco Book Company, 1976)

Reasons for the frequent inappropriateness of transfer of existing modern technology to the LDCs are easy to see· The leading edge of technology in the established industrial nation, is competing in a technological market which is characterized by high entrepreneurial ability, a highly skilled and educated labor force, high labor costs, a relative abundance of investment capital, a highly developed national and international marketing system, and extensive national transportation and communication systems. In contrast, the LDCs typically experience a shortage of managerial or entrepreneurial talent and have largely uneducated labor forces, untrained in the techniques demanded by modern industry and unaccustomed to working under industrial conditions. Labor costs are very low, labor is abundant, and unemployment is a major national problem, far more severe than in the industrial

countries. Investment capital in the usual sense of domestic monetary savings is very limited, and the primary potential source of capital is the underutilized labor time of the people; interest rates are very high except when held down artificially by governmental action. National markets may not be well developed. National transportation and communication systems are often very limited in the modern sector and otherwise very primitive.

Aside from the fact that modern industrial technology is often far from optimized for the economic conditions of the LDCs, its deployment in the LDCs is often fraught with great peril and accompanied by great economic inefficiency. Workers with the required skills may not be available, so that foreign technicians must be imported. The quality of locally available raw materials may be inadequate, so that not only the capital investment but also the operating input raw materials consume scarce foreign exchange resources. A wide range of supporting services, taken for granted in the industrial nations, simply may not be available. Spare parts may be difficult to obtain. Climatic conditions can cause problems. The available repair and maintenance capabilities may be such that the plants involved are often working far below capacity. In all cases, transfer of capital-intensive, labor-scarce technology will at best make no contributions toward easing the capital shortage and employing people.

The overwhelming need of the LDCs is for technology for employment. This means among other things technology for evolutionary upgrading of the capabilities of the traditional sectors of the economy where the vast majority of the population lives and works. The technologies needed must be effective on a small scale, use locally available raw materials, serve local needs, and be capable of operating without sophisticated repair and maintenance services. The unemployment crisis facing the developing world is mammoth:

> "About 200 million people have flooded the labor markets of developing countries during the 1970's, and an additional 700 million are expected to require employment by the turn of the century.... The capital required to create enough jobs in modern industry and Western-style agriculture would be staggering. It now costs an average of $20,000 to establish a single workplace in the United States, and modern industrial jobs in the Third World are no easier to create.... But the difficulties of taking an alternative to the high-technology route should not be underestimated. All technologies require extensive development and testing before they can be widely used. Low-cost technologies are no exception. Indeed, considerable ingenuity is often required to scale down production processes and to develop equipment that can be easily maintained by local people. Small producers who lack financial resources are in no position to experiment with unproven technologies."
> (C. Norman, "The Staggering Challenge of Global Unemployment," pp. 223-228, *The Futurist*, August 1978.)

In the words of E. F. Schumacher (*Small is Beautiful*, Harper and Row, 1973):

> "The 'dual economy' in the developing countries will remain for the foreseeable future. The modern sector will not be able to absorb the whole. If the non-modern sector is not made the object of special development efforts, it will continue to disintegrate; this disintegration will continue to manifest itself in mass unemployment and mass migration into metropolitan areas; and this will poison economic life in the modern sector as well. The poor can be helped to help themselves, but only by making available to them a technology that recognizes the economic boundaries and limitations of poverty--an intermediate technology "

One of the thrusts of the "intermediate technology" movement stems from the recognition that, in the course of their historical development, the industrial nations have employed and later abandoned many technologies that are "intermediate" in many senses between those in use today in these countries and those characteristic of preindustrial economies. It may often be more appropriate to employ one of these older technologies in a newly developing country than to use the most recent the industrial nations have to offer.

Recognition of the deficiencies of simple transfer of the currently leading technologies from the industrial nations to the LDCs led a number of years ago to a train of thought that has often been labelled "appropriate technology". The concept is simple and unarguable in principle: the technology employed in an LDC should be selected and adapted to be appropriate (i.e., optimized) for the situation in which it will be used

Recognition of the employment problems of the LDCs and of their scarcity of capital has led to another formulation of this basic concept, namely, "light capital" technology A useful rule of thumb is that a developing nation can afford to invest in the technology for a new workplace only about an average worker's annual wage, a sum which typically is only a few hundred dollars. The most appropriate "light capital" technologies will be those for which it is possible to employ underutilized local labor in the generation of the required capital equipment, thus "congealing" this surplus labor as capital investment.

5.3 Sources of Technology and Science for Development

Five sources or paths for acquisition of technology and science for development are commonly recognized:

The first is technology transfer, the transfer of existing technology from an industrial nation to an LDC, as discussed above. Since this knowledge is usually the property of an industrial concern, technology transfer typically involves questions of licensing of patent rights, sales of capital equipment, construction and operation of plants, training of operators and managers, and the like. Any connection from the LDC back to the home-based corporate R&D laboratory appears usually to be very remote.

The second is another form of technology transfer, namely technology information and consulting services. Again, the objective is transfer to the LDC of existing knowledge, either that deposited in writing somewhere, or that residing in the minds of consultants. Industrial R&D laboratories seem rarely to be the sources of such information or consultants.

The third is what seems to be the mainstream of the "intermediate technology" movement, an attempt to identify out of the developed nations' historical pasts technologies that will be relevant today to the LDCs.

Fourth, the U. S. scientific community, primarily academic, has through the Board on Science and Technology for International Development of the National Academy of Sciences been a source of much analysis and advice concerning science and technology for use in the LDCs.

Fifth is indigenous R&D, creation in the LDCs of the technological knowledge that they specifically need. It is generally recognized that the LDCs must have their own scientifically and technologically trained people capable of receiving and using transferred technologies, and that they must be able to conduct R&D in response to local problems and local market needs.

A problem with many efforts at developing indigenous technological and scientific capabilities is that they are often modeled on the visible examples of the industrialized nations and are not well matched to local needs. LDC scientific faculty members often train in prestigious universities in Europe or the United States and seek to develop similar capabilities in their native countries. Typically, for scientists, this means an emphasis on basic research unfettered by concerns for practical applications. Such research has very little chance of making any direct contribution to the economic development of a less developed country. Similarly, when research institutes are established specifically to aid industry, they are often staffed by people who have had little experience with the real-life problems of industry and who have little comprehension of the need to sell their services, or of how to go about relating themselves to industry.

The source that seems to be almost universally overlooked in seeking technology and science for the development of the LDCs is the industrial R&D laboratory community of the major industrial powers. There seems to be little or no effort to find or to create in these laboratories *new* technology specifically needed by the LDCs. It is the purpose of this paper to contribute to rectification of this situation.

5.4 U.S. Industrial R&D and Economic Development

The primary source of the technology and science used in the economic development of the United States has for many decades been the industrial research laboratory community of this country, and the primary driving force in U.S. economic growth has been for many decades advancements in technology. The industrial R&D laboratory community in this country includes laboratories directly owned by industry, such as Bell Telephone Laboratories; nonprofit R&D contract organizations, such as Battelle Memorial Institute; university-affiliated contract research organizations, such as the Denver Research Institute; and some governmental laboratories, such as those associated with the Department of Energy and NASA.

Some statistical data are relevant:

"In 1976 there were some 1.7 million qualified scientists and engineers in the United States. Of these, 542,000 were engaged in research and development on a full-time equivalent basis. This total was apportioned as follows

Industry	346,400	67.2%
Universities and colleges	72,400	13.4
Federally funded research centers	13,400	2.5
Federal government	65,300	12.0
Nonprofit organizations	26,400	4.9

"In 1976 total national research and development funding (private and governmental) was $38.09 billion. This was apportioned as follows

Industry	$26.50 B	69.9%
Universities and colleges	3.66	9.6
Federally funded research centers	1.08	2.08
Federal government	5.60	14.7
Nonprofit organizations	1.25	3.3 "

(Data from a draft of the U.S. National Position Paper for the UN Conference on Science and Technology for Development.)

Industrial Research/Development magazine in its January 1978 issue estimated that $81.7 billion of industrial R&D would be performed during 1978 world-wide, of which $43.2 billion would occur in the United States. Of the amount done in the U.S., $26.3 billion would be financed by the U.S. Federal Government.

It is a noteworthy fact that whenever the Federal Government determines to effect any major scientific/technological accomplishment, it enlists the aid of industry. Typically, most of the funding is actually expended by industry. Examples include the Department of Defense, the old Atomic Energy Commission, NASA, the FAA, NBS during World War II--essentially any agency of the Federal Government with a tightly defined technological mission. The typical pattern involves cooperation and collaboration among government laboratories, selected academic institutions and nonprofit organizations, and private industrial concerns.

The pattern of deployment in this country of Federal Government support for technology and science for development appears to be in significant contrast to the observations of the previous paragraphs. For instance, analysis of the key authors and contributors to some 15 reports produced during the past eight years or so for the Agency for International Development by the U.S. National Academy of Sciences produced the following results: Overall, some 303 contributors were identified. Academic institutions accounted for 52% of them, the Federal Government or international organizations 15%, miscellaneous private sources 6%, private nonprofit industrial research institutions 3%, and private industry, only 14%. This pattern is not inevitable in National Academy of Science panels. For instance, 65% of the panel that produced the above-mentioned report on R, D and E was composed of industrial members. That one panel accounted for over 25% of the total number of panel members from industry. If that one report is excluded from the analysis, then only 10% of the total number of contributors came from industry.

There are a number of possible reasons for the lack of involvement by private industrial R&D laboratories in this field. Two probable reasons are immediately apparent. First, industry may be absent by default; the academic community has been willing and eager to get involved, industry has been reluctant or oblivious. Second, industry can move into a new field only when there is sufficient profit potential to justify the effort; industry may not have been able to see the profit potential in industrial R&D directed toward technology and science useful for development of the LDCs.

A third probable reason is also evident: The Federal Government has never had a commitment to innovation in technology and science for development sufficiently urgent and focussed to bring into play its traditional pattern of turning to industry to get the job done.

A fourth possible reason may underly the previous three, namely, concern that technological and scientific efforts cannot have any significant impact on the problems of the poor nations. After all, given the problems of winning the "War on Poverty" here at home, how can technology and science play much of a role in the war on national poverty abroad? One obvious answer is that

technology and science certainly cannot do it alone. They are only tools that must be employed by the right people in the right circumstances to be effective. On the other hand, the poverty of the less developed nations is not necessarily of the same kind as that of the poor people in the United States The preindustrial nations are poor, first and foremost, because they are preindustrial. Only part of the poverty in the United States (e.g., that of our Amerindian nations) appears to be due to this cause. Industrialization works to alleviate this kind of poverty both at home and abroad, and industry can and does contribute in both cases.

5.5 Deployment of U.S. Industrial R&D to Meet LDC Needs

The subject now is what to do about this situation.

I. Nothing substantial will happen unless governmental and private policy makers become aware of the challenge of U.S industrial R&D for LDC needs and become more persuaded of its significance. Input into the planning of the proposed Foundation for International Technological Cooperation and the preparations for the UN Conference on Science and Technology for Development provide one channel for expression of industrial R&D awareness and for stimulating a governmental response. The Conference itself could provide additional impetus toward recognition of the validity and importance of the points being made here.

II. The absence of industry by default could be handled several ways. One approach would be to set for the National Academy of Sciences goals for industrial participation in its panels in this field, e.g., that 1/3 of the members of all panels be industrial and over 1/2 on the average. Another approach could be to use industrial associations such as the Industrial Research Institute, Incorporated, as mechanisms toward obtaining industrial commitment to participation in this field. After all, the issue under consideration at the moment--industrial participation in advisory panels and study groups--does not involve a heavy financial outlay and can be accepted by industry as part of its ordinary civic responsibilities.

III. However, enthusiastic and spontaneous participation by industrial R&D laboratories in technological and scientific innovations for use in the development of the poor nations of the world will come about only when industry can see the profit potential of these activities. In some cases, seeing the profit potential may require only uncovering a natural potential that is already there. In other cases, governmental actions may be necessary to provide adequate profit incentives. Some of these could be by our government; others may have to be taken by LDC governments.

A. A management problem always faced by the director of an industrial R&D laboratory is that of channeling the creativity of

the laboratory staff in directions that might be useful to the company. Anything that can be done to broaden the horizons for potential pay-off from the work of the laboratory will be welcomed. The needs for technology and science for development in the LDCs can provide such broader horizons. The very factors that may make current best practice technology in the U.S. inappropriate in an LDC may make a new laboratory development a strong competitive candidate in the LDC, and factors that may prohibit wide utilization of an innovation in the United States may not apply in an LDC. In any case, just knowing that there are circumstances where the ground rules of technological competition are different than in the United States enlarges the range of laboratory outputs that can be of potential applied value.

For example, a problem that innovations almost always face in the United States is the existence of a strong vested interest. It is no accident that the major vacuum tube manufacturers did not become the leading semiconductor device manufacturers: They had a strong internal vested interest in not making their own technology and products obsolete. In telephony, new products introduced by a telephone company have to work compatibly with equipment that may have been installed 40 years ago; also, the last thing that a telephone company would want to see is an innovation that would lead customers en masse to asking the company to replace its existing equipment--what would the company, or our economy, do with all that perfectly serviceable but unwanted equipment? In an LDC, the current vested interest situation may be such that the LDC can make a fresh start, employing the most recent technology. In such cases, the most appropriate technology for the LDC may be more advanced than that in use in the older industrial nations. Examples include the acquisition by Indonesia of a national satellite communications system and the experiments in India with satellite broadcasting of educational television programs. Introduction of such economically and technically revolutionary services in this country is impeded by the existence of thousands of miles of coaxial cable and microwave relay links.

Another problem that an innovation faces in the United States is the necessity of being able to perform in a superior fashion, both technically and economically, almost from the first instant it is put on the market or into commercial service. The usual customer will buy only better performance or substantially lower cost that is here *now*. Often, he will not buy significantly lower performance than he is accustomed to, no matter what the cost differential.

In the poor nations of the world, the cost-performance tradeoffs will be different than in the American market. If the choice is between modest performance at modest costs, or no performance at all, the choice might indeed be made for modest performance. An example could be the use of laser devices for telephony. In the United States, laser beam communications through the

atmosphere are severely limited in their acceptability because the laser beams will not penetrate fog, dust, or heavy rain. In an LDC, if a village faced the choice between an inexpensive, reliable, battery-powered laser telephone system, that sometimes would not be operable when the weather was bad, or no telephone system at all, the laser system might be chosen.

B. The approach that appears to prevail in the U.S. multinational corporations toward technology transfer to the LDCs appears to follow a version of a "trickle down" theory, with adaptations to local LDC conditions made only when clearly necessary. New science and technology originate in the U.S. corporate research laboratories and are translated into profitable products and processes within the United States. Then, when it appears that operations within an LDC can be profitable, the technology is transferred in as intact a state as possible to a subsidiary or indigenous organization in the LDC. During the process of technology transfer, there will be many opportunities for things to go wrong, and Murphy's law will be in full operation. anything that can go wrong, will. Things that go wrong cost money. The way to prevent such costs is to control the process of technology transfer very tightly, so that the technology is implemented in the LDC in exactly the form that is known to work effectively in the U.S. All the natural profit-oriented or efficiency-oriented forces seem to be opposing any efforts to adapt the technology to local LDC conditions. Perhaps later, after the plant is running smoothly, it will be safe to experiment with adaptations. By then, of course, all of the heavy capital investment has already been made. Further, the U.S.-based R&D laboratories probably never hear of the technological challenges or opportunities that are unique to that LDC.

It appears that new opportunities for company profit from the work of its R&D laboratory and advanced engineering groups could be opened up if these groups were able to make contact directly with the needs of the LDCs and come up with product or process innovations or adaptations specifically oriented toward meeting those needs Corporate R&D could lead the way to new business in the LDCs.

C. U.S R&D efforts not associated with large multinational companies can also be of value in the LDCs. Opening up channels for connecting the capabilities of even very small firms with the needs of the LDCs could be particularly rewarding for both sides.

IV. Creation of the Foundation for International Technological Cooperation appears to be the first clear commitment by the Federal Government to innovation in technology and science for development. Hopefully, the Foundation will examine the job to be done and will use the urgency of demonstrating that its creation is in fact bringing about some dramatic changes to enlist the cooperation of U.S. industry in this program.

5.6 Creation of Linkages from U.S. Industrial R&D to LDC Needs

If anything whatsoever is to happen to connect the capabilities of U.S. industrial R&D laboratories with the needs of the less developed nations, institutional linkages must be created between the U.S. laboratories and organizations in the LDCs capable of identifying national needs for technology and science for development and for directing efforts to apply technology and science to meet those needs. Possible linkage mechanisms include the following:

1. As suggested above, the National Academy of Sciences could deliberately seek an enlarged industrial representation on its Board on Science and Technology for International Development. Such actions would also create connections between U.S. industry and the Academy's counterpart organizations in the LDCs.

2. Interested industrial participants could go knocking on the Academy's door, asking to be let in.

3. The Industrial Research Institute (I.R.I.) could form its own equivalent of the Academy of Science's Board on Science and Technology for International Development, to function for the industrial R&D community. This I.R.I. unit could be a separate committee or a subcommittee of the present I.R.I. Federal Science and Technology Committee.

4. R&D vice-presidents or laboratory directors could designate senior staff members to become knowledgeable about LDC needs in fields or countries of potential significance for the laboratories and the companies. These people could then provide inputs for technical program planning and could assist in identifying potential paths of exploitation in the LDCs of laboratory results. These individuals could also maintain close contact with the companies' existing international activities.

5. Companies and laboratories could bring in seminar speakers knowledgeable about LDC problems to raise the consciousness of senior managers and technical staff members about the technical needs and business opportunities in the LDCs.

6. Companies and laboratories could make known to the Agency for International Development, the Volunteers in Technical Assistance (VITA), and similar organizations their interest in providing consultants for assignments in the LDCs and their willingness to accept LDC guest workers in their laboratories. Industrial secrecy problems can be handled.

7. I.R.I. could find ways to support the World Association of Industrial and Technological Research Organizations (WAITRO) and its member organizations. Since these organizations are typically quasi-governmental and not owned by manufacturing companies, they are not eligible for membership in I.R.I. under I.R.I.'s present rules.

8. I.R.I. could modify its rules for industrial research organizations in LDCs to make membership in I.R.I. more accessible to them. For instance, I.R.I. might establish an "associate membership" category, which would allow these organizations to send representatives to I.R.I. meetings to gain much valuable insight by direct exposure to the top managers of the U.S. industrial R&D community.

9. Senior R&D laboratory staff members could be sent to selected LDCs to personally seek out research opportunities for their laboratories.

10. Arrangements could be made for review by the R&D laboratory or advanced engineering units of a company of all impending cases of technology transfer to an LDC. The originators of the technology might be able to identify simple and safe changes that would make the technology more appropriate for the environment into which it is going.

11. Direct technical-man-to-technical-man contacts could be established with LDC users of the company's products to determine the problems encountered and the opportunities for improvement. Such contacts could uncover technical opportunities that would not be identified by the company sales force

12. Direct liaison contacts could be established with the LDC research institutes to identify areas in which collaboration would be fruitful and to identify other R&D or business opportunities for the U.S. firm.

13. U.S. trade associations and professional groups could establish contact with counterpart organizations in the LDCs. For instance, the Leather Research Institute in Jojakarta, Indonesia, could benefit from contact with the American Association of Hides, Skin, and Leather Merchants, the National Industrial Leather Association, and the American Leather Chemists Association.

14. The proposed U.S. Foundation for International Technological Cooperation could be designed to have direct input from U.S. industry through industrial members on an advisory board similar to the Department of Commerce Technical Advisory Board or the National Bureau of Standards Visiting Committee.

15. The Foundation could set about systematically identifying scientific and technological needs of the LDCs and publishing these needs widely throughout the industrial community, perhaps through a publication similar to the *Commerce Business Daily*.

16. Industry can look at technical areas that are already clearly moving in the direction of appropriate, light capital technologies, as in electronics and computers, and specifically seek to orient part of its work to LDC needs.

17. The U.S. Government could establish some priority areas for technology and science important for economic development of the LDCs and let competitive contracts to private industry for development of the appropriate technologies.

5.7 Summary

5.7.1 The Opportunities

A. Awareness of and effective access to the technological needs of the LDCs can substantially expand the available range of economic pay-offs for the work of the industrial R&D laboratories in the United States.

B. Some forefront technological trends, such as in electronics and the applications of computers, that are inherently moving in the direction of light capital technology, can receive additional stimulation from consideration of the needs of the LDCs.

C. Industrial R&D staff members will have an opportunity to look at a vastly expanded range of professional problems and to work in some of the lesser-known areas of the world. The drives of the activist generation of the 60's to make this a better world to live in can find real outlets for their expression.

D. The parent corporations will acquire new channels for pay-off for their investments in R&D, for identification of new international business opportunities, and for effective public relations both here and abroad.

E. Both public and private establishments in the LDCs will acquire working access to tremendous technical resources, which can be exploited in many ways.

5.7.2 Potential Pitfalls

A. U.S. industrial R&D may be substantially irrelevant to the needs of the LDCs.

B. U.S. industrial R&D laboratories may be unable to make contact with the real needs of the LDCs or to find channels through which to make contributions that will actually be used.

C. The profit potential for U.S. business may not justify a significant effort.

D. LDC concerns about the political impact of U.S. businesses in their economies may impede true technological collaboration with U.S. industrial R&D laboratories.

E. Company positions with respect to proprietary knowledge may impede true technological collaboration with the LDCs.

F. Governmental bureaucratic situations in either the United States or the LDCs may make real contributions to development of the LDCs very hard to realize and demonstrate.

5.8 Appendix. Needs of the LDCs.

5.8.1 Problem Areas (per Harman, loc. cit.)

"Many of the poor countries are so trapped in self-perpetuating stagnation that the outlook appears almost hopeless. Characteristics common to such countries appear to be both cause and effect·

Primitive agriculture (involving a high proportion of the labor force)
Inefficient industrialization and low labor productivity.
Low income levels and a low material standard of living
Chronic unemployment and underemployment.
Deficient transportation and communication.
Low levels of literacy, education, and scientific and technological knowledge.
Chronic nutritional deficiencies, widespread health problems, and limited health care
High rates of population growth
Low levels of saving and investment, and limited accumulation of capital
Excessive dependence on foreign trade and capital
Underutilization of natural resources
Coexistence of modern and primitive industrial sectors."

5.8.2 Areas of Technological and Scientific LDC Need (as defined by existing background studies)

Post-harvest food losses.
Management systems for sustained crop production on tropical soils
Water management for irrigation.
Pest management systems for both crops and livestock.
Environmental problems of insecticides.
World-wide collections of germ plasm and of organisms injurious to crops and livestock.
Biological limits to plant productivity
Delivery of primary health care.
Water for human use.
Infectious diseases of the tropics.
Biomedically oriented contraceptive research.
Organization of new metropolitan growth and revitalization of slums.
Science and technology for smaller cities.
Transportation infrastructure.
LDC industrial research organizations, centers of support for small industries, and "productivity center" extension services.

Engineering and management institutions in LDCs.
U.S. curriculum development, teaching, research, and technical assistance programs oriented to needs of LDCs.
Research on the industrialization process.
Energy.
Enhanced use of LANDSAT.
Broadcasting and communications satellite systems.
Agroforestry.
LDC programs in marine environment.
Exchange of professors, senior scientists, engineers, or managers.
Training of U.S. experts on LDC problems.
Linkages among LDC research and development institutions.
LDC capabilities in information management, training of information specialists, and access to U.S. information sources.
Non-orthodox types of educational activities.
Development-related training by private U.S. industry and industrial training programs in the LDCs.
Incentives for development-related research in the U.S.
Reduction of tax and regulatory restrictions on technology outflow.
Coordination of tax, antitrust, and trade control treatment.
Settlement of disputes by impartial arbitration.

6. AGENDA

WORKSHOP ON
INDUSTRIAL RESEARCH AND SCIENCE AND TECHNOLOGY FOR DEVELOPMENT

Ramada Inn, Rosslyn, Virginia

Wednesday, November 8 Dinner Speech

The Challenge of Science and Technology for Development -
Mr. Charles Dennison

Thursday, November 9

9:00 Call to Order, Welcome, and Introduction -
Mr. B. K. Wesley Copeland

Motivation, Objectives, and Organization of Workshop -
Dr. Raymond C. Sangster

UNCSTD--The UN Conference on Science and Technology for Development--Challenges and Goals for the U.S. -
Mr. James Stromayer

Science and Technology for Development--Needs, Opportunities, and Constraints -
Mr. Henry A. Arnold

The Foundation for International Technological Cooperation -
Mr. Clint Stone

Realities of R&D Linkages with Developing Countries -
Mr. James P. Blackledge

Realities of Technological Development in an LDC -
Dr. George S. Hammond

Introduction to Workshop Cybernetic Discussion Sessions -
Dr. Sangster

11:45 Lunch Break

1:00 Workshop Discussion Sessions

3:15 Plenary Reporting Session - Workshop Rapporteurs

A. Opportunities for U.S. Companies in R&D for LDCs -
- Mr. Copeland
B. Potential Contributions to LDCs of U.S. Industrial R&D -
- Ms. Iris Lloyd
C. Mechanisms to Link U.S. Industrial R&D with LDC Needs -
- Mr. John Hall
D. Obstacles/Problems/Solutions to U.S. Industrial R&D for Int'l Development - Mr. Nihal W. Goonewardene

Concluding Discussion - Recommendations for UNCSTD

4:30 Adjournment

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