Research Management and Technical Entrepreneurship: A U.S. Role in Improving Skills in Developing Countries (1973)

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Research Management and Technical Entrepreneurship:

A U.S. Role in Improving Skills in Developing Countries

A Report of an Ad Hoc Advisory Panel of the
Board on Science and Technology for
International Development

Office of the Foreign Secretary

National Academy of Sciences
Washington, D.C. • 1973

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National Academy of Sciences
2101 Constitution Avenue
Washington, D.C. 20418
Office of the Foreign Secretary

September 1973

Dr. Joel Bernstein
Assistant Administrator
Bureau for Technical Assistance
Agency for International Development
Washington, D.C.

Dear Dr. Bernstein:

As the role of science and technology in the development process is better understood, a point of weakness looms: the limited capacity of developing countries to organize research and apply it productively. This report reflects an initial effort by concerned U.S. specialists to devise a U.S. technical assistance program aimed at remedying the problem.

The main theme of the report is that U.S. knowledge and experience in research and technical management can be marshaled and adapted to provide training opportunities suited to the needs of the developing countries. U.S. practice in this context is not extensive, however, and we are not as aware as we should be of the cultural and other constraints that impede the assimilation of technology by developing countries.

The report argues for an experimental approach to try out and perfect avenues of training, in concert with other countries similarly engaged, and to the fullest extent possible within the developing countries themselves.

We are pleased to note that the Agency for International Development, represented by observers at some of the panel's deliberations, has already proceeded to act on several ideas discussed in the report. We hope these initiatives will grow into a broad-based, long-term effort in cooperation with educational, scientific, and corporate institutions.

Sincerely,

Harrison Brown
Foreign Secretary

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I. Introduction

Two decades of work have been invested in building up scientific and technical institutions and manpower in the less developed countries (LDCs). It is now time to consider the results and, particularly, the means to bring about a more effective utilization of the resources that have been created.

It is generally acknowledged that LDC scientific and technical infrastructures, largely patterned on those of advanced industrial societies, have proved to be less effective than was hoped in stimulating technological change and industrial growth. Of the many explanations advanced, one is preeminent and valid for both developed and developing countries: Generating new technology does not by itself result in industrial development; invention is not a synonym for innovation. Economic growth depends on the degree to which industry assimilates and commercializes technology. Hence, melding technology and capital with entrepreneurship and management is of critical importance.

LDCs are increasing their investments in science and technology and are seeking new ways to promote the indigenous development of technology. Most technological development efforts in LDCs have centered on training scientific and engineering manpower and establishing institutions through which this manpower could be put to creative use. Today, the critical importance of the *management* in developing countries of research, development, and engineering (R, D & E)—particularly in serving the industrial sector—is widely recognized.

In workshops on industrial research conducted in Brazil, India, Indonesia, the Philippines, and the Republic of China (Taiwan), the Board on Science and Technology for International Development of the National Academy of Sciences found managers of technical organizations unanimous on the critical need to improve managerial practices.

In 1969, a workshop in the Philippines, noting the much increased resources allocated to strengthening the nation's scientific and technical poten-

tial, stated that "now the *management* of [Philippine] research efforts becomes fully as important as the research itself."[1]

In 1970, a workshop in Baroda, India, reported:

> . . . one of the serious gaps in effectively optimising and utilising the research in India comes from the managerial and organisational aspect of this effort. . . . in the absence of such managerial and organisational experience, the research effort in the country tends to become academic.[2]

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

> There already exists a substantial nucleus of dedicated and trained personnel in several government research institutes and universities. The problem of increasing their effectiveness and productivity is at the heart of more efficient management of research.[3]

In a recent (1971) WAITRO survey[4] of approximately 50 industrial research institutes of advanced and developing countries, members of the organization assigned high priority to industrial training of technical personnel, training in industrial application of R & D results and in industrial exploitation of R & D results, and training personnel for managerial responsibility.

The United Nations Industrial Development Organization (UNIDO) has done pioneering work in this field. As early as 1964, a UNIDO interregional seminar in Beirut on industrial research institutes in LDCs concluded:

> Of the many problems faced by such institutes in developing countries, that of management is of paramount importance. The problem stems from the difficulty of finding persons for appointment as institute managers or directors who have the training and experience pertinent to the requirements.[5]

[1] *Philippines–U.S. Workshop on Industrial Research.* 26 January–1 February 1969. Baguio City, Philippines. Part 1. Sponsored by National Science Development Board [Phil.], Council for Economic Development [Phil.], National Academy of Sciences [U.S.], and U.S. Agency for International Development. p. v.

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

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

[4] World Association of Industrial and Technological Research Organizations. *Priority of Needs of Industrial Research Institutes in Developing Countries.* Publication No. 3. Vancouver, 1972.

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

Conceiving its assignment to be broader than the activities usually designated as "management of research and development," the panel reviewed the gamut of technical functions involved in improving industrial operations in LDCs; it examined research management as a part of *technical management*—from quality and production control, through product and process improvement, to the development of indigenous technology or assimilation of advanced technology from abroad, and finally to project or process evaluation.

The panel discussions and the studies quoted suggest that revitalizing the R, D & E institutes in LDCs involves both the institutes themselves and the technical and management practices of their clients, be they government departments, public industrial corporations, or private industries, with the view of bringing about effective communication and interaction between them.

For historical and other reasons, the major problem in LDCs has been a lack of technical orientation in most enterprises, private and public. To simplify greatly, LDC industrial enterprises may be classified in three major groups: (1) The largest organizations, small in number and usually concerned with the export of primary products, are based chiefly on imported technology. Their productivity is kept high with continued infusion of advanced technology. (2) A few medium-sized indigenous companies produce consumer goods largely for domestic use with known technologies. Although they may have developed some internal technical competence, they need help with further improvement of products and processes or with diversification of product lines. (3) Most enterprises are small- to medium-size firms, some of which rely on dispersed household operations. They are generally outside the orbit of national research and development organizations and lack information on technical improvements that they could make. To remain internationally competitive, large organizations can, and usually do, take advantage of new technologies as they become available; the small- and medium-size enterprises, generally less aware of market opportunities and technological developments, need help from ministries or departments of industry, and from industrial research-and-extension and engineering organizations.

LDC industry's lack of in-house ability to bring about technological improvements, as well as a lack of appreciation of their importance, puts a special burden on the technological institutions that many LDCs have established. These institutions should be able to perform the necessary function of helping to educate the entire industrial sector on the types of activities that must be incorporated in the management of their operations. Such activities include, at the low end of the technical spectrum, information services, quality control, troubleshooting, and engineering adaptation. Depending on its capacity to absorb new technology, the recipient industry may need assistance on new product and process development. Technical institutions that monitor new technological developments in selected industrial fields can play a critical role

in helping indigenous industry to choose technologies that make the best use of the nation's factor endowments.

The panel noted that even in industrialized countries systematic technical management–planning, staffing, overseeing, controlling, and evaluating–is a fairly recent development and is continuously improving. Only by widespread discussion, exchange of information, and adaptation of accumulated experience will both developing and developed countries achieve progress in managing technological development.

Over the years many principles of technical management have become "universals," but, in the panel's view, differing cultural, political, and organizational behavior among LDCs may make it necessary to adapt known techniques to each LDC environment. This opinion, derived in part from observations of unsuccessful efforts to assist LDC research and development organizations, points to the influence of cultural constraints on the assimilation of technological change. Further research is urgently needed on the character of such cultural constraints in the LDCs and on ways for the LDC technical manager or his foreign collaborator to overcome or accommodate to them. Meanwhile, prior experience, sound common sense, and a consciously developed feel for cultural relativity are the best guides to solving problems in which cultural factors are suspected to inhibit progress.

Attempts to upgrade technical management in LDC institutions and enterprises immediately lead to a larger group of closely related problems that cry for equal attention. For fundamental improvement, LDCs will need to work simultaneously on many of the following fronts:

1. Formulation of national science and technology policies;
2. Structure of national research institutions, including an assessment of their organizational strength and weaknesses;
3. Identification of development priorities requiring R, D & E and planning of an integrated R, D & E capability;
4. Coordination of program objectives with national agencies responsible for industrial development, and with international agencies assisting in the process;
5. Training and utilization of scientific and technical manpower;
6. Provision of supporting elements in the R, D & E infrastructure, such as patents, licensing procedures, and scientific and technical information services;
7. Creation and administration of incentives for local and foreign industry to perform R, D & E inside the country, in both public and private sectors;
8. Creation of favorable conditions–through appropriate economic policies–for the use of R, D & E results by industry; and
9. Creation of mechanisms and institutions for monitoring technical devel-

opments outside the country and for exploiting them after appropriate techno-economic studies have been completed.

This agenda for action also identifies the target groups and institutions for technical-management training, an important first step in the panel's deliberations. The panel discussed the role of external assistance in these tasks and concluded that the responsibility for coordinating external assistance in this area, as in others, should rest with the LDCs. But donor agencies could well act in concert to maximize the value of their collective effort and to conserve their own limited resources, as well as those of the country receiving assistance, for the improvement of technical management.

II. Problems Confronting Technical Management in LDCs

Many problems in industrial research institutions in LDCs are also encountered in corresponding institutions in the developed countries. This chapter examines problems specific to industrial R & D operations in LDCs to provide a framework of topics on which to base a technical-management development program.

INSTITUTIONAL DEVELOPMENT

A basic obstacle to the effective operation of existing R, D & E organizations is their failure to attain a critical threshhold of resources and effort. Research institutions are often too small to be viable. The range of skills in a single organization is usually too limited to keep up with worldwide advances in technology, or to permit the formation of broadly based, interdisciplinary project teams. Furthermore, small organizations often splinter their activities into several isolated subunits, each inadequately staffed. Poor communications and a lack of cooperation among different units of a laboratory often worsen the general condition. Other constraints include inadequate equipment and low or fluctuating levels of funding.

Especially regrettable is the failure to use interdisciplinary project teams because, in the panel's view, such teams are vital to comprehensive solution of industrial problems. The failure is due, in part, to the prevailing hierarchical professional relationships: senior researchers are often unwilling to work on an equal footing with colleagues from other sections of a laboratory, or with competent younger staff members responsible for a project. The inability to set up project teams and address problems from an interdisciplinary perspective also stems from a lack of personnel with diverse backgrounds and skills. In most laboratories, professional staff is confined to physical scientists and engineers, with no specialists in marketing, technical economics, operations research, and the social sciences.

Because the industrial sector has been too weak to take the initiative, the

government has generally launched industrial research institutes as government agencies, with all the attendant bureaucratic problems. Recently, however, recognition that research institutions cannot thrive under rigid bureaucratic controls has led a number of LDCs to transform these institutions into self-administering organizations. Despite this transformation, other incentives will need to be created to promote greater interaction between these institutions and their clients.

INDUSTRIAL R, D & E PERSONNEL

Though the supply of LDC scientists and engineers may be growing significantly each year, careers in institutional R, D & E are severely limited by a shortage of attractive career opportunities. Salaries for technical personnel in government, universities, and technical institutions are generally low, compared with those in industry. The consequence is a serious internal brain drain of technically trained personnel into nontechnical positions and an imbalance in the quality of available technical competence between industry and research institutes, which hinders interaction between the two. (Much talent is also lost through emigration, the external brain drain.) Furthermore, lack of mobility between industry and the research establishment keeps personnel disposed to a career in institutional R, D & E from acquiring the necessary industrial orientation. In U.S. experience, open interchange of personnel has proved extremely valuable in attuning research institutes to the needs of industry and in encouraging industry to seek outside technical help. Panel members from industry emphasized the advantages of industry-research personnel interchanges, especially when the researcher receives direct, practical exposure to industry early in his research career. In LDC experience, a vicious circle exists, of unattractive employment opportunities, low demand for services, ignorance of industrial problems, and all too small a pool of qualified persons to rise to positions of institutional management. There is often a propensity to invest limited resources in ambitious physical facilities and to neglect the strengthening and enrichment of staff competence.

RELATIONSHIPS WITH INDUSTRY

At a recent meeting, directors and executives of technological institutes and industrial enterprises from 12 Latin American countries,[6] attributed many

[6] United Nations Industrial Development Organization. *Joint Consultation on the Stimulation of Industrial Research Activities in Latin America.* Bogatá, Colombia. April 19–26, 1971. (10/WG.90/5) Vienna: UNIDO.

obstacles to the use of services provided by technological institutes solely to potential clients. The panel, however, felt that since a dynamic relationship between the client and the supplier of technical services is necessary, the research institutes must share in the blame. The problems cited at the meeting and the rejoinders offered by the panel follow:

Problem: The value of the services of industrial research institutes is usually not understood by the clients they seek to serve, namely government and industrial enterprises. *Comment*: The institutes orient their public relations activities chiefly to the scientific community and neglect contacts in the industrial sector.

Problem: Industry lacks confidence in national expertise. *Comment:* Industrial confidence must be generated and sustained by successful solution by the institutes of problems referred to them.

Problem: Managers in industry are usually reluctant to seek and accept the assistance available from industrial research institutes. *Comment*: This situation exists everywhere and can be overcome only by demonstrated competence, aggressive salesmanship, and persistent effort by the institute staff.

Problem: The usually intangible benefits from industrial research make it difficult to sell. *Comment*: This universal difficulty can be met only when the institutes identify those industrial problems for which research promises a profitable solution.

Problem: Staffs of industrial research institutes encounter difficulty in gaining access to industrial plants in order to become familiar with problems of industry. *Comment*: Relationships are built over time on evidence of competent handling of problems. Technological institutes must progressively earn the confidence of industrialists. The few large enterprises have their own well-defined channels for securing technical help; the many small and medium operations have difficulty dealing with research organizations, which do not cultivate relations with them.

Problem: In the present state of industry in LDCs, industrialists tend to be concerned more with production problems than with process and product development, which makes it hard for industrial research institutes to convince them of the value of their services. *Comment*: A beginning can be made in helping industry solve immediate problems connected with production and minor alterations in product or process design. This will provide a foothold for involvement in more sophisticated research problems at a later stage. When industry finds it cannot bring its minor, immediate technical problems to a research organization, it will not be inclined to submit its major ones.

Problem: Many companies operating in LDCs are branches of multinational corporations, which usually have their own well-established central research-

and-testing facilities. Branch companies direct their problems to central facilities abroad rather than use the services of local research institutes. *Comment*: Subsidiaries must be convinced by demonstration that they can obtain prompt and effective services locally. However, LDC policymakers concerned with technology and industrialization could provide incentives to encourage multinational industry and local research organizations to interact more productively with each other.[7] In addition, the LDCs' increasing insistence on higher local content of materials and labor in products of multinational corporations will force the latter to strengthen local supplier sources. This will prompt such small national companies to turn to the research institutes for help.

ORIENTATION OF R, D & E ACTIVITIES

Applied research institutes in industrialized countries are successful to the extent that they make their capabilities and services responsive to the needs of their clients. In LDCs where neither industries nor governments have clearly asserted themselves as customers, most research institutes steer a course of their own. Consequently, their research priorities and project choices are susceptible to misorientation—to individual interests rather than community needs, to basic science instead of applied problem solving.

Lack of interaction with industry is matched by lack of communication with government bodies responsible for national planning. Seldom do national and sectoral development plans identify R & D requirements, nor is the scientific and technical community given an opportunity to analyze such plans for their technological feasibility or for their implications in terms of required R & D effort. Unfortunately, even when such opportunities are afforded, the technological institutes find themselves unequal to the task, because most of them are staffed by persons whose intellectual orientation makes them more inclined to solve basic scientific problems as a contribution to their disciplines than to apply science to solve problems within national industrial development priorities.

ACCESS TO WORLD SCIENCE AND TECHNOLOGY

The barriers to LDC access to world science and technology are now receiving careful study as part of the worldwide interest in the transfer of technol-

[7]See National Academy of Sciences. *U.S. International Firms and R, D & E in Developing Countries.* Washington, D.C., 1973.

ogy.[8] In addition to the various financial and economic factors impeding the flow of technology to LDCs is the absence in LDCs of information on what is known and done abroad in specific technological sectors. Scientific and technical information resources are poor; the indigenous stock of know-how is small and uninventoried. The informal person-to-person information networks—so efficient in advanced countries that they are a major substructure for productive research—are nonexistent. Without these deterrents to error, LDC institutes may reinvent or duplicate work already done elsewhere, or discarded by more sophisticated organizations as technically unpromising.

OBSTACLES FROM UNDERDEVELOPMENT

The problems affecting technical management in LDCs cannot be isolated from the larger group of problems that constitute underdevelopment. The panel recognized that to initiate a process of self-generating growth in which science and technology can play a legitimate role, LDCs will need to introduce far-reaching structural changes. The technical manager who has limited understanding of the scope and complexity of these processes, and who confines his attention to his own organization and its immediate operating environment, will not see the obstacles that confront him or be able to deal with them effectively. This caution applies equally, if not more, to the foreign organization or individual who proposes to give instruction to, or perform in, LDC technical management. Indeed, as one administrator from an LDC told the panel, they are often misleading.

> It is often assumed that every Ph.D. holder is capable of teaching in a university or is well equipped to manage a research unit by virtue of his degree. One does not have to look hard to come to the conclusion that such is not the case. In fact, most Ph.D. holders are not good administrators. Furthermore, good scientists who are also good administrators are few and far between. In developing countries, where the production of scientists is low keyed, the general tendency is to call on available scientists to become instant managers, not because of their ability as administrators but because of their academic achievements. I may point out that in some cases these persons are neither. In some cases scientists are appointed managers because of their political inclinations. These types of makeshift administrators have governed the scientific institutions of the developing countries and to some extent the developed countries over the years. Some of the managers have made tremendous strides; others have proved abysmal failures.

[8] For example: National Academy of Sciences. *Scientific and Technical Information for Developing Countries.* Washington, D.C., 1972; United Nations Department of Economic and Social Affairs. *Transfer of Operative Technology at the Enterprise Level.* New York: United Nations, 1972; Research Reports of United Nations Institute for Training and Research (UNITAR); and continuing output of United Nations Conference on Trade and Development (UNCTAD), Organization of American States (OAS), United Nations Industrial Development Organization (UNIDO), etc.

The business of technical management is to energize institutions engaged in developing or utilizing technology. Technical managers are as much agents of change and entrepreneurs as are those formally performing various modernizing roles in traditional societies. They should have an acute awareness of the larger aims of the society, the capacity of people and institutions to respond to rapid change, and the critical points at which useful intervention is desirable and possible.

NEW CHALLENGES FOR TECHNICAL MANAGEMENT IN LDCs

For many years, the LDCs' drive to improve their economic well-being has been based on a twofold strategy: to lessen dependence on imported goods and services and to enlarge earnings by increased exports of primary products. More recently, LDCs have sought to increase the value of their exports by additional local processing or manufacturing. More recently still, LDC governments have realized that objectives of economic growth cannot be divorced from the need to generate employment and to achieve a more equitable distribution of income.

These new concerns have great implications for technical management and technical institutions. The effort to increase exports of manufactured goods puts exacting requirements on the R, D & E capabilities of LDCs. International markets are intensely competitive in both price and quality. A nation determined to compete must improve its entire manufacturing capabilities, including quality control, engineering, production methods, and applied research.

The need to generate employment brings into question the appropriateness of the technology utilized. Some technologies exist in varying labor-to-capital ratios but require intelligent selection to make them accord with local factor endowments. Other technologies require local adaptation to increase their labor absorptiveness. In yet other instances, technology from abroad may be wholly unavailable or inappropriate; technology will need to be developed locally to make use of local resources or to meet local needs. The greatest prospects for the use of labor-intensive technology appear to lie in such sectors as housing, public works, agriculture, and agribusiness.

Agriculture, particularly, presents a great challenge to industrial research institutes. In the past, the traditional sector received scant attention from R, D & E establishments. New rice, corn, and wheat varieties, and marked changes taking place in rural economies where these varieties have been introduced, present wide opportunities for research to stimulate the development of agribusinesses. The possibilities range from providing agricultural inputs such as farm machinery, rural transport, pesticides, and fertilizers;

to treating agricultural outputs by storage, processing, new-product development based on agricultural raw materials; and to improving the rural infrastructure of roads, schools, and health facilities.

In conclusion, it is evident that designers of technical-management training programs for the LDCs will confront some problems familiar to all R, D & E organizations in their interactions with industrial clients, and some new problems and opportunities as LDC organizations prepare themselves to tackle the age-old problems of the rural sector.

III. Programs To Develop Technical Management

In the panel's opinion, training programs should be considered for three different levels of technical, managerial responsibility:

- National planners and administrators
- Institutional managers
- Project managers

The composition of these groups and suggested topics to include in courses for each are discussed in this chapter, but no attempt is made to outline detailed curricula for training programs. A selected bibliography is appended to this report.

Some general principles of management apply to all institutional and project managers who work in government agencies, autonomous technological institutes, or research and engineering departments in private industries. These principles could be isolated to provide the basis of core courses, with examples drawn from participants with experience in their application in different settings. In the LDCs, courses for composite groups have the advantage of promoting communication and understanding among different types of institutions.

FOR NATIONAL PLANNERS OF SCIENCE AND TECHNOLOGY

Most developed, and an increasing number of developing, countries, considering science and technology to be vital factors in socioeconomic development, have established national policy planning and coordinating agencies. The types, functions, and activities of these agencies vary from country to country, providing a broad spectrum of experiences from which LDCs can choose the patterns of organization best suited to their society and stage of development. Much published information on alternative structures and functions is now available.

On their boards and staffs national research organizations include administrators, planners, and specialists from ministries and development agencies

and physical and social scientists from universities. For questions related to technology, some countries have found it valuable to provide for participation of spokesmen from industrial and financial circles.

The broad functions of these national planners and entrepreneurs require training programs to include, among others, such comprehensive topics as the following:

1. The distinct and interacting roles of science and technology in economic development: increase in employment opportunities; discovery and utilization of indigenous raw materials; reduction of imports and expansion of exports; methods for reducing technological dependence; lowering costs of technological transfers; improvement of productivity in existing industries; establishment of new industries.
2. Appraisal of technical resources: national surveys of renewable and nonrenewable resources; analysis of supply and demand for technical personnel; identification of needs for improvement or expansion of technical institutions; quality control, information, standards, export promotion, management development.
3. Resource allocation for scientific and technological development: criteria for allocating financial resources for national scientific and technological development; balance between long-term basic research and applied research; measures to promote industrial investment in research and development; coordination of external assistance to scientific and technical development.
4. Measures to promote an industrial climate favorable to invention and innovation: patent policies, resources of venture capital, public awareness of scientific and technological policy issues; identification of sources of technical innovation in the society; reducing bureaucratic impediments for successful transfer of technology, including streamlining procedures for importing scientific and engineering supplies and equipment; professional associations and their role in technology transfer; industrial estates.
5. Strengthening institutions devoted to the study of national research policies: roles of technological institutes, universities, government departments, and industry in formulating national research policies, including allocation of resources, manpower development, and choice of technology.

FOR MANAGERS OF TECHNICAL PROGRAMS

This group includes the managers of technological institutes, technical agencies of the government, and technical departments in private or public enterprises. Project managers could also be included; the general principles and content of the training apply to them as well. Representatives from this

group might, and generally do, serve on national advisory committees on science and technology. A key group in the scientific and technological hierarchies of most nations, managers of technical programs should be viewed as a source of leadership and professorial talent for national management-development programs.

Topics for emphasis in a management-development program at the organizational level have received much attention in the developed countries and by now are the standard content of management seminars conducted in universities and professional and business organizations. Even today, however, few management development programs are specifically designed for managers of multipurpose, multiclient research institutes, especially the smaller institutes.

In industrial organizations of developed countries, role and functions can be covered in job descriptions; even so, it is becoming evident that the functions of a good manager transcend these descriptions. Certainly in an LDC setting, the manager of an institution is asked to perform such a variety of roles within and outside his organization that a standard management-development program rarely fits his needs. LDCs are confronted with the large task of finding individuals, who, as an LDC leader said, must perform as technological entrepreneurs though shackled by a myriad of bureaucratic impediments.

If a candidate has the personal qualities of commitment to service, energy for getting things done, and sensitivity to interpersonal relations, the following techniques could, the panel believes, help him improve the effectiveness of his organization and the productivity of his staff. The panel repeats for emphasis that these general principles and techniques must always be related to the LDC background.

PLANNING AS A MANAGEMENT FUNCTION

1. Comparing the planning processes in R, D & E with other industrial activities: technical objectives, policies, alternatives, and evaluations; national development criteria; technical feasibility, market acceptance, operating practicality, regulatory compliance, cost-benefit justification and acceptance by management.
2. Planning the phases of technological development: exploratory research, applied research, product development, process development, engineering, testing, production, distribution.
3. Integrating national and sectoral plans with the institutional research and development programs; criteria for selection.
4. Composition of planning staffs; interdisciplinary groups; training and planning personnel.
5. Technological forecasting; technological monitoring.

ORGANIZATION OF THE MANAGERIAL FUNCTION

The emergence of large-scale R, D & E programs in industrialized countries has been accompanied by the gradual evolution of managerial techniques to guide and control them. The process has not been without conflict and disagreement over the best ways to design and implement these techniques, nor is it clear to what extent they are culturally dependent. For developing countries, more experience is required to determine the most effective management systems. This is particularly true of the many small, understaffed industrial research institutes for whom the content and instructional approaches in management-development programs must be considerably simplified. The best that could be offered now is an outline of the kinds of topics included in management-development programs in several advanced and some developing countries:

1. Comparative analyses of alternative organization structures: the uniqueness of technical organizations and, in particular, conditions required to encourage innovations; analysis of the major patterns of technical organizations—by size, by discipline, by type of product, by project, by phase in the innovation cycle, by formal and informal organization.
2. Managerial functions in a technical organization: planning, programming, budgeting, staffing, coordinating, controlling, evaluating.
3. Analysis and assignment of decisionmaking responsibilities in technical organizations: delegation of authority and responsibility; distribution of management functions according to level; roles and functions of technical director, department managers, project managers.
4. Project design and administration: cost and performance controls.
5. Administration of support services: library, glassblowing, machine and electronic shops, staff travel and other logistical services.
6. Organization and management of liaison functions with government, industry, and international organizations.

EXECUTION AND CONTROL OF TECHNICAL PROGRAMS

Once a technical program has been designed and the projects selected and authorized, management concentrates on completing the assignments effectively and promptly. As an LDC specialist appearing before the panel noted, "It is often easier to start a project in a research laboratory than to stop one." Despite some new techniques for forecasting cost overruns, analyzing the operating characteristics of successive stages in a technical program and measuring individual, group, project, or department performance are still more an art than a science. Determing whether an R, D & E program is on the right track in both technical and market terms relies so much on the sophistication

of the organization and the judgment (or hunch) of the managers that it is difficult to offer many generalizations. Case studies of current experiences of LDC managers may shed some light on how financial, technical, and management controls are exercised in LDC technical programs whose budgetary systems differ widely from those in the United States.

FINANCIAL ADMINISTRATION

Many R, D & E activities in developing countries receive both initial financing and operating funds from several sources—national governments, industries, and international agencies. Financial administration is often limited to financial reporting to meet contractual obligations and bureaucratic regulations, rather than maintaining a system of managerial accounting and budgeting. In common with their counterparts in the developed world, LDC technical managers have difficulty in interpreting the intricacies of a budget for an R, D & E program to those who hold the purse strings. Financial consultants from the developed world who have mastered accounting systems of developing countries and are therefore able to teach how to improve practices within the existing LDC budgeting systems are rare. National specialists who through additional training or observation can learn to systematize financial planning and project-cost control are urgently needed in the LDCs.

A partial list of suggested topics for inclusion in a management-development program follows:

1. Financial administration at the organizational level: annual budgets, long-term financial plans, analysis of income sources and amounts.
2. Analysis of income and expenditures: gross, by projects and sectors, project and overhead expenditures, forecasting and evaluating of expenditures.
3. The budgeting process: R, D & E budgets—program, project, organization, and capital budgets.
4. Project cost accounting: defining research costs, cost controls on research, auditing research costs, management reports, public reports.
5. Research and development proposals for clients; preparation, negotiation, and administration of research contracts; financial and narrative reports to clients.

MANAGERIAL STYLE AND PERSONNEL PERFORMANCE

It is clear that management style influences the climate of an organization and its staff's performance and that certain recurring factors contribute to effective technical management, but it is much less apparent what these spe-

cific factors are and what their relative importance is. Social and behavioral psychologists are adding to our understanding of the motivational factors that characterize a good manager, but the sensitivity of these factors to cultural influences in developing countries remains to be explored. Research is needed to test in LDC settings the several hypotheses that have become dogma in management training in developed countries. Topics that need to be subjected to further investigation include: (1) the dual hierarchy—technical and managerial—in research; (2) the transition from scientist or engineer to manager; and (3) interpersonal relations in an LDC technical organization. Perhaps of much more limited application are (4) decision theories applied in other cultural settings; (5) decisionmaking under uncertainty; and (6) quantitative techniques in decision making.

During the past decade many LDCs have concentrated on improving physical facilities of technical organizations. Today, it is recognized that behavioral factors at individual and group levels often inhibit progress even after problems of inadequate equipment and remuneration have been solved. As international conferences on the effectiveness of industrial research laboratories in LDCs have frequently pointed out, questions on status and value orientation of the professional staff must be resolved before technical organizations can play the dynamic part in development for which they were created. Among the aspects to be considered are (1) the rigidities of civil service regulations that hinder mobility and stifle creativity, (2) distortion of interpersonal relations in a hierarchy, and (3) nonobjective criteria used to evaluate performance.

EVALUATING R, D & E ACTIVITIES

Although evaluation and feedback appear at the bottom of some lists of managerial functions, they are matters of continuous concern in the exercise of managerial responsibility. The idea of systematic evaluation is, however, quite new in developing countries (in developed countries, too), even though frequent commissions and committees of review are part of the national political scene and a common recourse of the civil service. Comprehensive reviews of the objectives and functions of technical organizations are often prompted by external funding agencies, but program and project evaluations occur only on an ad hoc basis.

An overall review—defining the scope of a technical program, developing criteria for program selection, scanning industrial sectors for specific projects, and evaluating the institute's capability to undertake serious development of

the projects chosen—leads next to evaluation of technical productivity and market acceptance of the project or process so developed.[9]

Technological entrepreneurship implies a combination of managerial, technical, and business skills, as well as personal characteristics, which are harnessed for the initiation and profitable development of a new technical venture, within an existing organization or an entirely new operation; therefore, the goals of management-development programs should be to identify the persons with these capabilities, to provide them with the skills and techniques of management, and to heighten their awareness of the importance of interpersonal relationships in an organization and motivation of fellow workers toward shared goals. Industrial countries give special attention to the support and encouragement of technological entrepreneurs, who are seen as principal agents in maintaining a high rate of technological development, especially in new, and often risky, fields. Entrepreneurship per se has held the attention of development specialists for some time, but the more specific attributes of the entrepreneur-cum-scientist, -engineer, or -technologist in the development process have received scant attention. The characteristics of technological entrepreneurs, the environmental factors that promote or inhibit entrepreneurship, and the ways to promote these qualities within an organization should be examined by LDC research administrators and technical managers to determine the responsibility of their organizations in assisting these entrepreneurs and improving their own management skills.

Another emerging subject that should interest technical managers, at any level of responsibility, is the process of technology transfer within the country and across national boundaries. It is extremely important for technical managers the world over to know more about

- Enterprise-to-enterprise technology transfer through wholly owned subsidiaries, joint ventures, technical-service agreements, licensing, engineering and construction contracts, management contracts
- Sources of nonproprietary technology
- Impact of alternative technology-transfer modes on local development
- New approaches to reducing costs of technology transfers
- Techno-economic feasibility studies
- Management information systems on technologies appropriate to the local economies.

Despite a burgeoning literature on this subject, successful experiences in technology transfer in the LDCs are only slowly finding their way into the

[9] See UNIDO. *Industrial Research Institutes: Guidelines for Evaluation.* Prepared with assistance of Lawrence W. Bass. (E.71.II.B.21) New York: United Nations, 1971.

case-study materials used in management-training programs. The panel felt that programs to develop technical management could be instrumental in developing case studies for wider dissemination among universities, business schools, and management-training agencies.

FORMS OF TRAINING

Because of the variety of management-training procedures available, and the need to adjust them to the different levels of technological development among the LDCs, the panel strongly recommends pilot efforts to test the relative merits and efficacy of each approach. In the panel's view, the major objective of programs for developing technical management should be to generate in each LDC a local cadre of competent managers who can provide the major direction for internal programs, with assistance from external sources called in only when local expertise in a particular area is deficient.

The question of locale—whether training should take place in a developed country, the LDC, or a third country with a higher level of expertise in technical management—cannot be answered dogmatically. Each place has advantages and disadvantages in terms of cost, number of individuals who can be trained, time participants can spend away from regular duties, and transferability of experience to the trainees' home country. A realistic approach is perhaps a mix of locales, with an increasing amount of training taking place in the LDC itself as its managerial competence grows.

A discussion of different forms of training follows.

ON-THE-JOB TRAINING

On-the-job training ranges from informal internships to structured programs in large organizations. Unfortunately, it is often training in name only because the trainee receives authoritarian direction instead of an opportunity to learn through actual participation in decisionmaking. A beneficial policy would be to specify that training subordinate staff in managerial techniques is an essential part of each manager's duties.

On-the-job training, of course, includes learning in another organization; for LDCs, usually in an appropriate organization in a developed country. Unless such programs are well-structured and last at least 2-3 months, the experience will amount to only superficial exposure to new techniques and managerial skills. Younger, up-coming managers should be able to invest a longer period in such training.

OBSERVATION TRAINING

Accomplished through visits to other organizations, observation training is especially suited to senior officials who cannot leave their jobs for long but can profit from an overview of how other institutions operate. It does not provide in-depth study of basic managerial techniques.

WORKSHOPS

Short workshops on carefully specified topics for groups of managers are valuable forums for discussing common problems and specific solutions developed in participating organizations.

MEETINGS AND CONFERENCES

Meetings and conferences offer an opportunity to hear formal presentations by acknowledged leaders and to make personal contacts with other R, D & E managers. Their value is enhanced if they are combined with small working groups to discuss pertinent topics.

FORMAL COURSES IN TECHNICAL MANAGEMENT

Formal courses in technical management are common in developed countries and, more recently, in LDCs. Flexible in length, sponsorship, and structure, they are more effective when groups are not unwieldy in size. Their relatively low cost per participant is an advantage.

COMPLETE ACADEMIC PROGRAMS ON TECHNICAL MANAGEMENT

Complete academic programs began to be organized only recently. Formerly, technical management was a subject of specialization in the general curricula of a few schools of management. Now that the institutional and disciplinary lines are dissolving among industrial engineering, business management, systems engineering, and engineering economies, an interested student can select many courses that emphasize technical management, to obtain, in some universities, a graduate degree.

Experience in actual management of technical programs is essential background for teachers in any training program. Teaching materials that pay special attention to the needs of LDCs should be selected from the large amount of literature on R, D & E management, which is directed mainly at problems in the developed countries. (A selected bibliography is appended to this report.)

IV. U.S. Expertise and Technical-Management Training in LDCs

In considering ways to mobilize U.S. expertise in technical management to assist the LDCs and to approach its recommendations logically, the panel examined briefly the evolution of U.S. expertise, reviewed the status of technical-management development needs in several LDCs, and then set out to identify certain elements in the U.S. experience that may relate to the problems of LDCs.

To keep within its terms of reference, the panel focused on the problem of making U.S. experience and resources available to LDCs. Nevertheless, the panel recognizes that many other developed countries, alone and in concert with UNIDO, have been usefully involved in both general and technical-management training programs in LDCs and hopes that future programs to meet the continuing needs of LDCs in technical management will profit from the rich experiences of these countries.

U.S. COMPETENCE IN TECHNICAL MANAGEMENT

In the course of 50 years, the United States has established a large, diversified, and productive applied-technology complex, thereby acquiring valuable information, insights, and experience in industrial development and technical management. This growth was achieved essentially without central direction; it evolved as the technical and industrial communities identified market opportunities and mobilized physical and intellectual resources to reach higher productivity and profits. Recognition of the deleterious consequences of unbridled technology is once again prompting a shift through R & D from sheer exploitation of market opportunities to a greater concern for societal needs and well-being.

PROMOTIONAL EFFORTS TO CREATE A FAVORABLE INDUSTRIAL CLIMATE

Promotional efforts have been based on the philosophy that it is not enough merely to create new science and technology; opportunities for their application must be pursued with great vigor.

Over the years, yardsticks and practices emerged for setting specific levels of corporate technical expenditures, for elevating R, D & E managers to top executive status, and for publicizing technical advances in company reports and the media. As a consequence, recognition has come about that national welfare is intimately connected with technological progress—a recognition tempered recently by concern with the effects of technology on the quality of American life.

IMPROVEMENT OF TECHNICAL MANAGEMENT

With the sizeable growth of corporate and governmental investment in R, D & E, technical managers were propelled to top echelons of organizational management; they were also put under great pressure to increase the productivity of these investments through the application of scientific methods of management. The concept of project systems to organize and control programs came to be adopted. An increasing volume of literature on technical management appeared. Discussion groups for R, D & E executives were organized, the first in 1923. University courses on R, D & E management were instituted as early as 1937. In more recent years, attention has been paid to incorporating social science concepts into the philosophy and practice of technical management.

These developments paralleled a growing emphasis on using the scientific method in business management, reflected in the establishment of special schools in many universities. Strangely enough, schools of business management have only recently included technical management in their general curricula, although individual faculty members have focused attention on the subject.

EVALUATION PROCEDURES

As corporate R, D & E expenditures increased, qualitative and semiquantitative methods of evaluation (including cost-benefit analysis and programming-planning-budgeting systems, or PPBS) were introduced. Unfortunately, direct measurement of the effectiveness of an entire R, D & E program is still difficult although it is generally agreed that individual major projects should be subjected to such scrutiny. Unlike sales and production, research departments do not generally have direct control of, or responsibility for, implementing

their findings. To ensure greater objectivity, the use of outside consultants for evaluation has been a salutary precaution.

Some facets of technical management were illuminated by collecting and analyzing extensive national statistical data; the size and nature of R, D & E programs were revealed for closer scrutiny. Systematic analysis produces data showing the allocation of R, D & E expenditures by sector, industry, and product and permits the individual firm to judge its expenditures against others.

INSTITUTIONAL DEVELOPMENT

In the United States, technical consultation for the private sector and involvement of university faculty as consultants began within the past century. A nonprofit contract research institution was established in 1907, and such organizations have greatly expanded in size and number since World War II, as have university and government research enterprises.

As said earlier, technical institutions grew in response to actual demand for service from industry and government rather than from central planning. Since the onset of World War II, however, heavy expenditures of government funds to support various mission-oriented projects have stimulated growth of R, D & E in industry, technical organizations, and universities.

EVOLUTION OF SPECIAL DISCIPLINES

Recognition of the importance of systematic planning, including its technical aspects, as a corporate function has been a major feature of U.S. development. It has stimulated the growth of techno-economic disciplines such as process engineering, industrial engineering, systems engineering, market research, information systems, and the use of interdisciplinary approaches.

TECHNICAL ENTERPRENEURSHIP

In the earlier days of applied R, D & E in the United States, new ventures were often carried through from small-scale work to commercialization by individual technical entrepreneurs active in all stages of the process. As professional specialization grew in large organizations, some form of group entrepreneurial action became necessary—in reality an interdisciplinary approach stimulated by the dissolution of barriers between organizational units. An open social and institutional structure favors this approach. There is a recent trend, however, to return to the practice of putting an individual entrepreneur in charge of a venture company to bring major innovations from the laboratory to the marketplace.

U.S. EXPERIENCE IN LDCs

In the past 20 years, the growth of international corporations and U.S. involvement in overseas development activities have given many technical specialists from the United States valuable experience in the transfer of technology to LDCs. These individuals, who come from industrial-research institutes and consulting organizations, private industry, university faculties, government departments, and suppliers of equipment, represent an important resource for continued U.S. participation in overseas development activities. The first formal training course in technical management in an LDC was presented under U.S. auspices in 1964.

OPPORTUNITIES TO HELP DEVELOP TECHNICAL MANAGEMENT

In the panel's opinion the United States, with its experience and background in technological development, can make a significant contribution to LDC development of technical management. Several salient techniques, described below, can be transmitted through the management-training methods discussed earlier and, in particular, through joint teams of U.S. and LDC personnel participating in special projects.

ANALYSIS OF TECHNO-ECONOMIC POTENTIALS OF INDUSTRY

U.S. development specialists, working with counterpart economists and technologists, have carried out analyses of this type in several LDCs. Preliminary surveys can reveal the industrial opportunities that make optimal use of available resources to supply new or modified products to satisfy the market.

The various industrial sectors should be examined from the standpoints of potential growth rates, technical and economic feasibility of new ventures, and incentives required for expansion. Surveys of this nature are often conducted by economists alone, but to ensure validity, technologists should participate actively in such analyses.

INVENTORYING HUMAN AND INSTITUTIONAL RESOURCES FOR RESEARCH

The following subjects are essential to the scientific and technical planning in which the United States has achieved high competence and the capability to transfer the requisite skills.

1. Supply of, and demand for, technical manpower;

2. Technical establishment surveys;
3. National R, D & E expenditures, including level of effort, by field and problem areas;
4. Monitoring of compensations of technical personnel, and of level of effort by field and problem areas;
5. Technological forecasting;
6. Science information and documentation systems.

DETERMINATION OF INDUSTRIAL NEEDS FOR TECHNOLOGY

Systematic surveys are needed to determine industry's need for technical assistance obtainable from national or international sources. These surveys should take into account the priorities derived from the analysis of techno-economic potentials mentioned earlier. Not only the type of manufacture but also the scale of enterprise should be considered. Studies of this type have been conducted by U.S. contract organizations and consultants for many years in the United States and in LDCs.

SELECTION AND EVALUATION OF IN-HOUSE PROJECTS

U.S. industrial and institutional laboratories have learned by experience that to avoid unproductive work on projects selected by their research staffs, early techno-economic evaluation is necessary. U.S. laboratories have been obliged to set up careful screening procedures to determine the intrinsic merit of projects and to consult frequently with the entrepreneurs and company managers who might utilize or commercialize the results of the research. Especially when a new venture firm is being established to commercialize a new idea or product, the research department is called upon to maintain continuous consultation on all aspects of the new venture.

PROJECTION OF MANUFACTURING ECONOMICS FROM SMALL-SCALE WORK

The importance given to estimating production costs and plant investment at the earliest feasible stage in the investigation, without hampering the creativity of the research staff, is a salient feature of U.S. research management. Development engineers have perfected techniques for such analyses, and a large volume of literature has been published on this subject.

A few technological institutes in LDCs have acquired expertise in production economics, but, unfortunately, most ignore the need for it. One of the most valuable contributions U.S. development engineers can make is to help transfer this know-how through intensive training courses.

MARKET ESTIMATIONS

U.S. companies and the consulting organizations serving them have accumulated a wide experience in market research, on both consumer and industrial products. Despite considerable published information on consumer-research methods, much of the know-how on industrial market research is not readily available in published form.

PREPILOT PLANTS FOR STUDYING MANUFACTURING FEASIBILITY

To avoid the heavy expense of installing and operating large pilot plants, U.S. development engineers have found that mechanized prepilot, or "desk top," small-scale models are satisfactory for studying new products and processes. When the technology is not radically different from existing know-how, the results can be scaled up to commercial size. Prepilot plants can provide insight into the possibility of developing "intermediate technology" more appropriate to the LDC economic environment.

COORDINATION OF TECHNOLOGY WITH PLANNING CONCEPTS

R, D & E departments in the United States have acquired wide experience in coordinating technical programs with overall corporate development plans. Coordination requires technical participation in making plans and adjustment of technical programs to meet the objectives. Such experience would help LDCs make more effective use of their resources to attain their industrial development goals.

INTERDISCIPLINARY TEAMS

A common feature of the U.S. industrial culture is the work of interdisciplinary teams in carrying an idea through from laboratory or model-shop scale to commercialization. This interdisciplinary approach departs from the traditional, cell-like structure of organizations and encourages a sense of group entrepreneurship.

V. Conclusions and Recommendations

Based on the foregoing analysis, the panel believes that the following principles should guide a U.S. program to improve technical management in LDCs.

1. New ideas permeating development thought—on mobilizing science and technology for solving development problems, on selecting and using technologies that will minimize harm to the environment, on realigning policies to promote employment through better utilization of technology, on helping the poorest groups in LDC societies—will in the 1970s give rise to programs requiring LDCs to have vastly improved competence in technical management. That the present deficit in technical management is a limiting factor to development should receive explicit recognition within the entire U.S. aid program. Each assistance project should be assessed from the standpoint of whether it contributes to the improvement of recipient's technical management capacities. New initiatives in technical-management training should be closely linked with technical-management activities that are integral parts of conventional development projects.

2. Given the still rudimentary experience in organizing comprehensive technical-management training programs for LDCs, the approach to be followed in program development should be gradual and selective, giving first emphasis to pilot experimentation. This approach should reveal which of the many elements in technical management are most transferrable, by which method, and within what cost boundaries with the goal of building up a U.S. aid capacity that is tested, flexible, and responsive to the needs of the LDCs.

3. The single most important goal of technical-management training should be to institute technological entrepreneurial qualities in the participants, be they from the research institute or from industry. It is essential that these two communities working at the two ends of the innovation continuum—one generating and the other using research results—be motivated by common objectives and outlook.

4. A major objective should be to implant within selected LDCs a cadre

of personnel, institutional resources, and other means adequate to sustain an ongoing, indigenous action for the improvement of technical management.

5. Until LDCs achieve this capability, the United States should commit itself to an effort endowed with assured continuity and coherence. Episodic, ad hoc programs will not be responsive to the need.

6. Several advanced industrial countries have great competence in areas of technical management and have an important contribution to make in assisting LDCs. The United States should actively encourage their interest and participation in this endeavor, which will meet the critical need only by commitment of resources and coordination of effort on the widest multilateral basis.

7. Several LDCs that have achieved an intermediate level of development and have acquired institutions or established practices of recognized quality should also be encouraged to participate. Their experience and their proximity to other LDCs in the region may help facilitate the organization of training programs on a larger scale and at a lower cost than possible in the United States or other advanced countries.

8. Programs should be designed to take into account, and to adapt to, the profound variations in local and regional conditions.

RECOMMENDATIONS TO THE U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

1. A SPECIAL UNIT OF THE OFFICE OF SCIENCE AND TECHNOLOGY, BUREAU FOR TECHNICAL ASSISTANCE

To provide a focus within AID, it is desirable that the Office of Science and Technology establish a position with clear responsibility for promoting and coordinating technical-management training programs, filled by a staff officer with experience in industrial technical management and familiarity with industrial conditions in LDCs. The office would monitor projects in technical-management training contracted with qualified institutions.

An advisory board or committee would be helpful in designing and orienting the program. Such a group should include representatives from industry, contract-research organizations, government laboratories, management schools, technical schools, and technical societies—all selected because of their interest in technical-management as a profession and their familiarity with technological activities in LDCs.

2. KEY ELEMENTS OF PROGRAM

The proposed key elements of the program to be undertaken, either within AID or through contracted services, are as follows:

a. An information clearinghouse should be maintained on U.S. and third-country sources of assistance[10] in management training and development. The clearinghouse function should include monitoring of LDC technical-management needs and evolving capabilities.

b. U.S. efforts in technical-management training and development should be coordinated with those of international and bilateral agencies concerned with, or engaged in, similar programs, including the following:

United Nations Industrial Development Organization
United Nations regional organizations
World Association of Industrial, Technical, and Research Organizations
Organisation for Economic Co-operation and Development
Organization of American States
International Bank for Reconstruction and Development
Bilateral technical assistance programs of other industrialized countries
Regional and national development banks for Asia, Africa, and Latin America

A principal objective of such coordination should be to identify gaps in present training activities in order to formulate specific training activities to fill them.

c. Clearinghouse data should be based on a systematic canvas of U.S. government laboratories, contract research organizations, and industrial firms. Although concern for security severely limits prospects for on-the-job training in industry, information on existing possibilities is uncertain and incomplete. However, multinational companies are increasingly aware of the need for indigenous R & D capability to provide required support services for the companies' local suppliers. Thus, possibilities for in-plant training, either in the United States or in an LDC, can be expected to improve. Several U.S. government laboratories have a record of successful participation in technical-management training. They are especially suitable for management staff of LDC public-sector institutions, particularly those involved in providing technical services.

On-the-job training should be directed toward providing

- Practical experience in putting R & D results into industrial practice;
- Management skills to motivate and orient R & D staff to seek solutions to actual industrial problems;

[10]See U.S. Department of State. *Technical Cooperation Training Resources Catalog.* Office of International Training, Agency for International Development, Washington, D.C., 1972; and *Selected Training Opportunities for Industrial Development*, a catalog published periodically by UNIDO (Vienna).

- Guidance in developing capability for "selling" R & D as a mutually profitable service;
- Training of young staff in industrial R & D.

d. A series of carefully designed specific training projects in the United States and the LDCs for technical management should be developed on a pilot basis. Successful projects can become models for wider-scale programming in the future. Insofar as possible, these projects should be carried out jointly with LDC institutions and personnel.

Primary emphasis should be placed on training for technological entrepreneurship rather than on research administration narrowly conceived.

Management-development programs, at either the institutional or national level, are necessarily long-term undertakings. In the design of any project, therefore, provision must be made for periodic follow-up review and project evaluation to assess the effectiveness of the project.

It is important also, in the design of a specific project, that LDC personnel in training be prepared and encouraged to introduce and administer such training projects within their own organizations.

Management-training programs designed specifically for multipurpose personnel of industrial research institutes in the LDCs are, in the panel's opinion, most urgently needed to enable these organizations to play a leading role in technological development.

The following specific pilot projects are among those that should be considered at an early date:

(1) A systematic supply-and-demand survey of technical manpower in an LDC to identify needs for technical-management training and to develop training modalities to suit local conditions. Such surveys could be conducted jointly by U.S. and LDC personnel.

(2) A comprehensive survey of institutional resources for technology conducted on a similar joint basis in selected LDCs.

(3) Courses in technical management for the benefit of students from LDCs in the general curricula of several U.S. schools of business administration or engineering. Similar courses in LDC business or engineering schools with financial provision for collaboration in the preparation of needed R & D case materials.

(4) Special short-term training on the characteristics of technological innovation for LDC students who lack technological backgrounds but expect to ascend to executive positions in development banks, planning ministries, or other public bodies.

(5) Short-term, workshop-type training courses in technical management for managers of technological institutes, industrial laboratories, and

government technical agencies. Linkages should be established between U.S. contract-research organizations, industrial laboratories, and LDC technological institutes with the objective of ultimate transfer of training capability to an LDC organization.

(6) Assistance to LDC technological institutes for development of technical extension services that provide technical and managerial help to small and medium firms.

(7) Workshops for LDC technological institutes on the methodology for economic feasibility studies and market analysis of consumer and industrial products. Emphasis to be put on the importance of these tools for identifying R & D projects of potential interest to industrial users and as a method of securing contracts for R & D by the institutes.

(8) Carefully selected pilot efforts to encourage LDC technological research institutes to transfer technological innovations developed in their laboratories to the marketplace through venture-capital firms. These pilot experiences should be aimed at providing realistic training for managers of these institutions and, in addition, helping these institutions achieve their true mission of being of service to industry.

RECOMMENDATIONS TO LDCs

The recommendations addressed to the LDCs are intended to stimulate local initiative for a comprehensive effort in technical management. The measures proposed would establish a basis for requests for specific types of assistance from U.S. and other organizations.

1. FORMULATION OF A NATIONAL POLICY FOR TECHNOLOGY

A number of LDCs have established national bodies to coordinate scientific activities; some have begun to formulate national science and technology policies. However, because their members often come mainly from academic communities or are unfamiliar with industrial problems, their interest tends to center on scientific research rather than technological development as such.

To secure a better balance, the panel urges LDCs to recognize and pay special attention to aspects of technology policies that are distinct from those bearing on scientific and educational development but perhaps sensitive to domestic and international economic stimuli. A sound national technology policy must provide for aggressive development of indigenous technical-management capability.

2. ASSESSMENT OF TECHNICAL RESOURCES AND NEEDS

No adequate plan for developing technical management can be formulated without an objective assessment of resources in trained manpower and the capabilities of technical institutions, as well as their potential for improved performance, to help to meet national goals. Methodologies for making such surveys have been developed in the United States and elsewhere; assistance would be available from contract-research organizations and universities for collaborative assessments of physical and human resources for technological development.

3. TECHNICAL SERVICES FOR SMALL ENTERPRISES

In developed and developing countries alike, large-scale enterprises generally have the resources and competence to mount management-development programs; small- and medium-size industries do not have access to outside technical assistance and are unable to meet the costs of technical-management development. Preferential policies to aid small- and medium-size enterprises, the backbone of the industrial sector in LDC economies, should be adopted.

4. FINANCIAL R & D INCENTIVES TO INDUSTRY

To stimulate the measures just listed, LDC governments should provide fiscal incentives to industry for R & D not only to improve products or processes but also to upgrade the technical and management competence of staff. Such incentives could be provided through cost-sharing or tax relaxation.

5. LOCAL AND REGIONAL INDUSTRIAL-RESEARCH MANAGEMENT ASSOCIATIONS AND PROFESSIONAL SOCIETIES

An important factor in the improvement of U.S. technical management has been the organization of groups for discussion and study of common managerial problems and for arrangements for training of present and prospective managers. Similar groups have been established in Western Europe and Japan. Forming such groups requires local initiative and leadership, and deserves official support. Leadership in the creation of such associations should properly come from LDC technological institutes, but development banks, governments, and industry should contribute to their support.

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