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AID/csd-3360  
ISN-33696

ADAPTATION OF INDUSTRIAL AND PUBLIC WORKS TECHNOLOGY  
TO THE CONDITIONS OF DEVELOPING COUNTRIES

Grant Number AID/csd-3360

Final Report to

Office of Science and Technology  
Agency for International Development  
United States Department of State

Technology Adaptation Program  
Massachusetts Institute of Technology  
Cambridge, Massachusetts  
September 1977

161  
196-5

TAP Report Number 77-12

## ACKNOWLEDGEMENT

The Technology Adaptation Program has been sponsored through a grant by the Agency for International Development, United States Department of State. The views and opinions expressed in this report, however, are those of the Program participants at the Massachusetts Institute of Technology and do not necessarily reflect those of the sponsors.

## TABLE OF CONTENTS

	<u>Page</u>
Acknowledgment	ii
Table of Contents	iii
I. Statistical Summary	1
II. Narrative Summary	2
III. Accomplishments of the Program	4
A. General Background and Purpose of the Grant	4
B. Organization and Management of the Program	5
C. Objectives of the Grant	6
D. Responses to Objectives	8
1. Research	11
2. Institution Building	11
a. Institution Building at MIT	11
b. Institution Building Overseas	15
3. Separately Funded Activities Generated by TAP	15
4. Special Programs in Colombia and Egypt	18
a. Colombia	19
b. Egypt	21
IV. Proposed Continuation of the Program at MIT	28
A. Development of Institutional Ties	28
B. Collaborative Research	29
C. Educational Opportunities	29
Appendix A: Individual Research Projects	
Appendix B: Institution Building: Meetings, Workshops, Seminars	
Appendix C: Institution Building: Course Development	
Appendix D: List of Publications	
Appendix E: Activities Related to Technology Adaptation Program	

I. STATISTICAL SUMMARY

Title: Adaptation of Industrial and Public Works  
Technology to the Conditions of Developing  
Countries

Grant Number: AID/csd-3360

Grantee: Massachusetts Institute of Technology

Program Director: Fred Moavenzadeh  
Professor of Civil Engineering

Period of the Grant: December 1, 1971 to September 1, 1977

Amount of the Grant: \$900,000

## II. NARRATIVE SUMMARY

A grant from the United States Agency for International Development entitled "Adaptation of Industrial and Public Works Technology to the Conditions of Developing Countries" provided the initial support for the establishment of a Technology Adaptation Program at MIT, designed to strengthen the Institute's ability to carry out research, analysis, education and training in this area.

Since its inception, the Program has provided funding for numerous research projects. Faculty and students in several departments have participated in investigations covering a wide range of research areas, such as:

- Development and testing of basic performance standards for urbanization and housing technologies in Kenya.
- Adaptation and implementation of research techniques developed previously at MIT to urban passenger transport systems analysis in Latin America.
- Development of an evaluation framework for the analysis of freight network alternatives in Latin American countries, and a subsequent in-depth survey of commodity flows in Colombia.
- Documentation and analysis of the experience of business managers in African countries in promoting economic development and the transfer of technology.
- Development of an electromagnetic prospecting technique for locating groundwater in arid regions.
- Evaluation of labor substitution techniques in road construction projects in Nepal.
- Investigation of the utility of systems analysis in national planning efforts related to food and nutrition problems in Central America.
- Analytical and experimental development of two small water turbines suitable to conditions in rural Colombia.
- Application of a framework for technical and economic evaluation of appropriate technology to several irrigation pumps currently in use in developing countries.

The program has attempted to fund projects which will build upon its already substantial ties with emerging nations and develop collaborative relationships with various institutions in selected countries, and, in the process, give the MIT community "real life" experience in dealing with the problems of technology adaptation and transfer. This TAP-funded field experience and the enhanced expertise of both faculty members and students has allowed MIT to increase that portion of the curriculum which deals with the problems of developing nations, and has also provided the impetus to initiate other ongoing research programs.

During the final two years of the program, emphasis was placed on developing overall programs in two countries, Colombia and Egypt. It was expected that active

ties would be developed with specific institutions in these countries which would enable the research programs to become self-supporting to a greater degree than had been the case previously. As a result, in 1978 the Program entered into a separate contract with AID to undertake a collaborative technological planning program with Cairo University, in order to assist them in developing capabilities which will contribute to the formulation and implementation of science and technology related policies to the end of aiding the realization of development goals of Egypt.

The enthusiasm generated by the Program, the increased sensitivity of the MIT community to the needs of the developing nations, and our enhanced awareness of the various social, economic and political tradeoffs inherent in any transfer or adaptation of technology testify to the success of the Program as a whole. Most importantly, the proven capability of the TAP to generate additional funding has insured the continuation of the Program's activities beyond the termination of the initial grant.

### III. ACCOMPLISHMENTS OF THE PROGRAM

#### A. General Background and Purpose of the Grant

In 1971 the Massachusetts Institute of Technology entered into an agreement with the United States Agency for International Development under which the Institute proposed to establish a program concerned with the transfer and adaptation of public works and industrial technology to the conditions of developing nations. MIT planned to integrate research projects and institution building within the context of a multidisciplinary program, drawing upon the Institute's existing body of knowledge dealing with industrialization and the process of development.

The Technology Adaptation Program has sponsored projects in a number of diverse areas of specialized knowledge; each project, however, has focused on some aspect of technological transfer, adaptation, or development. Some have dealt with broad areas of development -- infrastructure, economics, long-range planning. Others have focused on more narrowly defined topics -- the development of a specific technique, the utilization of a nation's unique raw materials, the case study of a particular problem in a particular region. The element binding together these varied projects is the desire to strengthen the Institute's ability to creatively apply technologies to the individual needs of developing nations, an objective which is also part of the MIT community's continuing interest in expanding the possibilities for applying technology to societal problems. In addition, since approximately 20 percent of the student body at the Institute is foreign, many from various developing countries, a special incentive has been felt to devote research and teaching efforts to discovering solutions which can be applied to developmental problems in these students' home countries.

## B. Organization and Management of the Program

Management of the Technology Adaptation Program has resided in a Director reporting to the Provost of the Institute. The Director has also reported to a Steering Committee, composed of professors from the Departments of Civil Engineering, Electrical Engineering, Management, Political Science, and Urban Planning. The committee's principal function has been to select specific projects for funding. In selecting these projects the Committee weighed a number of factors. The members first assessed the potential of the proposed project for improving our understanding of the processes enabling technology to contribute to industrialization in the less developed countries. They then explored the extent to which the project might contribute to MIT's long-term research capabilities in the area of technology transfer and adaptation and encourage institution building both within the Institute and in the emerging nations. The potential research contribution was judged both in terms of its ability to refine research techniques and orient them to the conditions of less developed nations. Emphasis was also placed upon the potential of each project for work beyond the initial phase supported by the Grant.

In 1976, when a separately-funded collaborative program with Cairo University was initiated, an Executive Committee was appointed to oversee the specific activities of this program. The TAP Steering Committee has continued to act in an advisory capacity to the MIT/Cairo University Technological Planning Program, providing advice and guidance in regard to how this program can optimally contribute to the academic and research goals of the Institute.

### C. Objectives of the Grant

The Program's objectives were set forth as follows in the proposal submitted to the AID Development Institutional Grant Program in August 1971:

"MIT's initial effort under this program [is] directed toward better understanding of the processes that enable technology to contribute to industrialization in the less developed countries, with emphasis on the following:

- 1) Understanding the kinds and characteristics of technologies that are appropriate to countries or regions in various early stages of industrial development, particularly those countries in which the factors of production have relative values different from those of developed nations.
- 2) Identifying the skills and criteria required to select and adapt technologies appropriate to the developing countries; examining the techniques for strengthening these skills, including technical education and appropriate design of products, processes and plants suited to the conditions.
- 3) Understanding the processes by which technological and managerial knowledge and skills can be effectively introduced, disseminated, and used in developing countries, including an understanding of cultural impediments and the obstacles to technological development that have been encountered in the past, and developing methods of improving the transfer and diffusion rates.
- 4) Examining, at the national and enterprise levels, the long-term and short-term economic and social advantages and disadvantages of importing rather than establishing indigenous manufacturing technology as these relate to technology and transfer.

- 5) On a case basis, finding effective technical solutions to be adopted or further developed by developing countries, including adapting existing technology for local conditions and needs or devising appropriate new technical solutions.

MIT will not attempt to cover all areas of technology but will concentrate on those which are of broad interest to both MIT and the developing countries."

#### D. Responses to Objectives

The original proposal for the program was written in rather generalized language to allow a broad interpretation of the objectives so that a wide spectrum of activities could be incorporated under the Program's sponsorship. It was indicated that the Institute would use Grant funds for the following Program Elements: (1) course and curriculum development; (2) workshops and conferences; (3) fellowships and student stipends; (4) library and resource materials; (5) establishing linkages with LDC institutions; (6) travel; (7) research; and (8) faculty development.

During the final two and one half years, the efforts of the Program were focused mainly on two countries, Colombia and Egypt. It was determined that the Program's abilities and resources could be most usefully employed in countries which had already created a sound technological base and were in the process of developing more sophisticated technical capabilities, and which still required a certain amount of assistance from and cooperation with institutions in the United States, such as MIT, in order to attain such advanced capabilities. Only those technological areas for which mutual interest was found both at MIT and in the developing countries were explored, and a shift took place to emphasize "soft-" rather than "hardware" solutions to problems of technology transfer and adaptation. The problems of implementing appropriate technologies were stressed, although research was still sponsored on purely technical problems when such promising opportunities arose. By concentrating on two countries it was expected that the various projects undertaken would become mutually supportive to a much greater degree than had previously been the case.

This revised approach was undertaken in accord with the AID Policy Determination Memorandum of October 1974, which states that the object of

211(d) grants is to build or enlarge upon educational and research abilities by creating, adapting, and strengthening the competence and experience of the grantee institution in dealing with key developmental problems in less industrialized nations. The grants are designed to yield results that will serve current and projected needs of both AID and the less developed countries, while the grantee is expected to develop multidisciplinary capabilities useful in knowledge transfer and joint problem solving with emerging nations.\*

For this report we have divided the general Program Elements into two broad categories, research activities and activities concerned with institution building both at MIT and abroad. The former area includes not only the specific research projects funded by the Grant, but also the Program Elements concerned with student and faculty support and development, travel, and the establishment of linkages with both individuals and institutions in emerging nations. With the area of institution building we have included course and curriculum development, workshops, seminars and conferences, and the acquisition of library and resource materials. Another important

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\*The guidelines contain criteria for selecting a grantee and for choosing problem areas appropriate for research. Criteria for selecting a grantee require that (1) the recipient institution be able and willing to prepare and develop special curricula, provide space and utilities, recruit and train personnel, engage in appropriate research, and organize its program and faculty so that joint collaborative working relationships with LDC institutions are established as an integral part of the grantee's academic and research life; (2) the grantee be receptive to long-term involvement in assisting and working with AID, LDCs, and other interested institutions; (3) grant funds not be used to build institutional capabilities where none presently exist, nor in areas of low priority to LDCs; and (4) the grantee show promise of bringing a multidisciplinary approach to the solution of development problems, where such an approach is feasible. Criteria for selecting problem areas appropriate for grant support are that (1) the project should be directed toward developing special competence in an area of skill or knowledge related to AID priorities, including the development of techniques such as sector analysis, project design, implementation, and evaluation; (2) the grantee should be able both to accommodate current and project demand from LDCs and AID, and to plan for the maximum utilization of its own institutional capacities; and (3) since the solution of any problem is ultimately the responsibility of the individual LDC, a key issue should be the grantee's ability to adapt and transfer knowledge to a specific foreign milieu.

indicator of the Program's success has been the number of projects and activities which have received additional funding from outside sources and the new separately-funded programs that have resulted directly from the TAP's activities, which are described in a third section below. The special overall programs undertaken in Egypt and Colombia are also described in more detail in a fourth section.

## 1. Research

Most of the Technology Adaptation Program's efforts have concentrated on individual research projects which are listed in Table 1 and described briefly in Appendix A. Each had its own emphasis, was directed by an individual faculty member with his or her own specific research interests and goals, and devoted a different fraction of its resources to the Program Elements listed previously. Some projects concentrated on "hard" research, others on collecting material for curriculum expansion, and still others on faculty and student development. Different criteria must thus be used to evaluate the relative "success" of the various projects in terms of the Program objectives and goals. Some conclusions can be drawn, however, about the overall thrust of Grant-supported research.

A large number of papers and reports were generated by individual projects; a complete listing of such publications is included in Appendix D. This material has encouraged additional funding from external sources for a number of projects and the reports, professional papers, and theses produced by various research groups have contributed to the total body of knowledge concerning technology adaptation and transfer.

In addition to financial support provided to faculty members engaged in TAP-sponsored research projects, student financial support has been provided by Grant funds in the form of research assistantships to carry out specific research and analysis tasks for a senior investigator, or for thesis research concerned with the project area (see Appendix D for a list of TAP-sponsored theses.)

## 2. Institution Building

### a. Institution Building at MIT

According to the original Proposal accepted by AID in 1971, the first

TABLE 1

TECHNOLOGY ADAPTATION PROGRAM - FUNDED RESEARCH PROJECTS

Initiated in 1971:

Application of Highway Cost Model to Venezuelan Road Transportation  
Technology Adaptation in Water Resources Planning  
Urban Transportation in Developing Countries  
Air Transportation in Developing Countries  
Systems Analysis as an Aid in the Development Process  
Materials Adaptation for Developing Nations  
Transfer and Adaptation of Housing Technology and Standards to the Needs of Developing Areas  
Development of Basic Performance Standards for Urbanization and Housing Technologies through Testing of Models in Nairobi, Kenya  
Organizational Studies and Development (Brazil)  
The Nature of Industrial Research and Development in India

Initiated in 1972:

Electromagnetic Prospecting for Subsurface Water in Arid Regions  
The Leadership Roles and Potential of Business Managers in Economic Development and Transfer of Technology in LDCs of Africa  
Technology Adaptation in the Textile Industries of LDCs

Initiated in 1973:

Transfer and Adaptation of Technology in Construction  
Colloquium on Assessing the Economic and Environmental Impacts of Alternative Growth Strategies  
Intercity Freight and Transportation in Developing Countries  
Efficient Utilization of Natural Fiber in Developing Countries

Initiated in 1975:

Analytical and Experimental Development of Hydraulic Turbines and Windmills  
Evaluation of Rural Roads in the Context of Development  
Planning Methodologies for Water Resource Investment and Allocation in Colombia  
Freight Commodity Transport Requirements in Colombia  
Political Determinants and Consequences of Technological Choice  
A Framework for Technical and Economic Evaluation of Appropriate Technology

Program Element to be supported by the Grant at MIT was to be Course and Curriculum Development -- "Central to the MIT program will be the development of new courses and the modification of existing ones, that will focus student undergraduate and graduate interest on the challenging problems of industrial and public works development in the LDCs." This aspect of Grant-related activities has been particularly successful; each academic year new courses devoted to the subject of the problems of the developing countries have been added to the catalog as regular offerings, while material from the various projects has also been incorporated into a number of existing courses. The TAP-supported research material added to the MIT curriculum has made the academic community more sensitive to the needs of the developing countries not only in the specific realm of technology transfer and adaptation, but also in the larger area of those problems which exist in the delicate relationship between the developed and the developing nations. A list of TAP-related courses available to the MIT community is given in Appendix C; several of these have been offered by faculty members who have participated in TAP research efforts.

An Interdisciplinary Graduate Program has been designed for candidates for the Master of Science degree who are interested in the transfer and adaptation of the technologies of their own areas of specialization to the needs of developing countries. This program includes the subjects required for the area of specialization, and

- 1) At least one subject which deals with management techniques of special importance to developing countries.
- 2) At least one graduate subject in economics which includes material related to the needs of developing countries.
- 3) At least one subject in the social sciences area which deals with

the structures required to support the application of technologies in developing countries, and

- 4) At least one graduate subject in an engineering area related to the transfer, adaptation, and/or development of new technologies for developing countries.

The student's proposed thesis topic requires approval of the TAP Steering Committee, as well as that of the department in which the student is registered, by the second term of participation in the program. The thesis is to include material relating the transfer, adaptation, or development of some aspect of the technology of the area of specialization to the needs of developing countries. The final document must be acceptable to the TAP Steering Committee as well as to the student's department.

The Program has held a number of seminars, workshops and conferences open to members of the MIT community. Meetings sponsored by the Program have included both Departmental and Divisional gatherings as well as more broadly-based colloquia attended by participants from national and international agencies and by developmental specialists from both the industrialized and less-industrialized nations. Appendix B contains more details on this Program Element.

At the beginning of the Program, most library and resource material acquisition depended upon the Institute's general library funds and facilities, and individual projects collected highly specialized material relating to individual needs. During the final two and one half years of the program, however, a sizable collection of papers, reports, conference proceedings, and monographs which had accumulated as a result of the program's activities was centralized and classified at the TAP administrative office. This list of acquisitions will be published as a TAP Report.

### b. Institution Building Overseas

Most of the members of the MIT community involved in the Technology Adaptation Program have contributed their time and energies to the dissemination of Grant-related information to development activities in emerging nations. In an attempt to use its institutional capabilities to aid less industrialized countries in the process of development, project members have traveled to various nations in connection with Grant-supported research in order to collect data, established collaborative working relationships with educational, governmental, and private institutions, serve as visiting instructors at various colleges and universities and as consultants to both private and governmental agencies, and, in general, have attempted to provide whatever form of assistance the particular country, agency or government feels is needed. The establishment of such linkages assumed special importance during the last two years of the program in Columbia and Egypt.

Many of the investigators also have participated in international conferences and workshops dealing with the problems of technology transfer and adaptation; the professional papers presented at such meetings have generally resulted from research generated under TAP auspices (see Appendix B for further details).

### 3. Separately Funded Activities Generated by TAP

The original Proposal for the Program stated that "By making limited resources available for research...the interest of the MIT faculty in the problems of the LDCs will be stimulated and its competence broadened. This can be expected to lead to a research program at MIT that should eventually command much greater resources than the initial AID grant."

Such, indeed, has been the case. Although not all new funding is

directly related to or a continuation of the research begun under the aegis of the TAP, a number of projects had their beginning either in research generated by the Grant or in the increased awareness of the MIT community to the problems of adapting sophisticated technology to less developed nations fostered by Grant-related research. The following are representative of these activities.

1. During the spring of 1974 negotiations were completed with the AID office of Science and Technology on a contract to continue the TAP's work on highway construction in developing countries, under the direction of Professor Fred Moavenzadeh.

The goal of this proposed research was to assist developing countries to better understand the relative merits of alternative possibilities for highway construction, taking into account certain social and national cost-benefit as well as more conventional economic factors. The specific objective of the research was to develop an evaluation framework for LDC use in analyzing and assessing the consequences of various available highway projects and alternatives. The work was to focus on one developing country, Ethiopia, and emphasis was placed on the identification, clarification, and resolution of major issues of highway planning, programming, and budgeting.

The research was further directed toward the refinement, modification, expansion, and application of computer-based models which have been developed in recent years for evaluating highway projects. The emphasis was on exploring and enhancing the applicability and utility of these models in real situations. In addition to the usual technical and economic factors, specific issues considered in developing this evaluation framework included scarcity of resources, factor pricing, returns from investment, time staging, and potential for using appropriate technology.

2. The Urban Settlement Design Program, under the direction of Professor Horacio Caminos and Research Associate Reinhard Goethert, received funding from the following agencies as a direct result of the TAP Grant:

- The Ministry of Housing and Cooperatives of Lebanon authorized a contract to investigate low income housing guidelines to be exhibited through the design of an actual project on the outskirts of Beirut. Funding was secured for one year for preliminary design, which enabled the USDP to utilize the experience in site and services projects and low income housing it had received through its TAP-sponsored research.
- The World Bank, also as a result of the previous experience in site and services projects, in particular the Dandora study in Nairobi, Kenya, authorized a contract for an extensive study of guidelines for future housing projects. The guidelines included the development of prototypical models to illustrate critical design principles.

3. Under the direction of Professor James Meyer, the TAP-funded project on Electromagnetic Prospecting for Subsurface Water in Arid Regions was awarded additional funds from the Center for Space Research.

4. Professor Willard R. Johnson's Business Management for Economic Development project attracted additional funding from the International Business Project of the Center for International Studies and the Department of Political Science, for travel to the Bata Shoe Headquarters in Canada and the Commonwealth Development Corporation headquarters in London, for partial summer salary support for Professor Johnson and other project members, and for expenses incurred in the production of reports.

5. As a result of his TAP-supported work on the construction industry in developing countries, the United Nations provided support to Professor

Fred Moavenzadeh to prepare and present the following two papers at international conferences:

- "Industrialization of Production and Assembly of Pre-fabricated Elements and Components" presented at the UNIDO Joint Consultation on Prefabrication for Industrial Construction, Poland, 1975.
- "Shelter: Experiences, Problems and Solutions Related to 'Formal' Building Industry," Habitat: United Nations Conference on Human Settlements, Vancouver, 1976.

6. In 1976, AID and MIT signed a contract for implementation of the MIT/Cairo University Technological Planning Program, described in the following section of this report.

#### 4. Special Programs in Colombia and Egypt

As discussed previously the final two years of the Grant, it was determined that in order to most effectively carry out research useful to the Institute, less industrially advanced nations, and AID, the Program required the development of active ties with specific institutions in a few selected countries which had already achieved significant infrastructures and a reasonably sophisticated technological base and were seeking explicit advanced technological cooperation. The basis for the selection of appropriate countries also included the presence of suitable and well-staffed agencies in the country, the willingness of agency officials to cooperate with MIT on mutually acceptable areas of interest, and the agreement of the AID Office of Science and Technology on the appropriateness of the chosen country and the subjects of collaboration.

After investigative trips to visit various agencies and institutions by the Chairman of the Program, it was concluded that Colombia and Egypt met all the requirements for establishing collaborative working relation-

ships with TAP-funded projects at the Institute. Ties with specific groups, institutions, and agencies were established and will be discussed below.

The primary areas of technology of interest to Colombia, Egypt, MIT and AID were identified as public works and industrial development, including the development of capabilities in project evaluation and analysis, application of system methodologies to problem identification and description, and the use of computer modeling. Specific sectors of technical interest included mechanical engineering systems, transportation, water resources, materials and technology in public systems.

a. Colombia

Colombia appeared particularly appropriate as a country in which MIT's Technology Adaptation Program might establish collaborative working relationships. Not only did it fully meet the requirements set forth by AID and TAP, but its government also appeared firmly committed to a wide range of programs designed to broaden the benefits of development, including specifically rural development. A rural development program, integrated on both public and private levels, had been established and funded both by major foreign loans and by government grants.

In addition to the conventional problems of agriculture and migration, the program dealt with rural energy development, nutrition, health care delivery systems, transportation, municipal services, rural industrialization, education, communication, and housing. Several of the groups with which the TAP collaborated, such as the Mechanical Engineering Department of the Universidad de los Andes, Foundation for the Development of Scientific and Technological Research (FICITEC), and Fondo Nacional de Caminos Vecinales, were involved in the program. The Colombian AID Mission also had a continuing interest in several of these areas, providing

partial support, for example, to the rural road and health care delivery programs.

The program of collaboration between TAP and Columbia was defined in a series of discussions and implemented in particular research agreements. The universities, primarily the Universidad de los Andes, certain government agencies such as the Department of Planning (Planeacion Nacional) and Fondo Nacional de Caminos Vecinales, and private institutions such as the Instituto Ser de Investigaciones (SER) and the Foundation for the Development of Scientific and Technological Research (FICITEC) provided research teams on the host country side. Fondo Colombiano de Investigaciones Cientificas (COLCIENCIAS), Colombia's equivalent of our NSF, acted as the primary liaison, providing the management, administration, and funding for the Colombian component of the joint research program. The collaborative research projects undertaken were:

- Analytical and Experimental Development of Hydraulic Turbines and Windmills
- Evaluation of Rural Roads in the Context of Development
- Planning Methodologies for Water Resource Investment and Allocation in Colombia
- A Study of Freight Commodity Transport Requirements in the Republic of Colombia

which are described in more detail in Appendix A. In each of these research topics the Colombian faculty member in conjunction with his MIT collaborator developed a well-defined research program which was acceptable to COLCIENCIAS and of interest to a particular ministry. Throughout the course of the program the collaborating faculty members and their graduate students visited each others' institutions to assure that the programs remained collaborative

and consistent with the initial goals and objectives.

Through this concentrated effort, valuable experience was gained in the coordination of research activities in one country, and it was demonstrated that the formation of research teams composed of MIT staff and host-country academic and government counterparts was a most effective means of obtaining useful and valid results for all parties concerned. This approach has been developed to an even greater extent in the MIT/Cairo University Technological Planning Program. In addition, institutional ties were created that may in the future facilitate development of separately-funded activities. For example, during a visit to Colombia by Professor Fred Moavenzadeh and Dr. Janet Rossow during the summer of 1977, the possibility of a conference on rural roads was discussed with the Centro Interuniversitario de Desarrollo Andino, Federacion Nacional de Cafeteros de Colombia and the AID Mission, for which funding is being sought. Many other project participants have also kept in contact with their Colombian counterparts, in order to investigate future activities of mutual benefit.

#### b. Egypt

In recent years, as a result of significant political and social transformations, the Government of Egypt has been faced with the increased responsibility to plan and execute programs contributing to national development. The commitment to substantial, long-term economic assistance from the United States government and other external sources (such as the World Bank and the United Nations Development Program), has been a major pressure on the government ministries responsible for these programs. The urgent need to convert these funds into effective development projects is taxing the government's capabilities to perform the needed sector and project level analyses. The lack of adequate Egyptian infrastructures to perform

these activities has hindered the achievement of improvement in these areas of development planning.

In June of 1975, several members of the Egyptian Delegation of the Joint United States-Egyptian Commission on Education, Culture, Technology, and Research and Development visited MIT in order to meet with Institute personnel concerned with various aspects of internationally-oriented research. The Chairman of the Delegation, Dr. Hassan Ismail, President of Cairo University, was accompanied by Dr. Hassan Kira, Vice President of Alexandria University, and Dr. Ahmed Azzam, the Egyptian Cultural Counsellor.

During the course of the visit, Dr. Ismail's group spoke with members of MIT's Departments of Economics, Civil Engineering, and Political Science, and with the Directors of the Center for International Studies, the Energy Laboratory, the International Nutrition Planning Program, and the Technology Adaptation Program to discuss specific areas of research of interest to both the Egyptian and U.S. groups and individuals working in the fields of economics, health, education, and science and technology. At this time, the development of a collaborative program between TAP and Cairo University was first proposed, since utilization of their combined resources presented a potentially effective means of providing the technical expertise and institutional support needed for the rapid and sustained expansion of ministry planning capability in Egypt.

In October 1975, Professors Fred Moavenzadeh, Nazli Choucri, and Richard Eckaus, members of the TAP Steering Committee, visited Cairo at the invitation of Dr. Ismail and his colleagues for further discussions. Meetings were held with several cabinet ministers, directors of national planning agencies, and members of the administration of Cairo University. At that time, several specific topics for collaborative research were identified and

initial discussions were held on the administrative design of a joint program. Concurrently, the funding for such a program was discussed with the AID Mission in Cairo and the Egypt Desk in Washington, and in February 1976 a formal proposal was submitted for a five year program. Continued negotiations took place during the year, with further visits to Cairo by Professors Moavenzadeh, Eckaus, and Choucri, and to the United States by Drs. Salah Shahbender and Ibrahim Badran of Cairo University. On December 15, 1976, a contract was signed by AID and MIT for the funding of the MIT/Cairo University Technological Planning Program. The three specific objectives of this program were identified as:

- Mobilization of academic interest in applied research on specific development plans,
- Organization of technical research in collaboration with Egyptian government ministries, and
- Establishment of an institutional framework through which permanent applied research and training capability can be organized.

Under TAP auspices, the program is now being administered and implemented at MIT by an Executive Committee, composed of Professors Eckaus, Choucri, and Moavenzadeh, who is serving as the Program Director. At Cairo University, the program is being administered by a counterpart Executive Committee, under the guidance of the Vice Rector for Research and Graduate Studies. A Liaison Office at Cairo University has been established to provide supervision and administrative support to all project personnel.

The original contract allowed for a one year feasibility phase in which the receptiveness and practicality of ongoing academic support to ministry planners could be demonstrated. A specific set of projects, listed below and described individually in Appendix A, was undertaken compatible with

the technical expertise of the MIT and Cairo University faculties. Project teams were organized with ministry personnel and faculty members from both universities playing active roles in planning, executing the research, and reporting the results:

- Stochastic Model of Nile Inflows to Lake Nasser
- Regional Groundwater Studies
- Housing and the Construction Industry
- Urban Transportation Policy
- Highway Transportation Planning
- Government Incentives for Small Scale Industry
- Development of Improved Macroeconomic and Sectoral Planning Methods
- Egyptian Labor Migration
- Health Care Delivery Systems
- Engineering Applications for the Plastics Industry
- Long-Term Investment Planning for the Egyptian Electric Power System

To date, a number of completed project tasks such as the following have demonstrated the utility of the research to the ministries' planning efforts:

- The initial survey and analysis activities of the Urban Transportation Project have produced a set of recommendations which were implemented by the Cairo Governorate and the Ministry of Transportation. Substantial reductions in traffic congestion and delays on the major river crossings in Cairo have resulted.
- Statistical models of the streamflow characteristics of the Nile River System have been applied to the operation of the Aswan Dam system with implications for the design of the Toshka depression spillway.
- The project to collect information on and develop government incentives for small industries has attracted the interest of a World Bank team

interested in establishing a loan program to support these industries.

- The MIT Highway Cost Model has analyzed one link of the Alexandria-Delta Road for three rebuilding options. Scheduled and responsive maintenance policies were considered for each, and the most effective construction/maintenance policy has been recommended for implementation.
- A testing program for plastic bags and pipes organized with public sector plastics manufacturing companies will lead to appropriate product standards and quality control procedures for the industry.
- A social cost/benefit analysis of a planned petrochemicals facility has been completed and submitted to the Ministry of Petroleum.
- A supply and demand model of the Egyptian Housing system has been completed with which alternate government housing policies can be tested.
- Inconsistencies between the national income accounts and input-output tables have been identified and resolved.

In addition, the following are representative project results scheduled for completion in the near future:

- A modern, stochastically-based, operating policy for the High Dam.
- A detailed analysis of the impact of groundwater withdrawals and storage on seawater intrusion in the Delta.
- A survey of two governorates to provide systematic data on health status and malnutrition.
- An assessment of nine basic construction materials identifying causes and degree of shortages, and options for expanded production and use of alternate materials.

- A complete 32 link, 21 node rural road network, in the Delta, will be analyzed for proposed and alternative maintenance and construction programs.
- An assessment of the social costs and benefits arising from migration of construction labor.
- An economic ranking of capacity expansion alternatives and assessment of the optimal mixture of different types of stations for variable demand in the electric power system.
- Collection and tests of consistency of data necessary for multi-sectoral economic planning models.
- An analysis of the Cairo street network, with recommendations for changes to improve traffic flow and urban mobility.
- Development of a prototypical programming methodology applicable to transportation project development and implementation.

These program results are indicative of the high degree of cooperation and commitment that has been received from the MIT and Cairo University faculty members, and the ministry personnel who have been appointed to participate directly in project activities.

In order to extend work on the individual projects and to design the proposed Phase II of the program, a 6.5 month extension of Phase I was approved and begun on December 15, 1977. It is anticipated that during Phase II the capabilities for university-based technical assistance to ministry planners will be further developed, primarily through continuing research programs in several technical areas. In addition, support will be provided to Cairo University to assist in establishing an Institute for Technological Planning. Once established, the Institute would eventually absorb the operations and staff of the MIT/Cairo University Technological Planning Program

Liaison Office, and would then be capable of providing a broad range of supplementary research, technical advisory and educational programs to complement the program of applied research. As presently envisaged, a Technical Advisory Service would be organized in the Institute in which project team participants and other Cairo University resources would assist ministry planners in organizing the numerous development projects regularly on their agendas. Field and literature surveys, terms of reference, and project evaluations would be representative of these efforts. It is also anticipated that an educational program, compatible with the research activity, would be organized. Such a program would include relevant courses from the regular university curriculum, courses developed by the staff of the Institute and short term subjects specifically related to the needs of the government agencies.

#### IV. PROPOSED CONTINUATION OF THE PROGRAM AT MIT

In summary, through programs such as the MIT/Cairo University Technological Planning Program, the Technology Adaptation Program fully expects to continue its activities beyond the termination of the initial Grant, and will provide an ongoing center for research and discussion of the problems of technology development and adaptation at MIT. The Program's overall objectives will remain the same, namely:

- Developing an understanding of the characteristics of technologies that are appropriate to countries in various stages of development;
- Identifying criteria for the selection and adaptation of technologies appropriate for use in developing countries;
- Developing an understanding of the processes by which technological knowledge and skills can be effectively introduced, disseminated, and used in developing nations; and
- Determining the long-term and short-term social and economic consequences of importing technologies rather than improving those which are indigenous.

The Program's future effort will center on three basic areas:

- Development of institutional ties between MIT and educational governmental organizations in each of several countries;
- Collaborative research; and
- Educational opportunities at MIT.

##### A. Development of Institutional Ties

The Program will continue to build upon its already substantial ties with various individuals, research and educational institutions, and governmental agencies in emerging nations, in order to foster research and promote

academic and professional growth among all personnel involved. The relationships which have been established in a few selected countries such as Columbia and Egypt will be continued with the expectation that the knowledge gained can be formulated and assessed in regard to its application for the solution of similar problems in other countries. The basis of the selection of such countries will continue to be the presence of appropriate counterpart research and educational agencies, and the willingness of such groups to work in collaboration with MIT in areas of mutual interest.

#### B. Collaborative Research

Depending upon available funding, the TAP will continue to provide an administrative center for research projects. The topics will be consistent with the personal research interests of the members of the faculty who initiate and supervise them, and will generally deal with the application of technology, although research on purely technical problems will also be sponsored when promising opportunities arise. Thus, some of the programs will deal with broad areas of development such as infrastructure or long-range planning, while others will focus on more narrowly defined topics. The projects undertaken in connection with the MIT/Cairo University Technological Planning Program described in Appendix A provide a representative sample of the types of projects the TAP expects to continue in the future.

#### C. Educational Opportunities at MIT

Many of the educational opportunities to be provided by the Program in the future will be similar to those offered under the initial Grant; others will be modified as follows:

- Interdisciplinary Master's Degree Program: Although financial support for students will be limited to that which is available through individual research projects, the Interdisciplinary

Master's Degree Program will continue to be offered to students interested in the adaptation of technology to the conditions of developing countries. The TAP Administrative Office will also continue to advise inquiring students as to faculty and staff members who may provide guidance in a given field of inquiry.

Graduate Research Assistantships: These will be provided to the extent possible through the sponsored research administered by the TAP. During 1977, for example, 13 students were provided with financial support through the MIT/Cairo University Technological Planning Program. Recipients are selected by the individual project leaders.

Subject Development: Development of new subjects will not be possible in the near future; however, project participants will continue to use material and experience obtained through their TAP-sponsored research to enrich the courses regularly offered at MIT.

Visits by Foreign Scholars: Although at present financial support cannot be provided to the TAP to scholars and research workers from outside the United States, except to those directly associated with sponsored research projects, qualified candidates may participate in MIT's research and education in the area of technology adaptation and transfer through options available at MIT's Center for Advanced Engineering Studies.

Workshops, Seminars, and Conferences: To help establish paths of international communication between academic researchers, professionals, and governmental personnel in countries around the world, seminars, workshops and conferences will be integrated into the activities of research projects whenever possible. In addition, efforts will be made to have those visiting MIT in connection with TAP research to

hold informal meetings and seminars open to members of the MIT community interested in the problems of international development.

- Reference Material and Publications: The TAP library will continue to classify and publish lists of acquisitions which are donated by MIT staff associated with the various research projects. In addition, a formal publication series has been established which will allow for more effective dissemination of the reports produced by TAP.
- Travel: Although limited to that which can be directly supported by sponsored research, it is expected that TAP-related travel will form a significant portion of the travel by Institute personnel to developing countries and provide them with on-site experience in dealing with problems confronting these nations.

Finally, the TAP will continue to draw upon the resources and expertise available through other formal research programs at MIT such as the Center for Advanced Engineering Study, Energy Laboratory, Center for Transportation Studies, Center for International Studies, Center for Policy Alternatives, and International Nutrition Planning Program, which are described in Appendix E, to maintain and strengthen the body of expertise at MIT in the fields of technology, economic development, and international affairs, and to provide a focus for more effective interaction between MIT faculty, students, and staff, and members of both the national and international development communities.

**APPENDIX A**

**INDIVIDUAL RESEARCH PROJECTS**

TECHNOLOGY ADAPTATION PROGRAM-FUNDED RESEARCH PROJECTS, 1971 - 1972

Title: Application of Highway Cost Model to Venezuelan Road Transportation

Principal Investigator: Fred Moavenzadeh  
Department of Civil Engineering

The objectives of the research were to validate, calibrate, and implement a Highway Cost Model developed at MIT in 1969-1970 under the auspices of the World Bank and expanded in 1970-1971 under the sponsorship of the Department of Transportation. The model was designed to provide developing countries with a quantitative means to evaluate alternative road construction options and select those most suited to their overall needs, and to provide the international aid and lending agencies with a similar tool to evaluate requests for grants and loans in road transport sectors.

During the 1971-1972 period the TAP-funded research stressed the testing and validating of the staged construction capability of the model. Through cooperative work with the appropriate agencies in Venezuela, Brazil, and Colombia, field data was collected for calibration purposes, and the capability of the model as a tool in the planning of highway links and in the scheduling of maintenance and reconstruction was tested and evaluated.

Title: Technology Adaptation in Water Resources Planning

Principal Investigators: Professors Frank E. Perkins and David C. Major  
Department of Civil Engineering

The object of the research was to study the adaptation of advanced water resources planning methods to conditions in less developed countries. The methods used consisted of modern optimal public expenditure criteria embodied in computer models primarily of the mathematical programming and hydrologic simulation types.

In 1971 most applications of sophisticated water resources planning methods consisted of technology transfers rather than adaptations. The TAP research was designed to improve this situation by developing a set of criteria for identifying the nature and types of mathematical models appropriate to conditions in less industrialized nations. The project related to the needs of less developed countries in water resources planning because the "simple" transfer of western technology was apparently one of the principal factors resulting in many inappropriate water resources projects and programs in these countries.

The research developed along three lines--(1) the analysis of countries in terms of water resources problems, available data, decision structures, and other relevant variables; (2) the analysis and evaluation of past applications of mathematical modelling techniques to water resources planning in emerging nations in

order to assess the favorable and unfavorable aspects of each of a selected number of cases as an aid in developing criteria for technology adaptation; and (3) the assessment of general theories and observations on technology transfer and adaptation to determine whether these are relevant to the adaptation of water resources planning technology for use in developing countries.

Title: Urban Transportation in Developing Countries

Principal Investigator: Professors Daniel Roos and Nigel Wilson  
Department of Civil Engineering

The program objective was to adapt and implement research techniques obtained from several ongoing projects dealing with urban transportation systems analysis in developing countries. The project attempted to build upon and apply results from these studies to problems of urban passenger transport in emerging nations. Latin America was the focus of this effort, although the techniques are applicable to other less industrialized countries.

The work proposed to model alternative transport systems in order to determine the correct mix of these systems and the optimal operating policies (fares, routes, schedules) for each system. Efforts were made to apply the models to specific cities in developing countries to demonstrate their utility.

Title: Air Transportation in Developing Countries

Principal Investigator: Professor Robert W. Simpson  
Department of Aeronautics and Astronautics

The purpose of this project was to develop within the Department of Aeronautics and Astronautics the capability of aiding authorities responsible for civil aviation in developing countries to deal with the problems of the growth of aviation. The program attempted to find the patterns of air transportation system development--airlines, aircraft, airways and airports--that would promote system growth to the advantage of a nation's overall economic development.

The project consisted of two overlapping phases--first, the education of MIT personnel about the nature of the problems facing developing countries in the air transportation area; and second, the initiation of appropriate research programs in the host countries and educational programs at MIT.

Title: Systems Analysis as an Aid in the Development Process

Principal Investigator: Professor Robert E. Stickney  
Department of Mechanical Engineering

The objectives of the project were to provide a detailed test of the usefulness and limitations of systems analysis as an aid to developing countries in their planning and evaluation of alternative development programs, and to prepare several case studies illustrating the application of systems analysis to development problems for inclusion in a new interdepartmental course.

1. **Systems Analysis as a Development Aid:** The initial test selected for the project was the development of a systematic method for evaluating nutrition programs for a developing country. The project drew upon two earlier graduate research studies; one formulated an analytical approach to the evaluation of alternative strategies for improving infant nutrition in developing nations, and another developed an approximate method for determining agricultural production patterns that would provide adequate nutrition for a given population while minimizing cost, land, water and fertilizer. El Salvador was the country selected for this study.

2. **Case Study Preparation:** Support was given to developing case studies illustrating the application of systems analysis to the problems of developing countries. These case studies were included in a new subject offered in spring 1973, "Modelling and Analysis of Systems Pertaining to National Development."

Title: Materials Adaptation for Developing Nations

Principal Investigators: Professors Nathan Cook and Peter Griffith  
Department of Mechanical Engineering

A recurrent technological problem facing developing nations is the lack of engineering materials--steel, cast iron, polymers, and so forth--and the resulting import burden on the economy. The objective of the project was to explore the availability of local material substitutes which would satisfy necessary functional criteria.

Initial work focused on the feasibility of using a cement-based substitute for conventional metals, possibly using the "ferro-cement" technology developed during the past decade for boat hull manufacture. Two problem areas were investigated, concrete heat exchange shells and the substitution of ferro-cement for machine components.

1. **Concrete Heat Exchange Shells:** The study attempted to determine the feasibility of substituting concrete for cast iron and welded steel heat exchanger shells. Two applications of this concept appeared particularly promising--steam condensers for power plants, and air conditioning or refrigeration system freon evaporators.

2. **Substitution of Ferro-cement for Machine Components:** The study investigated the feasibility of adapting "ferro-cement" technology to the construction of machine parts such as pump housings, machine frames, and the like. The total problem was subdivided into several tasks concerned with material properties, strength, corrosion, and so forth; methods of attaching mating parts; "machining" of ferro-cement parts; and rotary and linear bearing problems in ferro-cement components.

Title: Transfer and Adaptation of Housing Technology and Standards to the Needs of Developing Countries

Principal                    Professors John F. C. Turner and Ian Donald Turner  
Investigators:            Department of Urban Studies and Planning

A study was undertaken (1) to analyze the simple, locally-inspired ways in which developing nations might use indigenous materials and capabilities, supported by new technology, to improve the safety, speed, and ease of self-help building methods; (2) to create several documented case studies and other teaching materials that could be packaged for short-term training institutes to be held at MIT or at various locations throughout the world; (3) to document the failures of industrialized housing technology transfers from developed to less developed nations and help to formulate policy guidelines to prevent the repetition of such failures in the future; and (4) to document the impact of new technologies, as less developed nations attempt to use them in construction sector modernization programs. In this context impact was viewed not only in terms of quantity and quality of dwellings produced, but also in terms of what segments of the population were the recipients of such dwellings, what settlement patterns were implied, and what effects such efforts had on construction employment, income distribution, balance of payments, migration patterns, and so forth.

Title:                            Development of Basic Performance Standards for Urbanization and Housing Technologies Through Testing of Models in Nairobi, Kenya

Principal                    Professors Horacio Caminos and Reinhard Goethert  
Investigators:            Department of Architecture

The objective of the project was to develop basic performance standards for urbanization and housing technologies, including environmental conditions, physical characteristics, utility networks, service facilities, regulations, circulation systems, housing systems and land development opportunities. The project was designed also to strengthen MIT's capabilities in the field of technology transfer by expanding the Department of Architecture's current Latin American expertise to an African context. In addition to broadening the experience of faculty and students involved in the project, the research contributed to the development of a course at the Institute on housing standards.

During the summer of 1972 a group of MIT faculty and graduate students visited Nairobi, Kenya, to evaluate local housing systems, future housing needs and performance requirements. Field studies, workshops, and seminars, in collaboration with the University of Nairobi and the Nairobi City Council, were conducted aimed at formulating tentative performance standards for comparison with U.S. and Latin American references. Models were prepared to test the standards during 1972-73.

Title:                            Organizational Studies and Development

Principal                    Professors George Farris and Anthony Butterfield  
Investigators:            Sloan School of Management

The project attempted to design a long-range program leading to the institutionalization of organizational research and development capabilities in Brazil. Little is known about organizations and how they relate to their environment in developing countries, or how they cause and are influenced by the processes of economic development. The project aimed at eventually creating a center or other type of institution for the study of these problems.

At the end of approximately eight years, such a center would have significantly advanced knowledge about organizations in their environments; would have assisted many Brazilian organizations to become more operationally effective; would have trained many Brazilian executives and administrators in organizational research and development; and would be producing advanced graduates with a Brazilian faculty and staff. Ideally the center would be to a considerable extent self-supporting through studies in client organizations, both public and private, and would serve as a "home base" through which MIT groups could work on problems of technology adaptation in Brazil, in collaboration with Brazilian colleagues. Such a center would also provide case material regarding problems in the management of technology in developing countries for inclusion in courses at MIT.

Title: The Nature of Research and Development by Industrial Firms in India (Research for a Doctoral Thesis)

Principal Investigator: Bruce Kutnick, Graduate Student, Sloan School of Management  
Supervised by Professor J. Bhagwati

A twelve-month study was undertaken on the nature of research and development by industrial firms in India, with particular emphasis on the chemical and pharmaceutical industries. Indian research and development was selected because it appears oriented toward adapting imported processes to the use of domestically available inputs, an approach different from that of other countries where research and development is aimed at product changes and "improvements" and toward cost reductions through such processes as capital savings. Research and development in India rather reflects the whole strategy of import-substituting development.

The study reviewed and analyzed research and development efforts, expenditures, and accomplishments in the Indian economy as a whole, but focused primarily on the chemical and pharmaceutical industries since they account for a substantial portion of industrial research and development. The research and development investment behavior of multinational corporations in these industries was also investigated.

TECHNOLOGY ADAPTATION PROGRAM-FUNDED RESEARCH PROJECTS, 1972 - 1973

Title: Application of Highway Cost Model  
to Venezuelan Road Transportation

Principal Investigator: Professor Fred Moavenzadeh  
Department of Civil Engineering

With the support of the Technology Adaptation Program Professor Moavenzadeh and his colleagues continued their work on highway cost modelling. Research activities focused on data collection and development and preparation of highway inventory systems. The purpose of this research was to test and validate stage construction capabilities of the model as a tool in planning highway links and in the scheduling of maintenance and reconstruction.

The model is designed to provide developing countries with a quantitative means to evaluate alternative road construction options and select those most suited to their overall needs, and to provide the international aid and lending agencies with a similar means for evaluating requests for grants and loans in road transport sectors.

Title: Technology Adaptation in Water Resources Planning

Principal Investigators: Professors Frank E. Perkins and David C. Major  
Department of Civil Engineering

The objective of this project was to investigate the extent to which modern water resource planning technology is applicable to the planning process in less developed countries, and to assess the potential benefits which might derive from the increased utilization of this technology.

Procedures currently used in less developed countries and even in some industrialized nations include planning single projects for single purposes, using investment criteria which are almost exclusively market-oriented, neglecting basin or regional considerations, and maintaining little relation among individual projects and overall national goals.

Modern water resources planning technology, however, can be characterized by an integrated use of the complete set of optimal public expenditure criteria, and mathematical modelling techniques relating investment criteria and the water resource system. Although the technology defined by these two components has been applied in a reasonably complete form in only a few cases, there is evidence that it will become a standard basis for federal planning in the United States and thus will have an influence on the criteria used by international funding agencies.

Title: Urban Transportation in Developing Countries

38

Principal                    Professors Nigel Wilson and Daniel Roos  
Investigators:            Department of Civil Engineering

The objectives of this study were to learn about factors influencing urban transportation planning and investment in large Latin American cities, many of which are now in the process of making major and far-reaching decisions about their future urban transportation systems. During the first year of the project a study was undertaken of the range of available systems and of those in the planning stages, the institutional, regulatory and economic frameworks for these systems, and the area's specific transport needs. In the second year attention was directed toward analyzing feasible transportation alternatives to identify the incidence of costs and benefits in different situations.

There were two primary goals of the project research. First, model systems describing the operation of alternative urban transportation modes were developed to determine the most efficient mix of transport services in a given environment. Second, an attempt was made to identify and measure the incidence and amount of benefits associated with a major urban transportation investment. An important output of this analysis was a review of the institutional and regulatory framework necessary for efficient urban transportation services.

Title:                        Air Transportation in Developing Countries

Principal                    Professor Robert W. Simpson  
Investigator:            Department of Aeronautics and Astronautics

The first objective of the project was to educate personnel at the Flight Transportation Laboratory about the nature of the problems faced by developing countries in the field of air transportation.

As a result of various investigations and visits to organizations active in international aviation, the Laboratory determined that the most immediate way it could help developing nations would be to organize an Advanced Study Program in Air Transportation at the MIT Center for Advanced Engineering Study. This multi-disciplinary program covers technology, management, economics, law, and operations research, and is designed to prepare the participant for a career in managing and planning the development of air transport systems.

Title:                        Systems Analysis as an Aid in the Development Process

Principal                    Professor Robert E. Stickney  
Investigator:            Department of Mechanical Engineering

The objectives of this project were to provide a detailed test of the usefulness and limitations of systems analysis as a planning and evaluation tool in less developed countries, and to prepare several case studies illustrating the application of systems analysis to development problems.

The initial test selected for the project was the development of a systematic method for evaluating alternative nutrition programs for a developing country. An attempt was made to develop a detailed model of the principal factors influencing the nutritional and health status of young children (0 to 3 years of age) of low income families in developing countries. In addition, research was performed in El Salvador on problems relating to nutrition planning such as the formulation of simple analyses to help the nutrition planning group design and evaluate low-cost food supplementation programs (including some nutrition education and medical care) for young children and pregnant women, and a qualitative examination of a systems approach to the evaluation of various alternative nutrition-related programs now being considered by the government of El Salvador.

Title: Materials Adaptation for Developing Nations

Principal Investigator: Professors Nathan Cook and Peter Griffith  
Department of Mechanical Engineering

The objective of the project was to explore and evaluate the possibility of using a cement-based substitute for conventional metals. Ferro-cement was chosen as a possible substitute material candidate in two areas, the construction of machine parts and the construction of heat exchanger shells.

The grant supported the research of four students in the area of construction of machine parts. The work of two students focused on an analysis of ferro-cement properties such as optimum mortar strength characteristics, qualitative mesh analysis tests, ultimate bending moment tests, and deflection due to bending tests. Another student worked on the application of ferro-cement in bearings.

Title: The Transfer and Adaptation of Housing Technology and Standards to the Needs of Developing Countries

Principal Investigator: Professor Ian Donald Turner  
Department of Urban Studies and Planning

During the second year of this project TAP funds supported the research activities of eight graduate students (five from developing nations and three from the United States), under the direction of Professor Turner, in the following areas: (1) the relationship between housing policy and technology in Korea; (2) the relationship between housing policy and technology in East Africa; (3) the political implications of foreign assistance in the area of imported/transferred housing technology; (4) the special aspects and requirements of emergency and disaster housing technologies; (5) compatibilities and misfits between housing technology and aspects of environment and life style; (6) the coordination of housing components and the feasibility of self-sufficient building kits; (7) case studies of the impact of industrialized building technology in developing areas; and (8) the industrialization and the site--new technology applied to site preparation and infrastructure.

Title: Development of Basic Performance Standard for Urbanization and Housing Technologies through Testing of Models in Nairobi, Kenya

Principal Investigators: Professors Horacio Caminos and Reinhard Goethert  
Department of Architecture

The objective of the project was to develop basic performance standards for urbanization and housing technologies, including environmental conditions, physical characteristics, utility networks, service facilities, regulations, circulation systems, housing systems and land development opportunities.

Housing standards in developing countries are generally more appropriate to the conditions of advanced nations. Revision of these standards to allow a transfer of housing technology compatible with local materials, techniques, and culture is badly needed.

During the summer of 1972 a group of MIT faculty and graduate students went to Nairobi, Kenya to evaluate local housing systems, future housing needs, and performance requirements. The media of the work were field studies, workshops, and seminars held in collaboration with the University of Nairobi and the Nairobi City Council.

Title: Organizational Studies and Development

Principal Investigators: Professors George Farris and Anthony Butterfield  
Sloan School of Management

The objective of this project was to design a long-range program leading to the institutionalization of organizational research and development capabilities within Brazil.

The research group visited Brazil to attend a conference of key parties who would be potentially involved in creating a Brazilian Center for Organization Management Technology. During this fact-finding mission they also held discussions with appropriate agencies regarding the Sao Paulo Technology Utilization Program, a project designed to upgrade the state of indigenous technology and increase its utilization by Sao Paulo industry.

As a result of the contacts made by Professor Farris, a Brazilian group headed by Dr. Jose Pastore visited MIT in May 1973 to further explore the possibility of collaborative research programs.

Title: The Nature of Industrial Research and Development in India

Principal Investigator: Mr. Bruce Kutnik, Graduate Student, Sloan School of Management  
Supervised by Professor J. Bhagwati

Mr. Bruce Kutnick spent approximately eight months in India studying the extent, scope, and underlying motivating forces of industrial research and development in India. He used multi-variable regression analysis to identify variables such as minimum firm size, annual profits, internal funds, investment behavior, import and export performance, and managerial attitudes, all of which influence the decisions to initiate and carry on research.

Mr. Kutnick also attempted to investigate such factors as the following: Within the firm, how are R & D decisions made and by what criteria are funds allocated to projects? How effective has the investment in research been? How has private business responded to the direct and indirect incentives for R & D established by the government? Have research efforts made Indian products more competitive in world markets? Do multinational corporations follow a different type of research strategy than indigenous Indian firms? To what extent is securing foreign technology a substitute for or a complement to domestic R & D?

Title: Electromagnetic Prospecting for Subsurface Water in Arid Regions

Principal Investigator: Professor George Simmons, Department of Earth and Planetary Sciences  
Professor John V. Harrington, Department of Electrical Engineering

The objective of this project was to develop a new electromagnetic prospecting technique for subsurface water for use in arid regions. An immediate urgency in this project stems from the severe drought conditions in West Africa coupled with the likelihood that the use of this technique will improve significantly the probability of drilling successful water wells.

In June 1973 field tests were conducted near El Paso, Texas, with laboratory equipment. The site was chosen because of its arid climate, ease of logistics, excellent understanding of subsurface hydrology, availability of previous geophysical data, well-control of depths of water, and the broad range of depths to the water table (5 - 100 meters). The simulations of both surface and subsurface conditions in Mali and Senegal were excellent. The first El Paso tests thus were intended to demonstrate the validity of the theoretical concepts and to perfect pre-prototype field equipment.

Title: The Leadership Roles and Potential of Business Managers in Economic Development and Transfer of Technology in LDCs of Africa

Principal Investigator: Professor Willard R. Johnson  
Department of Political Science

The purpose of the project was to document and analyze the real life experience of business managers in certain African countries in promoting general political and economic development and the transfer of industrial technology to the host environment. The project developed collaborative relationships with relevant East African professionals, business leaders, training institutions and government agencies. The project also investigated the need and potential for undertaking

a long-range program focused on developing local management skills needed to permit a particular African country to take over the control of highly sophisticated industrial technology.

Title: Technology Adaptation in the Textile Industries of LDCs

Principal Professor Stanley Backer and Dr. Stelios Arghyros  
Investigators: Department of Mechanical Engineering

The Fibers and Polymers Division of the Mechanical Engineering Department has provided Institute students with courses dealing with fundamentals of textile science and engineering, particularly in the area of materials properties, textile processes and their interaction. In addition, undergraduate and graduate students in collaboration with faculty members have been involved in basic and applied research projects that bring them in contact with the most recent developments in the field of textiles.

The emphasis, however, has been on the technical problems of the textile industry in the United States. The objective of this project was to strengthen the curriculum in the textile area by developing case studies, and technical and economic information directly applicable to the problems of the textile industries of developing nations.

TECHNOLOGY ADAPTATION PROGRAM-FUNDED RESEARCH PROJECTS, 1973 - 1974

Title: Transfer and Adaptation of Technology in Construction

Principal Investigator: Professor Fred Moavenzadeh  
Department of Civil Engineering

With the continuing support of the Technology Adaptation Program, Professor Moavenzadeh undertook a project which consisted of studies of three separate aspects of the construction industry--(1) the Construction Industry and the Process of Development; (2) Labor Substitution in Highway Construction in Nepal; and (3) the Cement Industry in Developing Countries.

1. The Construction Industry and the Process of Development: Efforts in this area focused on preparing two reports on the industry, the first dealing with construction in the U.S. and the second with construction in developing countries. The emphasis in both reports is placed upon the importance of construction to the national economy, and upon the issues facing the industry as a whole. These issues are divided into four categories--economics and financing, labor, technology, and management and organization.
2. Labor Substitution in Highway Construction in Nepal: This project attempted to develop a comparative study of five road construction projects in Nepal. The purpose of the study was to provide the necessary data base for economic evaluations of labor substitution techniques used in these projects.
3. Cement Industry in Developing Countries: Work in this area is intended to provide an insight into those aspects of construction which are most similar to the manufacturing process, that is, the construction materials' industry. Cement was chosen for this study because it is the only material used solely in construction, its production is relatively regionalized, and it is one of the first modern building materials that the developing countries attempt to produce locally.

Title: Technology Adaptation in Water Resources Planning

Principal Investigators: Professors David C. Major and Frank E. Perkins  
Department of Civil Engineering

The objective of this project has been to investigate the adaptation of modern water resource planning technology to the water resource planning process in less developed countries. The project then attempted to assess the potential benefits and tradeoffs which might result from such a technological transfer and adaptation.

On the basis of the literature review and case study work of the first year, Korea, specifically the Han River basin, was selected as the focus of a detailed case study of water resources technology transfer and adaptation. The Han River

basin was chosen because of the substantial aid given to the Korean government by the U.S. through the Bureau of Reclamation, which resulted in the Han River Basin Report (1971). In addition, good relationships had been established both with the U.S. and the Korean planners of the Han through the previous year's work, so that during 1973-1974 a body of data on the transfer and adaptation of technology in the Han planning effort was built up that is unusual in scope and quality.

The main purpose of the study and extensive data collection was to develop substantial instructional materials for course work at MIT. The study will probably be published eventually for educational use elsewhere, based on the experience gained from the use of the case study in the MIT subjects.

Title: Urban Transportation in Developing Countries

Principal Investigators: Professors Nigel Wilson and Daniel Roos  
Department of Civil Engineering

The objectives of this study were to learn about the characteristics of urban transport systems and the factors influencing the financing of these systems in large Latin American cities. Two major research projects were completed during 1973-1974. The first dealt with the characteristics of typical urban transport systems including organizational, institutional and regulatory environments as well as cost and ridership relationships; the second dealt with financing alternatives for public transport in developing countries.

One of the most significant problems the group discovered was the lack of regulation of the transport industry and the convoluted structure of those regulations which do exist. In general, regulation is weak and uncoordinated, resulting in a highly variable amount of service and in fare levels which are not related to cost structure.

In this project, theoretical, current, and potential policy alternatives for financing urban mass transit were examined. Performance and cost models were developed in order to investigate the role of each transport mode. The major conclusion reached by applying this methodology to several case studies (Bogota, Caracas, San Jose) was that inefficiencies in operations, encouraged by inadequate regulations, currently result in ineffective service even though a large amount of resources is consumed. More effective monitoring and regulation could result in better services at the same or slightly reduced fare levels.

Title: Air Transportation in Developing Countries

Principal Investigator: Professor Robert W. Simpson  
Department of Aeronautics and Astronautics

The original purpose of this grant was to develop within the Department of Aeronautics and Astronautics the ability to aid authorities responsible for civil aviation in developing countries in dealing with the problems of the growth of aviation. During 1973-1974 the Flight Transportation Laboratory pursued the objectives of identifying the problems faced by developing countries in the air transportation area, and of expanding MIT's educational program to respond to the needs of developing countries.

The multidisciplinary program developed at MIT's Center for Advanced Engineering Study during the first year of the grant, the Advanced Study Program in Air Transportation, was continued. The Flight Transportation Laboratory continued its efforts to make the program known to personnel from developing countries through personal contacts and, more formally, through periodic mailings. The program is becoming reasonably well known throughout the world as MIT continues to receive inquiries concerning its activities.

Title: Systems Analysis as an Aid in the Development Process

Principal Investigator: Professor Robert E. Stickney  
Department of Mechanical Engineering

The principal concept of this project was that a simplified form of systems analysis could prove to be an extremely useful tool for national planning groups in developing countries. The research focused on the potential use of systems analysis in planning efforts relating to food and nutrition problems. To gain a more realistic understanding of this problem area Professor Stickney arranged to spend nine months (September 1973 to June 1974) at the Institute of Nutrition of Central America and Panama (INCAP) in Guatemala, an organization with which he had established a close collaborative relationship during preceding years. Both Professor Stickney and INCAP were sufficiently enthusiastic about their collaborative work that arrangements were made to enable him to stay for a second year, until September 1975, and MIT agreed to extend Dr. Stickney's leave of absence.

The grant from the Technology Adaptation Program enabled Professor Stickney to continue to employ Kyriakos Sarris as a research assistant at MIT; Mr. Sarris was assisting in the development of a preliminary model of the dependence of child mortality on malnutrition, as well as the dependence of malnutrition on previous nutritional status and age.

Title: Materials Adaptation for Developing Nations

Principal Investigators: Professors Nathan H. Cook and Peter Griffith  
Department of Mechanical Engineering

This project evolved from its primary area of research into a considerably broader program. The researchers initially planned to investigate only the adaptation or substitution of specific engineering materials, particularly ferro-cement, in developing nations. As a result of a visit to Colombia, however, the scope of the work was enlarged to include other manufacturing-oriented problems. The ferro-cement effort in Colombia was directed towards the development and testing of ferro-cement railroad ties, a project which was an outcome of the collaborative working relationship developed with the personnel of the Instituto de Investigaciones Technologicas in Bogota.

During 1973-1974 all MIT personnel supported by the TAP were concerned with research related to ferro-cement. The efforts ranged from determining basic characteristics to producing a relatively large centrifugal pump-housing from ferro-cement.

During the past two years of the project the primary group has been conducting research to determine whether ferro-cement can be used as a building material for simple machine parts. The first year was spent determining the optimum sand, cement, and water ratios, best mesh configuration, and basic properties of the composite. During the second year the group effort was concentrated on three tests--(1) creep, (2) fatigue, and (3) use of ferro-cement for journal bearings.

The project also involved investigating whether ferro-cement can be used for machine parts. For this investigation the group built an axially-split centrifugal pump casing. The next step will be the casting of ferro-cement over an integral wax mold.

Title: The Transfer and Adaptation of Housing Technology and Standards to the Needs of Developing Countries

Principal Investigator: Professor Ian Donald Turner  
Department of Urban Studies and Planning

During the third year of this project research was undertaken by Professor Turner and graduate students working under his direction in the following areas: (1) a study of squatter housing policy and national development in the Philippines; (2) the development of a methodology for evaluating a national housing plan in a developing nation, based on a case study of Taiwan; (3) an evaluation of the applicability of self-help techniques to residential infrastructure systems, recommending the use of irregular, small-scale, incremental systems for residential utilities; (4) a study of the need for alternative technologies for residential infrastructure, particularly water and waste disposal systems, and development of the performance criteria and relative costs of a number of alternative technologies; and (5) a field survey on alternative water supply systems for the squatter settlements of Seoul, Korea.

During the second year of the project a draft textbook and reference set on housing policy and technology in developing areas was prepared and distributed to a number of institutions for trial use. The book had five major

sections--a review of the economic, social, and political contexts of housing; a critique of public housing programs; a study of the relevance of industrialized housing; a review of the relevance of self-help housing technology; and a study of land and financing aspects of housing low income families.

Title: Development of Basic Performance Standard for Urbanization and Housing Technologies through Testing of Models in Nairobi, Kenya

Principal Investigators: Professors Horacio Caminos and Reinhard Goethert  
Department of Architecture

During 1973-1974 the project focused on four major areas--(1) the development and editing of the "Urbanization Primer"; (2) updating the previous research on 20 case studies in Nairobi, Kenya; (3) studying guidelines for urban low income housing in Beirut, Lebanon; and (4) instituting a course on urbanization issues in developing countries for a wider MIT audience.

The major work of the project was the further development and final editing of a study on basic urbanization standards, the "Urbanization Primer." The original guidelines utilized much of the past experience of the Urban Settlement Design Program which focused primarily on Latin America; the further development concentrated on incorporating information from the field studies in Kenya in the summer of 1973. Additional sections were added, including case studies of evaluations, surveys, and models of both dwellings and urbanization projects.

The third area of work dealt with developing a pilot project for urban low income housing for the Ministry of Housing and Cooperatives of Lebanon. The model not only suggested guidelines for housing but was also a specific proposal for the development of a particular site.

The last area of emphasis was the creation of a new seminar course, "Urbanization in Developing Countries: Dwelling and Land Uses," which deals with those topics in such a way as to allow the larger MIT community to gain an understanding of urbanization issues.

Title: The Nature of Industrial Research and Development in India

Principal Investigator: Bruce Kutnick, Graduate Student, Sloan School of Management  
Supervised by Professor J. Bhagwati

Mr. Bruce Kutnick spent approximately eight months in India studying the extent, scope, and the underlying forces motivating industrial research and development in India. In the course of his research Mr. Kutnick interviewed personnel from more than 80 firms, industrial associations, research centers, and government agencies and ministries.

Some of the preliminary results of Mr. Kutnick's study include the following: (1) Indian firms that undertake R & D have not, in general, been more prone to export their technology or to establish manufacturing operations overseas than have non-R & D performing firms. (2) Affiliates of multinational corporations, were found to follow a somewhat different research strategy than wholly-owned Indian firms. The majority undertook development activities that dealt only with their local manufacturing problems, looking almost exclusively to their parent corporation for new products or different manufacturing techniques. Most of the wholly-owned Indian firms engaging in R & D, however, were primarily involved in import substitution development activities, and were more likely to search for new products and new technologies from several different sources, including Indian national laboratories. (3) In the pharmaceutical and dyestuff industries a positive correlation was found between research intensity and some characteristics that one might associate with a "progressive" firm--i.e., export intensity, profitability, net capital investment, and sales growth. None of the firms studied, however, claimed that their current success was a result of their own R & D output, since research was frequently undertaken in response to the government's policy restricting imports of industrial goods and technologies. Firms that conducted R & D expected that the government would show them preference when allocating expansion and import licenses.

Title: Electromagnetic Prospecting for Subsurface Water in Arid Regions

Principal Investigator: Professor James Meyer  
Energy Laboratory

The initial phase of this project was completed during the past year under the direction of a new principal investigator, Professor James Meyer of the MIT Energy Laboratory. Originally sponsored by the TAP, the project was awarded an additional grant during 1974 by the Center for Space Research and is now seeking funding for the next phase of the program.

The primary objective of the project was to develop a method for finding ground water in arid regions. It appeared that techniques originally developed for electromagnetic probing of the lunar interior and other techniques developed for the generation of high-power audio frequencies could be combined to create a magnetic inductive coupling system for rapidly measuring ground conductivity profiles, which are immensely useful when prospecting for the presence and quality of subsurface water.

The project undertook the study and eventual conceptual design of a system which involves measuring the direction, intensity, and time phase of the magnetic field observed near the surface of the earth at a distance from a horizontal coil

energized so as to create a field that penetrates the earth. The research group hoped to be able to deduce the conductivity and stratification of the subsurface from such observations.

As a result of the theoretical studies and a rudimentary experiment in an arid region of the United States, the group can now show that the approach under consideration is conceptually valid and that this geophysical prospecting technique deserves to be developed into a pragmatic system for the economical exploration of subterranean water resources.

Title: The Leadership Roles and Potential of Business Managers in Economic Development and the Transfer of Technology in African LDCs

Principal Investigator: Professor Willard R. Johnson  
Department of Political Science

During 1973-1974 TAP funds for this project supported travel within the United States, to London, and to Africa to conduct interviews and collect documentary source materials, and to prepare this interview material for analysis. The researchers also accumulated and analyzed relevant documentary material and wrote draft reports and study papers on their findings.

During the summer of 1973 Professor Johnson and his research assistant focused their studies on two areas, (1) the role and performance of international business and parastatal business organization as vehicles for transferring technology to developing areas and in promoting economic development; and (2) management training for business contributions to economic development.

Professor Johnson made several field visits in order to examine documentation concerning the various issues under investigation, including company and organization files, annual reports, newspapers, and government reports and statistics. In addition, he visited with personnel in charge of management training operations in individual businesses, training institutes, and at universities.

Title: Technology Adaptation in the Textile Industries of LDCs

Principal Investigators: Professor Stanley Backer and Dr. Stelios Arghyros  
Department of Mechanical Engineering

The objective of the project was to strengthen the curriculum in the Fibers and Polymers Division of the Department of Mechanical Engineering in the textile area by developing case studies and technical and economic information pertaining specifically to the problems of the textile industries of less developed countries. The project has now been completed, as has the process of incorporating the material developed during 1972-1973 into new and existing courses. Professor Backer hopes

to continue emphasizing the subject of technology adaptation; in the original proposal for this project, one objective was the generation of interest in further research on technical problems relevant to LDCs. Such interest did, indeed, develop; a new project, under the direction of one of Professor Backer's research associates, was funded by the TAP and is discussed later in this Appendix.

Title: Colloquium on Assessing the Economic and Environmental Impacts of Alternative Urban Growth Strategies

Principal Investigators: Professors Lloyd Rodwin and Lawrence Susskind  
Department of Urban Studies and Planning

In the spring of 1973 members of the School of Architecture and Planning held a series of colloquia to investigate the reciprocal relationship between rapid urbanization and the quality of the human environment. The major result of these efforts was a realization that little is known about the interface of these two policy areas and that it is difficult to even formulate a framework for analysis.

The Department of Urban Studies and Planning, therefore, set out to develop a long-term teaching effort that would begin to broaden our understanding of the policy options and processes involved. A seminar format was selected as the most efficient vehicle for evaluating the current state-of-the-art as perceived by leading international experts. The results of the seminar could be used as the basis for establishing a more comprehensive program designed to attract new faculty members and train students in the fields of environmental planning and economic development.

A list of topics and seminar participants was developed. Speakers were invited to explore the feasibility and possible advantages and disadvantages of harnessing urban growth strategies to achieve a wide range of positive environmental effects. The group hoped to examine the experiences of economically advanced countries in order to deduce the extent to which existing policies, technologies, and administrative and fiscal approaches might serve the needs of developing nations.

Since the discussion was restricted to what could be accomplished within one or two generations, the participants were forced to deal with transfer and adaptation processes rather than with purely "hardware" solutions. The direction of the seminar was towards the policy, programming and institutional aspects of devising and executing plans to influence urban growth within the constraints, and, if possible, with the assistance of, the natural environment. Futuristic and utopian visions gave way to a sober appraisal of what could be accomplished given the harsh realities of rapid urbanization.

Title: Intercity Freight Transportation in Developing Countries

Principal Investigator: Professor Joseph Sussman  
Department of Civil Engineering

This project proposed to focus on the development of an evaluation framework for the analysis of freight network alternatives in developing countries, particularly in Latin America. The research team concentrated on integrating existing proven methodology with newly developed techniques, particularly in the rail area, to develop an overall analytic framework for multi-modal network design alternatives.

The project included the following specific areas of research: (1) a review of existing national freight transport networks in countries at various stages of economic growth with special emphasis on historical development, capital and operating costs, modal performance and impact on the economy; (2) a review of existing freight transportation problems and opportunities in South America undertaken in conjunction with national officials, with a goal of identifying alternative courses of action as well as major issues and tradeoffs; (3) the adaptation of existing models and methodologies to the problems of those developing countries identified in the first two phases of the research; and (4) the development of an analytic framework that identifies important issues and tradeoffs in network design and suggests the appropriate models and methodologies needed to attack these questions in the context of developing nations.

Title: Efficient Utilization of Natural Fibers in Developing Countries

Principal Investigators: Professor Stanley Backer and Dr. Subhash K. Batra  
Department of Mechanical Engineering

This project was a direct outgrowth of Professor Backer's research on "Technology Adaptation in the Textile Industries of LDCs", which was completed successfully during 1973-1974.

When the synthetic fiber industry became a major economic force after the second World War, the primary motivation for improvements in the fabrication technologies of natural fibers was to benefit the economies of the less developed countries. More recently, however, the "energy crisis" has provided an additional reason for the efficient utilization of natural fibers since petroleum, the essential raw material of the synthetic fiber industry, is a limited energy resource. It appears reasonable, therefore, to assert that the effective utilization of natural fibers could help both the developing countries, by making their industries economically viable, and the developed countries, by reducing the demand for petroleum products.

The present investigation focused on the natural fibers other than cotton and wool with the following objectives: (1) the identification of the sources of supply of a given type of natural fiber and the geographic distribution and potential quantities available; (2) the identification of the physical, mechanical, and chemical properties of the fiber so that end use applications can be projected to as large an extent as possible; (3) a review of current fabrication practices of products using natural fibers at the cottage and more advanced industrial level; (4) the identification of existing technologies which could be used to improve the process or quality of current fabrication methods with respect to specific end products; and (5) the identification of market research needs for new potential areas of fiber utilization.

## TECHNOLOGY ADAPTATION PROGRAM FUNDED-RESEARCH PROJECTS, 1975 - 1977

Title: Analytical and Experimental Development of Hydraulic Turbines and Windmills

Principal Investigators: Professor David G. Wilson  
Department of Mechanical Engineering  
M.I.T.

Professor Francisco A. Rodriguez, Dean  
Department of Mechanical Engineering  
Universidad de los Andes

Two five-kilowatt water turbines were studied for very different conditions in Colombia. One used the velocity head in a swift-moving river, and was designed to be suspended below a catamaran-type raft, which would be moored away from the bank near a village using the power output. The second was a reaction machine designed for ten-meters head for farms and small communities, such as coffee plantations in the Colombian uplands.

### Raft Mounted Turbine for Swift Rivers

A raft-mounted mill-generator system to provide electrical power for swift rivers in rural Colombia was designed. Several requirements had to be met by the design:

1. A single unit was to provide 5 kw from a river flowing at 4 m/s.
2. The entire raft was to be anchored through some means in the stream.
3. The raft was to be easy to remove from the stream for periodic maintenance.
4. The design should incorporate as many locally obtainable materials and manufactured items as possible.
5. The entire unit should be capable of being assembled with simple tools and in a rural environment.

The water mill was designed in sufficient detail for it to be constructed by skilled craftsmen at the village level.

### Small Water Turbines for Farms and Small Communities

The purpose of this part of the project was to study alternative water turbines producing 5 kw electric power from an available hydraulic head of 10 meters and a sufficient amount of flow, and to recommend one for manufacture. The work consisted of the preliminary design of different types of water turbines which could be used for this application. Then one was selected and designed completely. A complete set of working drawings was produced for the selected type.

Four different types of water turbines were studied: a cross-flow (Banki); two types of axial-flow turbines; and a radial-flow turbine. Each one had some disadvantages, but one of the axial-flow turbines was chosen for detailed design as presenting the optimum combination of simplicity and efficiency. This design appeared to be considerably simpler and less expensive to make than the only other known similar design, one for VITA (Volunteers in Technical Assistance). In addition, the construction method employed in building the prototype using glass-reinforced polyester resin with Plaster of Paris molds appeared to be well suited for small-scale industrial production in developing countries.

Title: Evaluation of Rural Roads in the Context of Development

Principal Professor Fred Moavenzadeh  
Investigators: Department of Civil Engineering  
M.I.T.

Professor Manuel Baquero, Head  
Department of Civil Engineering  
Universidad de los Andes

A lack of adequate roads has often been cited as an important factor impeding the achievement of social and economic development in many areas of the developing world. Roads are perceived as critical in providing access to social services, and as an important factor in stimulating development in rural areas. Road construction itself has also begun to be viewed as a potential means for generating public sector employment. Road construction, however, is an expensive activity, and in the past has often "squeezed out" investments in such areas as public health, education, and agricultural development, without necessarily providing comparable benefits for the poorest segments of society. This problem has been accentuated by the tendency to emphasize well-designed but costly road projects.

This research focused on the development and preliminary implementation of a methodology for investigating the complete set of social, political and economic impacts of rural road projects, specifically those of the "Pico y Pala" program in Colombia and similar programs in Mexico and elsewhere. A multi-level method of analysis was designed, based on a combination of research methods used in the social sciences, including content analysis, interview, survey, and participant observation techniques. At the national level, it is important to locate the "Pico y Pala" program within the overall Colombian planning process and plan for development, as this is the level at which decisions about the program are made. At the regional level, where the program is implemented, identification of the role of Caminos Vecinales and other agencies in program implementation, their views of the objectives and expected benefits of the program, and so forth are needed. Finally, at the local level, the actual impacts of the particular projects on the community must be ascertained in terms of: (1) economic effects such as employment, income, consumption, and transport cost; (2) migration effects such as changes in the propensity to migrate and in preferences for living environment; (3) cultural effects such as education, cultural interchange, and

attention to mass media; and (4) political effects such as community action groups, public services, and political opinions. By means of this multi-level analysis, what is learned at the local level may help in ascertaining whether program objectives at the national level are being met and why or why not. What is learned at the regional and national levels, on the other hand, might help explain the final outcome, expected or not, of a specific project and put it into a context such that the findings might be more generalizable.

Title: Planning Methodologies for Water Resource Investment and Allocation in Colombia

Principal Investigators: Professor David H. Marks  
Department of Civil Engineering  
M.I.T.

Professor Alejandro Deeb  
Department of Civil Engineering  
Universidad de los Andes

This project investigated planning methodologies that would better incorporate the uncertainties in demand in order to guide investment in decision making for municipal water supply expansion.

Municipal water and wastewater investments represent a large and important segment of the expenditures made by local governments. The response of designers to the problem of sizing increments to capacity has been to overbuild in order to assure safe and adequate supplies. A growing body of evidence suggests that the magnitude of overbuilding has been excessive.

This study focused on capacity expansion for water and wastewater related services. In particular, it was concerned with the implications of different levels of modeling detail on single facility capacity expansion planning, for a well defined service area. The general approach followed was the development of a controlled theoretical framework for classifying alternative methods for capacity expansion, model formulation for several cases of input assumptions, and application of the models in specific case studies.

It was found in the course of sensitivity studies that traditional engineering design horizons for water supply facilities are probably too long. Instead of designing to satisfy demands 25 years into the future, building to satisfy demands projected to occur in less than half the time into the future appeared far superior in economic efficiency terms. This sort of conclusion is especially important in the Colombian planning environment where true economics of scale in facilities are probably low, and social discount rate is probably high.

Title: A Study of Freight Commodity Transport Requirements in the Republic of Colombia

Principal Investigators: Professor Joseph Sussman and Mr. James Sloss  
Department of Civil Engineering  
M.I.T.

Professor Manuel Baquero  
Department of Civil Engineering  
Professor Ulpiano Ayala  
Department of Economics  
Universidad de los Andes

The status of freight transport services in countries undergoing economic and social evolution had been examined in a prior study performed by the Technology Adaptation Program in 1973-74 entitled "Intercity Freight Transportation in Developing Countries". This project focused on goods transportation facilities in four Latin American countries, specifically Argentina, Brazil, Colombia, and Mexico, with particular emphasis on the performance of these countries' railways. This second project surveyed in-depth commodity flows in one of these countries - Colombia. It concentrated on the present and prospective viability of that Republic's railway system in the context of a need for an efficient and economical transportation agency with a capability to facilitate product distribution and thereby contribute to the development process.

As a result of a prior study conducted by the Netherlands Economic Institute, it was demonstrated that serious operational and financial difficulties characterized each of the components of Colombia's transport network viewed as an entity. While some of these difficulties were attributable to the topography and demography of the country and consequently not readily subject to modification, there did appear to be numerous opportunities to make changes which would improve the flow of commodities and provide benefits both to producers and consumers of goods of every description.

Unmistakably, the present and future role of the National Railways constituted the single most challenging problem and one where the combined expertise of faculty members at the University of the Andes and the Transportation Systems Division at M.I.T. might make a major contribution. A transfer of technology, based on the experience gained in several years of reviewing the economics and operations of freight transport by railroads in the United States, was planned because a preliminary survey of problems confronting Colombia's National Railway systems indicated a remarkable similarity with those experienced by the American lines. The reports produced by the M.I.T. project team dealt, in one form or another, with many of these critical areas. It was hoped that, with appropriate modifications, this knowledge might prove extremely relevant to the railroad problems of Colombia.

The study was designed to supplement the previously described research of the Netherlands Economic Institute as well as several studies performed by the International Bank for Reconstruction and Development in connection with its provision of financial assistance to the railway.

In general, it dealt with the long-term role of the F.C.N. (Ferrocarriles Nacionales de Colombia) in the transport network of Colombia, with emphasis on its role in the haulage of major commodities and on alternative scenarios for line rationalization and improvement of the operations of the railroad. The general approach consisted of the identification of key issues of national and regional development which affect commodity flows, followed by an examination of the role of the railway system in ways such that the problems were viewed from a national perspective.

In contrast with previous studies, the collaborative effort concentrated its focus on the appropriate extent of operations of the railway system, looking at suggested new lines and establishing criteria for abandonments of superfluous lines, as well as considering the operational improvements which should be made to maximize the competitive position of the railroad in seeking to attract more traffic for which it is well suited. Throughout the project, the development of a methodology for decision-making by appropriate ministerial and railway officials was viewed as more important than the decision itself, insomuch as vital factors may easily escape the notice of an independent analyst. The logic of any decision must be validated by those persons directly involved on the scene.

Title: Political Determinants and Consequences of Technological Choices

Principal Investigator: Professor Nazli Choucri  
Department of Political Science

The objective of this study was to develop a framework for the systematic analysis of political factors in the process of the transfer and adaptation of industrial technologies and the identification of ways and means by which such factors serve to shape technical choices. A detailed analysis was performed of development plans for several countries in order to identify the national goals specified in the plans, the underlying social objectives, the extent of consistency among objectives, and changes in each over time. The major emphasis was on Middle East countries, including Egypt, Kuwait, Algeria, and Morocco.

In undertaking the development plan analysis, the investigators sought to determine the major procedures for national planning in the countries in question, and the extent to which plan goals represented national consensus. They also tried to determine the extent of technical work that had initially gone into the plans, and the sophistication of the work. It was found that with few exceptions, the economic analysis was cursory and the demographic inputs minimal. This was especially true of countries that formally acknowledged the population problem as a major obstacle to development. Both in Egypt, where the rate of growth is viewed by the leadership as of paramount importance in hindering growth, and in Kuwait, where the size of the alien population is regarded as a major problem, there appeared to be little technical input into development.

Title: A Framework for Technical and Economic Evaluation of  
Appropriate Technology

Principal Professor Richard S. Eckaus  
Investigator: Department of Economics

This project was established to apply technical and economic analysis to the description and evaluation of specific methods proposed as "appropriate" or "intermediate" technologies in developing countries. In carrying out this project it was decided to focus on some of the most fundamental processes in agriculture for which alternative methods existed ranging from "traditional," through modern "intermediate" to modern "high" technologies. This necessitated identifying the functional requirements of the processes and the technical and economic characteristics of the various methods. The latter was particularly difficult for both the traditional, and modern intermediate methods. It was found after a careful survey of the relevant literature that very few careful technical or economic studies had been done of any technology proposed as an "appropriate" technology for developing areas.

The first type of technology which was analyzed was low lift pumping utilized to irrigate fields from adjoining rivers and canals in developing areas, primarily for rice cultivation. A number of alternative types of pumps were considered ranging from the simplest human-powered pump through more sophisticated but still human-powered pumps to internal-combustion engine powered pumps of various designs. A program was developed to simulate the use of the alternative pump types taking into account pumping rates, water requirements and plot sizes. The analysis also considered manpower requirements for operation and set-up of the pumps and the capital costs of the pumps.

The main conclusion from the analysis of alternative low lift pumping technologies was that small internal combustion engine-power pumps dominated all types of human-powered pumps except when local practices and institutions required that a farmer on a plot of 10 hectares or less own his own pump. Otherwise some type of engine driven pump would provide water at lower costs. This result was not sensitive to reasonable variations in the design and cost parameters.

There are important implications of this result. The continued use of human-powered pumps must, therefore, imply either an inability of small farmers to pool their requirements in order to make a motor powered pump economical or, alternatively, some market "imperfection". The latter could be lack of information, imperfect labor or financial markets, or non-participation in labor, equipment or financial markets. The analysis suggests that there would be important benefits from changing from human powered to engine powered pumps.

Another area of agricultural technology investigated was the preparation of land for cultivation. In this case hand, animal, tiller and tractor methods were analyzed. The conclusions in this case were analogous but not exactly the same as in the analysis of low lift pumping methods. Comparative cost estimates of land preparation techniques indicated that animal powered methods were lower in cost than hand methods and, often, than tiller or tractor methods. However, a

major advantage of tiller and tractor cultivation is in the "timeliness" of cultivation by these methods, i.e., in their ability to perform the necessary tasks within a relatively short period. Use of these methods thus insures that land preparation requirements would not be a time constraint on output. The "bottleneck breaking" function of tillers and tractors would often permit double or triple cropping.

Again, with respect to land preparation techniques, if plot sizes were quite small and individual ownership of tools and equipment were required, animal and even hand techniques might dominate tillers or tractors. This demonstrates the importance of pooling the requirements and resources of small farmers, either through the markets, government-sponsored organization or cooperative methods. These results also have important implications for policy. Hand cultivation, and often animal cultivation, implies the inability to pool requirements and resources, or some type of "imperfection." The elimination of such restrictive conditions would result in increases in output and reductions in per unit costs.

A third area of agricultural technology which was investigated was drying methods for rice. At maturity rice contains 20% to 30% moisture on a weight basis. This must be reduced to 14% for short period storage and to 10% to 12% for long period storage. The techniques available range from solar, open-air drying to various types of "artificial" drying using machinery for exposing the rice to a heated air draft. The type of drying technology used will also affect rice quality and yield.

Solar drying has low absolute labor requirements but needs some space and, of course, suitable weather. However, the space requirements and the weather requirements, as well as labor requirements, may also be subject to the constraints of timeliness. If labor and/or solar drying encroach on the land preparation times needed for another crop, it may well be dominated by artificial drying methods. Or if climatic conditions after harvest make solar drying risky, then again artificial drying methods may be preferred.

The investigation of the alternative technologies also resulted in a critical review of a standard work on the employment effects of alternative rice marketing methods and facilities.

MIT/CAIRO UNIVERSITY TECHNOLOGICAL PLANNING PROGRAM

FUNDED RESEARCH PROJECTS, 1977

Title: Stochastic Model of Nile Inflows to Lake Nasser

Principal Investigators: Professors Rafael Bras and Peter Eagleson  
Department of Civil Engineering  
M.I.T.

Professors Hassan Ismail and Ismail Mobarek  
Faculty of Hydraulics and Irrigation  
Cairo University

Efficient utilization of the Nile waters requires the joint consideration of:

1. uncertain water supply, as provided by a complex and highly variable natural physical system which is augmented by engineering works; together with
2. growing water demand, as generated by expanding municipal, industrial and agricultural sectors.

Modern planning technology seeks to match supply and demand over the range of expected conditions, both present and future, while insuring efficiency as defined in terms of economic, social and political factors. It accomplishes this through a variety of mathematical formulations which allow the planner and engineer to explore both the economic and the physical consequences of proposed actions.

The Master Water Plan provides for the forecasting of water demands, for the establishment and weighting of objectives, for the development of regulatory controls, and for the scheduling of investments over time to match gross water supplies and demands.

This project will focus on the uncertainties in the Nile River flows entering Lake Nasser, thus providing information for use in reservoir operation and in policy formation. Two categories of uncertainty will be considered:

1. Uncertainties in the short-term (e.g., monthly) flows to be expected at Wadi Halfa as a result of observed precipitation and streamflows in the headwaters of the White and Blue Niles. This knowledge will be used to establish a method for short-term forecasting of reservoir inflows as an aid to improved reservoir operation. Improved forecasts of the inflows to Lake Nasser should permit operation of the reservoir in such a way as to minimize downstream erosion or to maximize power production.

2. Uncertainty in the long-term (e.g., yearly) volumes of riverflow to be expected at Wadi Halfa as a result of possible development projects in the Sudd region of the White Nile. Here, knowledge of the interaction of climate, soil and vegetation will be used in the assessment of the expected benefits and risks of the proposed projects. For example, understanding the water balance of the Bahr el Ghazal will produce improved estimation of the expected changes in both the annual volume of White Nile flow and the annual volume of groundwater replenishment resulting from possible land reclamation projects in this portion of the Sudd. This information will be of benefit to both Egyptian and Sudanese development planning.

Title: Regional Groundwater Studies

Principal Investigators: Professor John L. Wilson  
Department of Civil Engineering  
M.I.T.

Professor Abdelwahab Amer  
Faculty of Hydraulics and Irrigation  
Cairo University

The two largest groundwater reservoirs in Egypt lie beneath the Nile Delta in the north and the desert to the west and east. Both are among the largest freshwater underground reservoirs in the world and are important resources in the future of the Egyptian economy

The Nile Delta reservoir is over six million acres in extent with eastern boundaries near the Suez Canal and western boundaries well into the desert. It fills a vast underground bowl situated between Cairo and the sea. If it weren't for the presence of a saline wedge of seawater along the bottom of this bowl, the Nile Delta aquifer could be easily exploited for the best interests of Egypt. But the threat of salt water intrusion has limited pumping of this aquifer to one billion cubic meters per year, equivalent to two percent of the annual Nile flow.

The desert aquifer, which was recently called the largest underground water reservoir in the world, has been the subject of long study by the Egyptian government. Its water is a primary requisite to the development of the desert. This vast reservoir is believed to be recharged in the border area of Egypt, Sudan, Libya, and Chad. From there the water flows north and east toward the Oasis at Kharga, Kakhla, Farafra, and Bahariya. These are, historically, nothing more than low points in the desert from which springs rise with their source in the western desert aquifer.

To aid the Ministry of Irrigation of the Government of Egypt in the development and management of these aquifers, two regional studies are underway. Both studies involve the use of numerical aquifer models. For the Nile Delta the regional study has the following objectives:

1. Develop a numerical model of the Nile Delta aquifer for the prediction of piezometric head and seawater intrusion;
2. Apply the model to the aquifer;

3. Evaluate the need for more sophisticated models in the future, due to the complexity of the seawater intrusion problem, and if necessary develop and apply them.

This effort will provide us with an evaluation of the aquifer's safe yield, its ability to serve as a seasonal reservoir for water released from the High Dam, and its interaction with irrigation and drainage activities. The result of such a study will lead to increases in power generation at the High Dam due to the availability of downstream storage. Progress to date primarily encompasses data collection, and model calibration and development.

In the Western and Eastern Deserts the project objectives are:

1. Develop a numerical model of the entire aquifer from its source in the border region to the sea;
2. Apply the model to the evaluation of water supply for future development in the desert region;
3. In accomplishing the above objectives, it will be the further goal of this project to evaluate the uncertainty of water development, associated with the various levels of data availability in the aquifer region, especially in the Eastern Desert.

This work is initially oriented toward an analysis of the impact of the Qattara Depression and Toshka Depression projects on the Western Desert aquifer, and is a natural outgrowth of the more localized modeling and data collection efforts of the Ministry and other agencies. The primary long term benefit to be derived from such an effort will be a comprehensive study that ties together myriad previous programs and efforts, and points to those areas requiring additional attention, while improving the chances for successful development of water resources in this region.

Title: Housing and the Construction Industry

Principal Investigators: Professor N. John Habraken  
Head, Department of Architecture  
M.I.T.

Professor Ahmed El-Erian  
Faculty of Building Engineering  
Cairo University

The objective of this project is to provide a set of pragmatic recommendations/guidelines for the public agencies concerned with housing and to construct a methodology through which these agencies can organize and monitor performance in this sector. The interdisciplinary team has organized three related subprojects: one focuses on the Housing Economy and Public Policy, another on the Housing Construction Industry and Materials Supply, and the last on Housing Construction Systems and Design Norms.

The objective of the Housing Economy and Public Policy subproject is to develop a model of the Egyptian housing economy in order to evaluate a range of policy options of potential interest. In the short run these might include changes in government set housing rents and material prices, public housing investment and factor supplies. In the longer run, the model can be adopted to study the consequences of institutional changes such as the elimination of rent control.

The focus of the subproject on Housing Construction Industry and Materials Supply is on materials as an input to construction and the technology and economics of their production, distribution, and use. The first year results lie in three areas:

- (1) a survey of the availability and utilization of major construction materials in Egypt;
- (2) tentative recommendations pertaining to the alleviation of the constraints imposed on housing production by particular materials; and
- (3) suggestions as to directions for future investigations.

Concentration is to be on conventional as well as nonconventional materials, assessed as to their future potential in Egypt. Future activities will be expanded to include the institutional aspects--managerial, organizational and financial--of the housing and construction industry as well as the other resources--manpower, capital, and land--constraining housing production.

The overall goals of the Housing Construction Systems and Design Norms subproject is to develop guidelines/references for appropriate housing and physical planning derived from physical and socioeconomic realities. The project contains two primary areas of concern:

- a) The Industrialized Building Systems Planned For Use in Egypt. The objective of the research would be focused on two aspects: the evaluation of the large-panel concrete systems now proposed, and how they may be better utilized or modified for their best use in Egypt. In addition, the concept of prefabrication itself would be explored in relation to their potential benefit in Egypt. The focus would be on the types of housing, and the space standards and performance criteria offered by the systems which will permit evaluation and prediction of future trends and needs.
- b) The Planning of Settlements, With Focus On The Provision of Utilities, Services and Housing For The Informal Sector And On The Larger Scale Land Use Issues. Particular stress is on land subdivision: types, methods, and controls. It is the intent to define guidelines/policies that maximize the government's (public) effort considering the administrative/technical/financial constraints, with maximum receptivity to private/individual efforts. In the long-term research alternative physical planning models will be developed for low-income areas based on existing and proposed codes, existing settlement realities, and developer/financing mechanisms.

Title: Urban Transportation Policy

Principal Investigators: Professor Ralph Gakenheimer  
Department of Urban Studies and Planning  
M.I.T.

Professor Mohammed El Hawary  
Faculty of Civil Engineering  
Cairo University

The purpose of the research is to improve the process of project development and implementation in urban transportation for the Cairo metropolitan area. This takes the form of preparing a project programming method and also providing elemental tools and analyses to government agencies for the solution of special problems and as general analytical resources. Briefly summarized, the contract activities have included three major elements: programming and project development, traffic survey and analysis, and auto ownership analysis.

In transportation project development, the project's staff has conducted interviews, reviewed documentation, and completed project questionnaires to better understand the de facto process by which projects come into acceptance and move toward implementation in Cairo. These studies have resulted in a working paper, "The Project Development and Implementation Process in Cairo". Also during the contract period the literature on project programming has been reviewed and memoranda prepared on the adaptation of these methods to the Cairo setting. These memoranda have culminated for this period in the tentative proposal of the prototype method to be the focus of our further study and refinement.

The traffic survey and analysis element began with the preparation of a traffic volume and travel behavior survey in April 1977. There was a brief pilot survey which focused on the 6th October Bridge-Tahrir Bridge axes. It served to refine survey methods and also resulted in recommendations to the Ministry of Transport for the solution of a difficult traffic problem. These recommendations were implemented almost immediately. The full-scale survey which followed then produced information adequate to construct a complete set of origin-destination matrices and street capacity standards. It was fully documented for replication in the future by the Transportation Planning Authority. Preparations have been made for the use of computer programs to analyze this data. These programs have been installed at MIT and are being operationalized at Cairo University to assess and analyze the consequences of changes in the transportation system, such as those represented by the completion of new facilities. Certain auxiliary studies were performed to adapt the trip analysis programs to use in the Cairo setting. The resulting trip assignment capability will serve as a basis for the development of further travel analysis method, and as a component of the programming method mentioned above.

Initial data collection was undertaken on auto ownership in order to gain perspective on the possibilities for an analysis of this phenomenon in the future. Information was collected on production in the industry, on imports, and on auto ownership. Plans were made for the study of auto ownership in Cairo at the level of O-D zones by relating it to economic and social characteristics.

Title: Highway Transportation Planning

Principal Investigators: Professor Fred Moavenzadeh  
Department of Civil Engineering  
M.I.T.

Professor Mohammed El Hawary  
Faculty of Civil Engineering  
Cairo University

The purpose of this research is to demonstrate the application of an existing analytic framework, the Road Investment Analysis Model, to read transport investment decisions in Egypt, and to develop the necessary procedures for its modification and adaptation to the local Egyptian conditions.

The scope of the research effort during its first phase was restricted to the evaluation of road transport in a zone comprising roughly one-fourth of the paved road network of the Delta. Five reconstruction and subsequent maintenance policy alternatives were analyzed on each of twenty-five links independently. The five alternatives included: "do nothing;" a premix overlay followed by either scheduled or demand-responsive maintenance; and a double (asphalt over premix) overlay followed by either scheduled or demand-responsive maintenance. For each alternative and on each link economic analysis of net present value, first year benefits, and internal rate of return were performed against the do-nothing alternatives. Where data were lacking or unreliable, surveys were undertaken or engineering judgments were used.

The results of the twenty-five link-evaluation applications of the Road Investment Analysis indicated that there were four classes of link performance in the study zone under the proposed structural overlays and subsequent maintenance standards. These classes were:

- i) links which are in excellent present condition and for which the proposed investments may be postponed;
- ii) links which are in poor present condition and for which the proposed investments produce acceptable results. This means that the heavier structural overlay performs satisfactorily for the entire analysis period thus requiring no major subsequent maintenance investments;
- iii) links which are in poor present condition and which performed marginally under the proposed investments in that the heavier structural overlay failed in from 5 - 14 years, requiring major subsequent maintenance investments at that time, and for which heavier initial investments should be considered; and
- iv) links which are of weak structural strength and poor present condition and which would have performed poorly under the proposed investments in that both of the proposed structural overlays failed in less than 5 years, where all of the net benefits accrued from major subsequent maintenance investments, and for which heavier initial investments or reconstruction must be considered.

A tentative general finding which held true on all links analyzed was that, of the four post-construction maintenance policies studied, the one with the heaviest overlay dominated the economic analysis, independent of the effectiveness of the original double (asphalt over premix) overlay, which was the more extensive of the two construction options analyzed. Thus, on all links studied, the heaviest construction and maintenance investments produced the greatest economic net present values. This and the above performance classification are being reviewed in light of assumptions made during data collection. A visual inspection was made of representative links in the study zone to verify these predictions.

The link analyses disclosed several key data items which must be developed before the network analysis could proceed and emphasized the need for acquisition of road evaluation equipment. During the next six and one-half months, further operating cost surveys will be made by the Transport Planning Authority; the Road and Waterway Authority will conduct traffic classification and axle load surveys; and Cairo University and Road and Waterway Authority participants will analyze the climatic and sub-surface drainage effects on road deterioration for representative Egyptian conditions. The network analysis model will be used to calibrate the traffic assignment parameters (value of time and diversion intensity) through a series of preliminary network analyses. The study network will then be analyzed under the proposed alternative maintenance policies and investment schedules.

Title: Government Incentives for Small-Scale Industry

Principal Investigators: Professor Suzanne Berger  
Department of Political Science  
M.I.T.

Professor Mostafa El Said Ibrahim  
Faculty of Economics  
Cairo University

The principal objective of this project is to analyze the ways in which government policy encourages or discourages innovation and growth in the small-scale private industrial sector in Egypt. The underlying rationale for the research is that if the obstacles to the expansion of the small private industrial sector were removed, increases in its production, its productivity, and its employment could be achieved that would increase the revenues of low-income groups in the population. The small firms being studied are those that employ one hundred or fewer workers (though the census definition of small industry is nine workers or fewer). The policies analyzed include a wide range of legislation: fiscal and social insurance taxes, laws on incorporation, price controls, and import regulations. We are studying as well the impact of the various bureaucracies that deal with small businesses on those firms' incentives to expand. The tax administration, the banks that lend to small businesses, the cooperatives, and the government control agencies are all institutions that deal regularly with small business and shape the environment in which decisions about growth are made.

In its first year, the project has studied one industry in detail: the shoemaking industry, which is predominantly small-scale. A survey was carried out in 200 shoemaking firms in the Cairo area. This industry presents the advantage, from the perspective of the long-term goals of the research, of being relatively labor-intensive and having a good export potential. The second major activity in the first year of the project has been interviews of government officials in the Ministry of Industry, the Ministry of Local Governments (which has responsibility for industry with fewer than nine employees), with tax officials, with inspectors from the division of industrial control, and with private businessmen with medium-sized firms. Political figures were also interviewed (members of the People's Assembly, cooperative officials) who represent the small-scale private sector in their constituencies.

Title: Development of Improved Macroeconomic and Sectoral Planning Methods

Principal Investigators: Professors Richard Eckaus and Lance Taylor  
Department of Economics  
M.I.T.

Professor Amr Mohie-eldin  
Faculty of Economics  
Cairo University

This project has as its goal the development of methods to assist in the formulation of overall and sectoral economic policy in Egypt. Current economic conditions and the achievement of development objectives at all levels are affected by decision-making at the center. These decisions include, for example, the allocation of foreign exchange and other investment resources, tax and general expenditure policies, price controls and subsidies, and so on. The significance of the issues warrants the attempt to make decision-making techniques as sophisticated as possible while avoiding reliance on mechanical procedures and allowing flexibility in the exercise of experienced judgment.

Methods are being developed which are both highly aggregated and sectorally detailed. The former attribute is useful in the formation of macroeconomic tax and expenditure and balance of payments policies. The latter is of assistance in determining the allocations of investment and foreign exchange resources among major sectors to achieve long term growth objectives.

The major effort in the project thus far has been in the preparation of a consistent set of national income accounts and input-output tables which show the interindustry flows of intermediate goods and services of each type. The problems in achieving consistency arise in part because the national income accounts are estimated in only seven-sector detail while policy decisions should be and are made at a much finer level of disaggregation. Part of the problem of data inconsistency arises from differences in the basic information which has been utilized in the preparation of the input-output tables and the national income accounts. In addition there have been changes in real relationships over time and in the relative prices of the various com-

modities which alter the input-output relationships.

After substantial work was put into the reconciliation of the data, tests were made of the data consistency which were, on the whole, negative. However, the tests provided guidelines for further adjustments. These have now virtually resulted in a set of data sufficiently consistent as to provide the basis for initial modeling attempts.

Models with several different types of analytical structures will be developed starting with simpler, and moving to more complicated, forms. The first aggregated and disaggregated models will essentially provide tests of static consistency of projections. However, by investigating the significance of alternative projections, considerable flexibility can be developed in the use of the models. Further development of the structure of the models will then be attempted to formulate and test dynamic consistency models and static and dynamic linear programming models.

Title: Egyptian Labor Migration

Principal Investigators: Professor Nazli Choucri  
Department of Political Science  
M.I.T.

Professor Amr Mohie-eldin  
Faculty of Economics  
Cairo University

By current estimates it is believed that approximately 1,000,000 Egyptians are presently working in other Arab countries. The precise number is not known, nor are their level of skills, their location, employment, earnings, or remittances. Since these individuals represent about 10% of Egypt's labor force, this migration may potentially become one of the most important issues in Egypt today. For example, it is presently estimated that migrant remittances exceeded LE 157 million in 1976--an important item in the deficit on the current account in the balance of payments.

The purpose of this project is to assist in the analysis of labor migration, and to identify the costs and the benefits to Egypt of exporting both skilled and unskilled manpower. Toward this end, we propose to model the process of migration across national boundaries in order to provide a framework for evaluating the costs and benefits to Egypt. An added objective is to identify and examine the potential effects of alternative policies designed to reduce the costs of migration and to increase the benefits.

The research design of the initial proposal was to survey six aspects of the migration issue in Egypt, and to undertake a more detailed analysis of those aspects that appeared, during this six month period, as most likely to yield useful results on short order. The six aspects were:

- (1) Compiling critical data on the Egyptian population and labor characteristics, and migration;

- (2) Determining the enrollment, recruitment, finances, and other aspects of higher educational systems in Egypt as it might bear upon, and be influenced by, migration;
- (3) Obtaining information on employment patterns and anticipating labor movements in order to develop some indications of magnitudes of potential shortages attributable to migration;
- (4) Identifying the demographic profile of other Arab countries in some broad terms;
- (5) Identifying the major interventions that can influence Egyptian migration; and
- (6) Developing a conceptual framework for evaluating the gains and losses to the country of the movement of its labor across national boundaries.

These six foci were originally conceived as distinct aspects of the general issues; however, as we progressed, it became clear that there was a high interdependence across all six that was reflected in a general shortage of data on various aspects of migration. That is to say that numbers were, in fact, available; but they were widely scattered; that when information was found, considerable work had to be undertaken in order to transform raw numbers into statistical data for use; and that, for the most part, it was necessary to obtain access to sources of information that were privileged and required special permission from government agencies.

Title: Health Care Delivery Systems

Principal Investigators: Professors Richard Eckaus and Lance Taylor  
Department of Economics  
M.I.T.

Dr. Salah Shahbender  
Faculty of Medicine  
Cairo University

This project has two objectives: 1) to assist the Egyptian Ministry of Health in its efforts to address malnutrition and early childhood mortality; and 2) to narrow the gap between promise and performance in the rural health service by illuminating various problems in system-society interaction.

During its first year, the project has launched three types of inquiry.

(1) A general assessment of malnutrition among pre-school children in Egypt and an "overview" analysis of the health systems as a vehicle for dealing with malnutrition. This work focuses on the Egyptian situation with reference to both the problem and its parameters, on one hand, and the structural and

operational attributes of the health care delivery system germane to the problem, on the other. Informing this context-specific inquiry is a more comparative "nutritional review" of the health sector.

(2) Computer analysis of governorate-level data on infant mortality, the birth rate, various indices of development, and dissemination of the health system. This work seeks to illuminate the interaction between mortality and fertility and to specify the effects of different forms of development on each. It is also probing the independent role of health interventions in these dynamics, while coming to grips with the problem of "reporting bias" concerning vital statistics in Egypt.

(3) Development and distribution of a questionnaire to a national sample of rural health centers and units (one per district). The questionnaire solicits three types of information: 1) perceptions, beliefs, attitudes, and reported behaviors on a range of issues, with the head doctor of each facility being the principal respondent; 2) retabulation of data already available on the RHC's and RHU's but using new categories, disaggregations, and combinations in order to make the data more informative and servicable; and 3) original data on nutritional status generated by a two-week exercise of weighing children in a subsample of centers and units (one per governorate).

Future plans call for more concentrated work on the periphery of the health system, including a population survey to complement the system questionnaire.

Title: Engineering Applications for the Plastics Industry

Principal Investigators: Professor Frederick McGarry  
Department of Materials Science and Engineering  
M.I.T.

Professor Salah Bayoumi  
Faculty of Design and Production Engineering  
Cairo University

The purposes of this project are:

1. To develop a group within Cairo University with competence in plastic materials.
2. To foster teaching and research by this group in the area of polymers and plastics engineering.
3. To encourage professional interactions and activities between the group and Egyptian industry and government organizations.

Accomplishments to date of the Cairo University Project Team include:

1. Designing and building a testing machine for plastics films which are produced and used in large quantities in Egypt for agricultural sacks and industrial packaging.

2. Designing and building a pipe burst testing apparatus. A large amount of pvc and polyethylene pipe is extruded in Egypt and used for a variety of purposes.
3. The development of materials and products standards and specifications for the local plastics industry. This will be of great value to the Petrochemicals Project and government Ministry Personnel are following this activity closely.
4. Setting up a library with reference texts and journals on plastics at Cairo University, adjacent to the newly inaugurated Plastics Research Laboratory.
5. Executing a consulting contract with the Egyptian Public Authority for Drainage Projects to advise and assist in the design, construction and operation of three new plastics drainage pipe manufacturing plants which will be built in Egypt, starting this year. It is estimated that the contract will amount to 15-20,000 Egyptian pounds per year, to the Cairo University group.
6. Establishing good working relationships with several large plastics fabricating companies in Egypt, the most attractive and promising of which is National Plastics, in Cairo.

The M.I.T. counterparts' activities have included the following:

1. Assembling a large amount of specifications and other information about plastics pipe and transmitting copies of it to the Cairo University group. The same was done in regard to their technical library on plastics.
2. Developing and constructing a special crack opening displacement gauge for pvc and polyethylene pipe samples, to use in applying fracture mechanics concepts to pipe failure predictions.
3. Developing and constructing a special, triaxial extensometer to measure strain in three orthogonal directions simultaneously, in plastics pipe specimens.
4. Assisting the Cairo University group in establishing and developing collaborations with local industry and government groups.

Title: Long-Term Investment Planning for the Egyptian Electric Power System

Principal Investigators: Professor Martin Weitzman  
Department of Economics  
M.I.T.

Professor M. S. Abou-Hussein  
Faculty of Electrical Engineering  
Cairo University

72

The basic objective of this project is to help develop professional skills in applying operations research, mathematical economics, and cost-benefit analysis to appraise specific projects or investment strategies in Egyptian electric power. There are six project areas:

1. A preinvestment survey for investment planning. The Ministry is confronted with the task of selecting electricity generating projects from a wide range of options, including hydroelectric, thermal using various fossil fuels, gas turbine, and nuclear. We have mathematically formulated the problem of expanding capacity at minimum present discounted cost and, under certain simplifying assumptions, derived a formula for an "equivalent cost per kilowatt" which has a rigorous foundation as the solution to the optimal capacity expansion problem and automatically corrects for project size. The formula can be used to cost out various investment alternatives and lends itself very readily to an economic analysis of varying the main parameters -- cost of fuel, interest rate, growth of demand, etc. The data have been collected, equivalent costs of capacity have been calculated for each type of plant and parametric analysis has been performed. The Ministry people will be using these results as an initial step in a more detailed capacity expansion smoothing algorithm currently available on a computer.

2. Demand for electricity fluctuates - daily, weekly and seasonally. Some types of plants (steam generators) are relatively cheap per kilowatt provided they are used at near full capacity. At low capacity utilizations they are relatively expensive per peak kilowatt, but the output can be easily and cheaply varied, and they are relatively cheaper at low outputs. The basic question is this: given the pattern of demand fluctuations, what should be the least cost mix of power station types? We have succeeded in mathematically formulating a simple version of this problem which captures the essential cost ingredients. Data have been collected and the model is being programmed for computer solution.

Four new areas which will be included in the next phase of the project are:

3. Reliability study of Egyptian electric power system - transmission, and distribution;
4. Cost-benefit study of radial vs. ring distribution systems;
5. Cost-benefit study of three phase vs. single phase transmission;
6. Cost-benefit study of three-core vs. three single-core distribution cables.

**APPENDIX B**

**INSTITUTION BUILDING: MEETINGS, WORKSHOPS, SEMINARS**

INSTITUTION BUILDING: MEETINGS, WORKSHOPS, SEMINARS, 1971-1972

A. At MIT

Technology Adaptation Program-related research has created a growing awareness of and interest in the total process of development both in the industrialized and the less industrialized nations. In accordance with the second Program Element listed in the original Proposal for this Grant, numerous seminars, workshops, and informal meetings have taken place within the MIT community in an attempt to focus on, among other matters, the "technical sequences involved in industrialization".

During 1971-72 the Program Steering Committee decided to begin Grant-related activities by increasing faculty understanding of MIT's past experience in work related to technology transfer and adaptation, and by establishing goals and priorities for the Program based on the direction of faculty interest. A series of faculty workshops were held in order to further these objectives; notes on each meeting were prepared and circulated to the Steering Committee. The speakers and topics were as follows:

- |             |   |
|-------------|---|
| February 14 | Presentations by Professor Fred McGarry, MIT Department of Civil Engineering; Professor Charles Savage, Harvard Business School; and Dr. Rao, Ford Foundation; on the MIT Inter-American Program in Civil Engineering, with which all three speakers had been associated. |
| February 22 | Presentation by Professor Everett Hagen on the early stages of industrial development and potential methods of investigating the later stages.  |
| February 29 | Presentations by Professor Richard L. de Neufville, Department of Civil Engineering, on approaches to transportation systems in LDCs; and Professor J. Schaake on integrating the development of the Rio Grande in Argentina.   |
| March 6     | Presentation by Professor Lloyd Rodwin, Head of the Department of Urban Studies and Planning, and members of the SPURS (Special Program for Urban and Regional Studies of Developing Areas) fa-   |

culty on the SPURS program and other on-going and planned department work in developing countries.

- March 14 A workshop on MIT's institution building programs overseas with discussion by a number of faculty members who were involved in these programs.
- March 28 Presentation by Dr. Jack Baranson of the World Bank and the NAS on defining appropriate technologies for developing countries.
- April 3 Presentation by Dr. Nevin Scrimshaw, Head of the Department Nutrition and Food Science, on worldwide problems and potential solutions to protein deficiency with particular attention to the production of single cell protein.
- April 11 Presentation by Professor Horatio Caminos of the Department of Architecture and graduate students from the Department on urban settlement design in developing countries.
- April 18 Presentation by Professor Carroll Wilson, Sloan School of Management, and Constantine Simonides, Vice President of the Institute, on the MIT Fellows in Africa Program (1960-1967) and the MIT Fellows in Colombia Program (1965-1968).
- May 2 Presentation by Dr. Walter Falcon of the Harvard Development Advisory Service on the operations and experience of the DAS in developing countries.
- May 8 Presentation by Dr. Bruce Old, C. Bliss, J. Mitchell, and D. Feeley of Arthur D. Little Company on the operations and experience of ADL in developing countries.

#### B. Overseas

Most of the members of the MIT community involved in the Technology Adaptation Program have contributed their time and energies to the dissemination of Grant-related information to developmental activities and programs in emerging nations. Project members have undertaken trips to various nations in connection with Grant-supported research in order to collect data, establish collaborative working relationships with educational, governmental, and private institutions to serve as visiting instructors at various colleges and universities and as consultants to both private and governmental agencies, and, in general, to attempt to provide whatever form of assistance the particular country, agency, or government needs.

In this Appendix we would like to mention a few specific instances in which members of the MIT community have shared their knowledge with, or in some other way contributed to the development process of various nations. Since the Program was not fully underway in 1971-1972, only two overseas trips were made by faculty members under the Grant. Professor Thomas Allen visited Guatemala on December 4-8, 1971, and Professor Richard de Neufville visited Colombia on April 4-8, 1972. Professor Jack Ruina traveled on an AID missions to Nigeria and Ethiopia using funds from other sources.

INSTITUTION BUILDING: MEETINGS, WORKSHOPS, SEMINARS, 1972-1973

A. At MIT

In connection with his project on "Water Resources Technology Adaptation", Professor Frank Perkins presented a summary of observations concerning water resource planning in Asia to the weekly Water Resources Division Seminar of the MIT Civil Engineering Department.

Professor Robert Simpson was the principal investigator for a TAP project on "Air Transportation in Developing Countries." As a result of investigations undertaken in pursuit of educating personnel at the Flight Transportation Laboratory about the nature of the problems faced by developing countries in the air transportation area, the Flight Transportation Lab determined that the most immediate way it could help developing nations would be to organize an Advanced Study Program in Air Transportation at the MIT Center for Advanced Engineering Study.

The program is designed for individuals who have supplied and will continue to supply the initiative, leadership and accomplishment needed for the development of the world's air transportation systems. It is a multidisciplinary program covering technology, management, economics, law, and operations research, and is designed to prepare the participant for a career in managing and planning the development of air transport systems.

To insure that the program was relevant to developing countries, a seminar of the Directors General of Civil Aviation was held in February 1973, the intent of which was to get the opinions of these informed professionals as to the content and duration of the study program. The response was favorable. Comments from the delegates of Brazil, Nigeria, Trinidad, and Tobago were particularly helpful in orienting the program.

## B. Overseas

In connection with his project concerned with applying the Highway Cost Model to road conditions in Venezuela, Professor Fred Moavenzadeh visited the country in 1973 in order to begin implementation and calibration of the model. The calibration was carried out through cooperative work with the appropriate agencies in Venezuela, Brazil and Colombia. During a trip to the above countries plus Argentina, strong working relationships were established with the following agencies:

Venezuela: Consejo National de Vialidad (CONAVIAL)  
Ministerio de Obras Publicas

Brazil: P.U.C.--Pontifica Universidade Catolica.

As a prelude to visiting water resource planners in several Asian and African nations, Professors Frank Perkins and David Major engaged in extensive discussions with personnel in both American agencies and in international agencies located in the U.S. The objective in these discussions was to assess the existing level of planning expertise and to determine the probable acceptability for establishing an ongoing research project in various countries. The agencies with which these discussions were conducted included U.S. AID, UNDP, UN Resources and Transport Division, and the World Bank.

Professors Perkins and Major visited with water resource planners in Asian countries selected on the basis of agency discussion. Professor Major visited African countries in March. Both trips were for the following purposes:

1. to learn about the sources and reliability of hydrologic, economic, and other water resources project planning data;
2. to examine specific project planning documents;

3. to discuss planning standards and criteria with local planning authorities and with local AID, World Bank and other mission personnel; and
4. to assess the personnel and computational resources available for water resource planning, both in the government and in the universities.

As a result of these activities, Korea was identified as the country with the greatest potential for future projects. A feasibility study was carried out on collection and evaluation of data for the Han River, examination of river basin planning models, and definition of the planning and operational decisions which were at issue on the Han River. This preliminary work fostered working relations between the investigators and the Korean Bureau of Water Resources (Ministry of Construction) as well as with the Korea Water Resources Development, the Economic Planning Board and the Korea Institute of Science and Technology (KIST).

During the course of the first year of Professors Daniel Roos' and Nigel Wilson's project on "Urban Transportation in Developing Countries" visits were made to Caracas, Bogota, Sao Paulo and Rio de Janeiro and close working relationships were developed with the following groups in these cities:

Caracas: Oficina Ministerial de Transporte, Metro de Caracas  
Direccion de Planeamiento Urbano, Ministry of Public Works  
Planning Department of the Distrito Federal  
Comision del Desarrollo Urbano del Pais  
Consejo Nacional de Vialidad

Bogota: Universidad de Los Andes  
Oficina de Planeacion Socio-Economica, Distrito Especial  
Planeacion Nacional

Sao Paulo: Economic and Planning Department, State of Sao Paulo  
Companhia do Metropolitano de Sao Paulo

Rio de  
Janeiro:

Grupo de Estados para Integracao da Politica de Transportes

As a result of visits made in connection with Professor Simpson's project on air transportation, personnel from the Flight Transportation Laboratory established a close working relationship with the Bureau of Technical Assistance, International Civil Aviation Organization. These contacts led in 1973 to the participation in the Advanced Study Program of a faculty member of the ICAO Civil Aviation Safety Centre in Beirut.

As a result of their research on "Systems Analysis as an Aid in the Development Process", Professor Robert Stickney and his colleagues established a close working relationship with various members of the Institute of Nutrition of Central America and Panama (INCAP). Professor Stickney worked for nine months with the Applied Nutrition Division of INCAP in Guatemala.

The grant also enabled Professor Stickney and a research assistant to travel to Mexico City in September 1972 to attend the Ninth International Congress on Nutrition, where they presented a paper summarizing preliminary work in the application of systems analysis to nutrition planning. One of the objectives of the trip was to establish communication with nutrition groups in developing countries and to identify systems projects that would be of value to their work.

The grant also supported travel for Professor Stickney to Europe and Algeria in late May and early June of 1973. The purposes of this trip were to (1) visit FAO in Rome to discuss nutrition systems analysis problems with members of their Nutrition Division; (2) attend the IFAC-IFORS International Conference on Systems Approaches to Developing Countries (Algiers, May 28-31) and present a paper summarizing work on nutrition systems analysis; (3) visit UNICEF in Algiers and Geneva to learn of the nutrition programs in North Africa based on the production of

high-protein foods; (4) visit WHO in Geneva to discuss the use of systems analysis in the planning of health and nutrition programs in developing countries. In addition Professor Stickney visited Chile and El Salvador as a member of the MIT Nutrition Planning Group (expenses were covered from sources other than the 211[d] grant).

One of the links established between the TAP project on "The Transfer and Adaptation of Housing Technology and Standards to the Needs of Developing Countries," Third World nations, and international institutions was through the provision of a draft textbook and reference set on housing policy and technology in developing areas. This was distributed to MIT students and international institutions (including the Asian Institute of Technology, Bangkok, Thailand; University of Nairobi, Kenya; Department of Architecture, School of Planning, Ahmedabad, India; Universidad Ibero-Americana, Mexico City, Mexico). The distribution of the textbook was for trial use, feedback and revision. In addition, the project also did field work in East Africa and Mexico, and established contact with the U.N., World Bank, Interamerican Development Bank, and the National Academy of Sciences Office of the Foreign Secretary.

The project investigators were invited to several national and international conferences and meetings, including

- The First International Congress on Technology Assessment, The Hague, Netherlands, May-June 1973, where a paper was presented.
- MIT Summer Session on Building Technology, Guest Lecture, August 1973.
- Seminar on Housing Technology, Sir George Williams University, Montreal, Canada, September 1973.
- Evening Seminar Series on Housing and Urban Problems, Boston University, Guest Lecture, September 1973.

During the summer of 1972 a group of MIT faculty and graduate students went to Nairobi, Kenya, to evaluate local housing systems, future housing needs and performance requirements. The field work was in connection with the TAP-funded project on the "Development of Basic Performance Standards for Urbanization and Housing Technologies Through Testing of Models in Nairobi, Kenya." The medium of the work was field studies, workshops, and seminars in collaboration with the University of Nairobi and the Nairobi City Council. Tentative performance standards were formulated and compared with United States and Latin American references, and models were prepared during the 1972-73 academic year for testing standards. The project activities involved the following:

1. Intensive field work was carried out during the summer in Nairobi, Kenya. The emphasis was on testing, updating, and further developing materials and studies initiated at MIT.
2. A two-day workshop concerned with housing issues in developing countries, sponsored jointly with the University of Nairobi, was attended by approximately 50-90 people.
3. Extensive filming of various urbanization issues was carried out during the two-month summer period in Nairobi, with the assistance of the MIT Film Section and Professor Kaj Anderson, University of Nairobi. Parallel film documentation was undertaken in Mexico City for eventual editing and combination with the work in Nairobi.
4. Summer collaborative work with the University of Nairobi was held in which seminars, informal class presentations and critical discussions were offered to faculty and students on the following themes: (1) Buildings and Urban Environments--the process of development, design, construction, utilization and evaluation; (2) Educational Buildings for Venezuela--primary and secondary schools, standards and prototypes, site development design, construction; (3) University Campus Buenos

Aires, Argentina--site development, design, construction; (4) University Campus Los Andes, Venezuela--site development, design, construction ;(5) Two reinforced concrete construction systems for self-help housing.

Many other agencies, institutions, and individuals were contacted during the summer in Nairobi in order to receive as many viewpoints as possible with regard to housing standards, income redistribution, and developmental problems in emerging countries. The agencies contacted included the Nairobi City Council, Town Clerk's Department; the City Engineer's Department, Urban Study Group, Planning Section, and Architecture Section; the University of Nairobi, Housing Research and Development Unit, and Design Research and Development Unit.

A study trip was taken in Kika, Kenya, an industrial town being developed 50 km. northeast of Nairobi. The town illustrates long-range planning and different types of low cost housing including a proposed AID funded project. Field trips were also taken to Kampala, Uganda and Dar Es Salaam, Tanzania, to observe other East African housing contexts.

Professors George Farris and Anthony Butterfield, principal investigators on the TAP project "Organizational Studies and Development", undertook a fact-finding mission to Brazil to attend a meeting of key parties who might potentially be involved in the creation of a Brazilian Center for Organization Management Technology. During this visit they also held discussions with appropriate agencies regarding the Sao Paulo Technology Utilization Program, a program designed to upgrade the state of technology and increase its utilization by Sao Paulo industry. Several other projects were also investigated.

As a result of the contacts made by Professor Farris, a Brazilian group headed by Dr. Jose Pastore visited MIT in May 1973 to explore further the possibility of collaborative working relationships.

Mr. Bruce Kutnick spent approximately eight months in India studying the extent, scope, and underlying motivating forces of industrial research and development in India.

In the course of his research Mr. Kutnick interviewed more than 80 firms, industrial associations, research centers, and government agencies and ministries. Investigation of the general state of industrial R & D in India as well as a more detailed study of the pharmaceutical and dye-stuff industries were undertaken.

During his stay in India Mr. Kutnick was affiliated with the Indian Statistical Institute in New Delhi. In addition, an informal working arrangement developed between himself and several people from the Council of Scientific and Industrial Research who were engaged in a similar project.

Although this project is supported by the Technology Adaptation Program, the actual funding of Mr. Kutnick's trip to India was provided from other sources.

85

INSTITUTION BUILDING: MEETINGS, WORKSHOPS, SEMINARS, 1973-1974

A. At MIT

Professor Fred Moavenzadeh identified and contacted several members of the Civil Engineering faculty who are interested in the process of development. A productive meeting was held during December 1974 which was attended by thirteen members of the Civil Engineering faculty; Professor Moavenzadeh and his colleagues intended to continue with these informal meetings during the spring semester.

Professor Willard Johnson's work with "Business Management for Economic Development" generated a good deal of interest within the MIT community. As a direct result of his involvement with the project, Mr. James G. Karunga, a Research Associate at MIT currently engaged in writing a dissertation for his doctorate in the Department of Planning, took a position with the United Nations Conference on Trade and Development in the Transfer of Technology Division. Although he was not supported by TAP funds, Mr. Karuga was deeply involved with the project during 1973-74.

Professor Johnson's Research Assistant, Carol A. Bloomberg, enrolled in the Harvard Graduate School of Business. Her principal field is the role of international business in developing countries, an interest which was stimulated by her work on the project.

Mr. Thomas Biersteker, a graduate student working under Professor Johnson's supervision, is doing field research on his dissertation on the impact of international business in Nigeria.

Dr. Stelios Arghyros, one of the Principal Investigators of the TAP project "Technology Adaptation in the Textile Industries of LDCs", participated in a

number of grant-related activities during 1973-74. Dr. Arghyros attended several international meetings as well as a number of conferences, seminars, and workshops dealing with problems of developing countries, which were held at various U.S. universities. He participated in the Contractors Conference set up by the OST/AID in Denver, Colorado, in January 1974, at which he presented in summary form the activities at MIT under the Technology Adaptation Program. On February 8, 1974, he participated in a workshop at Yale University organized by the Economic Growth Center. The theme of the Workshop was "Microanalysis of Employment Generation", and in May 1974 he represented MIT on the External Advisory Council of Georgia Tech, which also has a 211(d) grant.

Two major TAP-sponsored colloquia were held at MIT during 1973-74. One was a semester-long seminar developed by the Department of Urban Studies and Planning under the direction of Professors Lloyd Rodwin and Lawrence Susskind; the second was the MIT Symposium on "Strategies for AID Programs in Selected Areas of Science and Technology" held at Endicott House in April 1974, which is discussed later in this Appendix.

#### Seminar on Assessing the Economic and Environmental Impacts of Alternative Urban Growth Strategies

The seminar used a comparative analytic approach to review the tools, techniques and strategies for guiding urban and regional growth. After two introductory sessions which set out the underlying issues, case studies were presented detailing experiences in three countries--Britain, France, and the United States--which have tried to deal with urbanization and the environment. The next session was devoted to an examination of the problem of transferring programming methods

developed in the technologically advanced countries to the poorer nations, specifically Argentina and South Korea. The seminar then turned to the cultural implications of technology transfer and adaptation, given the forces and patterns of urbanization in developing countries. The last three speakers focused on sectoral studies emphasizing technological alternatives. These five sessions (Professor Richard Meier met with the seminar for three consecutive weeks) addressed problems associated with housing, energy, food, transportation, and water resources as well as with the design of development strategies that combined facets of all these factors simultaneously--Professor Sachs, for example, spoke on "eco-development".

The last two meetings were devoted to a synthesis of the diverse issues raised by the speakers, and student members of the seminar were offered a chance to present their own work.

The seminar attracted fifteen graduate students from the Department of Urban Studies and Planning as well as students from other departments at MIT and Harvard. This group was often augmented by other members of the MIT community, both faculty and students, who were attracted by a particular discussion topic. The participating students came from varied disciplinary backgrounds; approximately half were from developing countries. In most cases the invited papers were available before the seminar convened, and the speakers were thus able to engage the other participants after a very brief introductory statement.

#### Symposium on Strategies for AID Programs in Selected Areas of Science and Technology

The second major colloquium held at MIT during 1973-74 under the auspices of the Technology Adaptation Program was the MIT "Symposium on Strategies for AID Programs in Selected Areas of Science and Technology" held at Endicott House

in April 1974. The aims of the symposium were to examine areas of science and technology that might merit more attention in the future, as well as to consider the scope, balance, and perspective of the Office of Science and Technology (TA/OST) of AID within the context of the current needs and conditions of developing nations. In order to foster the interchange of more than superficial ideas about gaps, opportunities and needs for change, the MIT Steering Committee intentionally limited the number of participants while attempting to keep the topics as broad and comprehensive as possible. The participants included U.S. academics, U.S. AID officials, and representatives from developing nations.

The subjects considered in the course of the symposium were construction, transportation, housing, water resources and nutrition--all highly relevant to concerns of the developing countries and all subjects of current interest at MIT.

After the presentation of the prepared papers, panels met on the afternoon and evening of the 25th of April to discuss each of the following five program areas of AID's Office of Science and Technology: (1) Science and Technology Policy, (2) University Orientation Strategy, (3) Strengthening Industrial Institutions, (4) Natural Resource Use and Conservation, and (5) Strategy for Reducing Public Investment Costs. In addition, the five Program Panel Chairmen convened a Master panel to consider and correlate the reports of the program panels, and to present their views on the five program areas of TA/OST and other AID programs of science and technology.

#### B. Overseas

Professor Moavenzadeh's visit to Nepal in connection with his study of labor substitution in highway construction produced the following observations; these were based on a review of an ILO interim report on the subject, the personal

observations of Mr. Ramesh Vaidya, a Nepalese graduate student; and Professor Moavenzadeh's own field inspections and discussions with Nepalese and foreign officials in Nepal. Professor Moavenzadeh believed that the conditions in Nepal were such that they afforded an excellent opportunity for a very broad and careful examination of the impact of bilateral aid programs on the development of a highway transportation network in Nepal. He felt that detailed case studies such as Mr. Vaidya's should be developed around each of the five road projects presently underway in Nepal, and that attempts should then be made to identify commonalities which may exist among them. The researcher should then be able to evaluate the impact of the choice of technology on the contribution that the projects would make to the national economic development plans of the country.

As was apparent from Mr. Vaidya's study, projects such as the Chinese which focused on labor- rather than capital-intensive techniques appeared to be the most successful in terms of full utilization of various limited resources.

Professor Major's visits to Korea produced excellent data for use in the Han River Basin Study, and consolidated the good relations MIT established with various Korean planners and officials. His visit to India included lectures at various universities, the extension of a possible teaching invitation, and the possibility of interesting Indian students in attending MIT.

In the spring of 1974 members of MIT's Flight Transportation Laboratory led an all-day seminar on "Air Transportation" at the International Bank for Reconstruction and Development in Washington, D.C. The seminar, which drew heavily upon results obtained during the TAP-funded research efforts of Professor Simpson and his group, was attended not only by Flight Transportation Laboratory personnel, but also by members of the World Bank Staff (Messrs. Bostrom, Ken, Zetterstrom, and Jaycox, among others), as well as by specialists in the field of air transport from various developing countries.

Professor Stickney, under a grant from the National Science Foundation's SEED Program, arranged to spend nine months at the Institute of Nutrition of Central America and Panama (INCAP) in Guatemala. The first two months of his stay were devoted to becoming acquainted with the activities and personnel of INCAP and in defining several projects to work on during the remaining time. The principal project was the initial development of a malnutrition model that would help planners to compare the estimated benefits and costs of potential programs for alleviating malnutrition among pre-school children below five years of age. The model was based upon the results of detailed longitudinal studies of Guatemalan children performed by INCAP. The work was truly a collaborative effort, involving four medical doctors (two with advanced study in nutrition), one microbiologist, and one statistician representing three different divisions within INCAP. The results of the research were presented in a paper at the Western Hemisphere Nutrition Congress in Florida in August 1974.

Professor Cook's visit to Colombia in the spring of 1974 produced two distinct sets of observations and a number of recommendations. The various government, university and consulting groups within Colombia seem to perform sound economic evaluations or assessments of various industrial development schemes; they are less able, however to identify and evaluate the specific technological methods for producing those products, thus apparently requiring mechanisms for obtaining very specific, practical technical information.

The second specific problem Professor Cook encountered was that quality control measures as we know them are scarce in Colombia. His discussions regarding quality control, or the lack thereof, resulted in a thesis now being researched by a Colombian graduate student at MIT. The goal of the research is to plan a quality control organization for Bogota which would produce instrumentation at moderate cost and give quality control service on short notice.

Professor Willard Johnson undertook a number of project activities during 1973-74 which, although not supported by TAP funds, were related to the Business Management for Economic Development Project in thrust and content. He traveled to Toronto to first establish contact with Bata Shoe International Ltd. and then with academic people with information about Bata Company activities. He later visited Cameroon to present a project paper, "International Investment and the Transfer of Power: Perspectives on Africanization of Management," to the International Seminar at the International Relations Institute of Cameroon. On his return from Cameroon Professor Johnson traveled to London to conduct further interviews and to gather information at the headquarters of the Commonwealth Development Corporation.

INSTITUTION BUILDING: MEETINGS, WORKSHOPS, SEMINARS, 1975-1977

A. At MIT

With the TAP's change in emphasis toward coordinated programs in Egypt and Colombia, the meetings and seminars held at MIT during this period of the program concentrated on the activities underway in these two countries. Several project leaders, for example Professor Joseph Sussman and Mr. James Sloss of the project on Freight Commodity Transport Requirements in the Republic of Colombia, gave informal presentations on their project activities at regular departmental seminars. Others, such as Professor David Marks and the staff members of the project on Planning Methodologies for Water Resource Investment and Allocation in Colombia, presented short courses which incorporated the findings of their TAP-sponsored work.

During this period, counterpart personnel from Egypt and Colombia visited MIT not only to confer with colleagues on the progress of the research projects, but to meet with other faculty and staff at MIT interested in technology adaptation and development. In addition, visits were made by Mrs. Lee de Gouffray, Advisor to the Director of COLCIENCIAS, and Dr. Eduardo Aldana, former Rector of the Universidad de los Andes, and Director of the Instituto Ser de Investigacion in Bogota, a non-profit research institute concerned with public policy in the areas of health, education, and regional and urban development.

The primary purpose of Mrs. de Gouffray's trip was to investigate the possibility of collaborative activities between MIT and Colombian universities in the field of housing and construction materials, and to discuss the general progress of TAP projects currently underway in Colombia. Dr. Aldana met with several faculty members in the Departments of Nutrition and Food Science,

Civil Engineering, Urban Studies, Management, and Political Science to discuss the possibility of future work on the role of technology in public systems.

Two formal seminars were presented to the MIT community; one in December 1975 by Dr. Hugo Perez la Salvia, former Venezuelan Minister of Mining and Petroleum, who spoke to members of MIT's Energy Laboratory and the TAP Steering Committee on technology transfer in Latin America in the field of energy. The other was given in September 1977 by Dr. Ahmed Abu Ismail, Former Minister of Finance, Government of Egypt, and Chairman of the Economic Planning Committee, Egyptian Parliament, who spoke about impacts of recent socio-economic changes in Egypt.

#### B. Overseas

Several MIT faculty and staff members traveled to Colombia and Egypt during this period in connection with the TAP's research in these countries. As was the case with counterpart personnel visiting MIT, not only did these staff members perform field work and confer with counterparts on the specific details of project research, but they also met with others to discuss general issues of technology adaptation and development.

Professors David Marks and Frank Perkins traveled to Bogota in August 1975 to finalize specific details of the project on Planning Methodologies for Water Resource Investment and Allocation, at the Center for Hydraulic Resources at the Universidad de los Andes. They met with Dr. Francisco Rodriguez Urrego, Vice Dean of the University, and with Dr. Jose Mejia, Dr. Jaime Milla, and Dr. Alejandro Deeb, principal counterpart investigator for the project. In March 1976, Professor Marks returned to Bogota with Mr. Donald Grossman, Graduate Research Assistant. The first part of the visit was devoted to

explaining the methodology developed at MIT on the project to three faculty members and three graduate students at the Universidad de los Andes. Then Professor Marks and Mr. Grossman met with Guillermo Mejia and others at the Departamento Nacional de Planeacion to discuss formulation of national policy and funding procedures and controls that the government is using to stimulate growth in intermediate towns in Colombia.

In connection with the project on Evaluation of Rural Roads in the Context of Development, Professor Fred Moavenzadeh and Dr. Janet Rossow initially visited Bogota in June 1975 for identification of Colombian participants in the project, clearer delineation of the scope of the research, and investigation of potential sources of funding for further work in this area. At the Universidad de los Andes they met with Dr. Manuel Baquero, the counterpart principal investigator of the project, and Ing. Gustavo Esquerra. Meetings were also held with Dr. Rafael Pardo, Acting Deputy Director of the Fondo Nacional de Caminos Vecinales, Sr. Pedro Nino, Planning Specialist at the Federacion Nacional de Cafeteros, and Sr. German Ospina at the Departamento Nacional de Planeacion. In addition, meetings were held with Dr. Alfonso Corredor and Mr. Philip R. Schwab, Deputy Director, at the USAID Mission to discuss proposed loans for rural road construction and institutional development. Several subsequent trips to Bogota were made by project staff, and in August 1977 Professor Moavenzadeh and Dr. Rossow visited the USAID Mission and other institutions in Lima, Peru to investigate the possibility of extending the research begun during this phase of the program to other parts of Latin America.

Mr. James Sloss of the project on Freight Commodity Transport Requirements in the Republic of Colombia, also traveled to Bogota, and contacts were established with Sr. Jorge Sossa Beltran at the National Railways and

Sr. Horacio Jaramillo at the Ministry of Public Works. The progress of the collaborative research was reviewed with the counterpart principal investigators at the Universidad de los Andes, Dr. Ulpiano Ayala and Dr. Manuel Baquero.

As Director of the Technology Adaptation Program, Professor Fred Moavenzadeh participated in several international conferences, such as the United Nations Conference on Low Cost Housing Technologies for Developing Countries held in Rotterdam in April 1976, and the Fourth Inter-American Conference on Highway Technology in Caracas, Venezuela, July 1975. During June and July of 1977, he made an extended visit to Argentina, Brazil, and Peru to confer with experts in the field of highway construction in Latin America.

Several trips to Egypt took place, starting in October 1975, in connection with the development of the MIT/Cairo University Technological Planning Program. Professors Richard Eckaus and Nazli Choucri also attended the Cairo Conference on Statistics and Computer Science in April 1976. Since the inception of the program, travel to Cairo by MIT staff has been extensive, and by the end of 1977 a total of 167 man-weeks had been spent in Egypt on program activities.

**APPENDIX C**

**INSTITUTION BUILDING: COURSE DEVELOPMENT**

## INSTITUTION BUILDING: COURSE DEVELOPMENT

### 1.203: Transportation Supply Models

The course examines basic characteristics of transportation technologies, the capacity for highways, railroads, air transport systems and terminals, and sea ports and terminals. Students will analyze network operations, transfer and classification systems, and cost and performance models and generalized parametric analysis. Problems in system unreliability will be investigated, as will the use of descriptive and prescriptive modeling techniques to analyze and design transport systems with stress on usable operating policies.

### 1.25: Innovative Urban Transportation Systems

The course investigates the technical and institutional issues involved in innovative urban transportation systems and the ability of such systems to meet present and future needs. The roles of government, private industry, labor, and the transit industry in urban transportation innovation are discussed, and case study analyses are performed on several new innovative systems including Dial-A-Bus, Personal Rapid Transit, and Dual Mode.

### 1.262J: Transportation Policy Analysis

The course considers policy at the national, regional, state, and local levels, and investigates the role of the U.S. Department of Transportation, the Interstate Highway Program, and the Urban Mass Transit Assistance Acts. Students will examine the mechanisms of achieving policy implementation and will compare U.S. transportation policy with policies in other countries. We will also look at principal policy making actors and interest groups at the metropolitan level, and at local funding sources.

### 1.45 Highway Technology

The subject applies problem solving techniques to highway technology-- design, construction, maintenance--with emphasis upon structural design. It attempts a systematic investigation of the impact of overall transportation goals on highway performance evaluation and user-based approaches to this evaluation in terms of serviceability, reliability, and maintainability. It derives functional requirements of physical facilities from performance evaluation, and attempts to formulate alternative design actions and selection with

economic and service quality criteria. The course deals with problems of construction and maintenance, and the observation of actions as feedback to problem solving. Students will finally attempt to arrive at a synthesis which will provide a framework for decision making.

#### 1.60: Introduction to Water Resources

The course deals with engineering, economic and political aspects of water resources management. It is designed as a multi-disciplinary introduction to the field for those who wish to consider further work in water resources, and for students in engineering, economics, political science, and management who wish to use water resources as a case study of an important resource sector greatly affected by government management. Topics to be discussed include pollution, ecological aspects of water development, water management institutions, engineering economic design of water systems, formulation of objectives and criteria for water resource development, the role of the U.S. Congress and Federal agencies, water reuse systems, and global water problems.

#### 1.732: Water Resource Systems

The course deals with flood forecasting, flood routing, flood plain management, and flood control. It discusses river basin simulation, the synthesis of hydrologic inputs, and the interactive use of simulation and mathematical programming models. Students will also attempt to evaluate long term net benefit and short run loss functions.

#### 1.74: Public Expenditure Theory

The course presents the full range of benefit-cost criteria required for the optimal economic design of public expenditure projects, emphasizing water resource systems as specific examples. It provides the necessary background in welfare economics and relevant material from political science dealing with the choice of objectives for public expenditures. Federal benefit-cost practices are described and analyzed, computer and mathematical programming techniques are related to public expenditure analysis.

1.913J (Department of Civil Engineering), 14.774J (Department of Economics), and 17.867J (Department of Political Science): Transfer and Adaptation of Technology in Developing Countries (This multi-disciplinary course is offered jointly by the above three departments, and is taught by professors from each discipline.)

The issues of the transfer of technology to developing countries will be introduced and described briefly from the engineering, political, and economic points of view. The economic rationale for the choice of technology will be presented, in the course of which the concepts of economic efficiency and the production function will be described. Econometric results in the study of technology will be presented, and the relevance of these analyses for the transfer of technology to developing countries will be discussed.

The engineering factors limiting the choice of technology will be discussed in two broad areas, manufacturing and public works. The technologically flexible activities where a spectrum of labor-capital mix is possible will be examined for the public works sector, and the influence of various phases of a public works project (planning, design, construction, and subsequent operations and maintenance) on the choice of technology will be discussed.

The major political dimensions of the transfer issue will be described in terms both of domestic considerations in the recipient country and the international interactions underlying the transfer. The problems of institution-building, interdependence and domination will be discussed as well as potential conflicts between donor and recipient. A discussion of the nature of politics in developing countries will provide the background for this session.

The motivations for economic cost-benefit calculations and the methods of such calculations will be described. The concepts of economic interdependence will be illustrated through input-output accounting, and the results of cost studies will be presented. The alternative approaches to economic evaluations of projects by cost-benefit analyses will be discussed.

The technique available for project evaluation in the public work sector will be reviewed. The conflicting interests of owner (public), designers, and contractors will be demonstrated using a highway construction project as a case study. The influence of employment, taxation, tariffs, monetary policies, codes, and regulations on engineering decisions will be discussed.

Some critical political issues in the decision underlying the choice of a particular investment will be described, including foreign and domestic policy considerations. Specific examples from the Middle East will be employed to illustrate general problems and tendencies, and the impact of political factors on economic performance, decisions, and engineering considerations will be described.

The economic and technical factors involved in establishing building materials industries in LDCs will be reviewed with emphasis on the cement industry. The influence of macro-economic factors on market base, availability of infrastructure, forward and backward linkages, micro-economic factors of production, and quality control will be discussed, as will the role of R&D in this particular market in LDCs.

## 2.190J: Modelling and Analysis of Systems Pertaining to National Development

An exploratory introduction to the application of the concepts and techniques of systems analysis to problems pertaining to regional and national growth in both developed and developing countries; e.g., nutrition and population, transportation and communication, energy and power, utilization and conservation of natural resources. The course considers the utility and potential as well as the limitations and restrictions of the approach as an aid in planning studies involving evaluation of alternative programs, strategies, and systems. Emphasis is placed upon modelling the technical and behavioral features of a system by employing production functions and causal modelling; searching for optimal system designs by use of marginal analysis, mathematical programming, and sensitivity analysis; and evaluating projects with respect to time, risk and uncertainty, and the preferences of different target groups. These concepts and techniques are illustrated through case studies and applied in term projects.

## 4.160: Urban Settlement Design in Developing Countries

4.161:

The course deals with advanced projects on urban settlement environments for low income groups in developing countries. It aims to prepare designers to participate effectively in the process of shaping the environment, to develop tools to define and evaluate design determinants, and to make these tools available to those concerned and responsible for action at the policy making level.

## 4.79: Urbanization in Developing Countries: Dwellings and Land Issues

Meetings will be conducted as follows:

- I. Topic presentation;
- II. Topic discussion;
- III. Individual and/or group discussion of work.

Individual and/or group work: Land and dwelling typology of a given urban area.

Topics:

1. Introduction. Two films on urban dwelling--THE BALLOON SELLER (Mexico City, Mexico), VILLAGE 4B (Nairobi, Kenya);
2. General background/context on urbanization in developing countries-- population explosion, low-income majority, limited resources;
3. Land and dwellings--case studies in Boston, Lima, Medellin;

4. Land and dwellings--case studies in Nairobi, surveys, identification, evaluation;
5. Urbanization model--a progressive development proposal, Dandora, Nairobi;
6. Urbanization setting--the national context, the urban context;
7. Site context--environmental, physical conditions;
8. Site context--utilities, services, community facilities;
9. Site context--government, municipal regulations;
10. Community context--land development, utilities and services, time, socio-economic-political;
11. Case studies--evaluations, surveys, models;
12. Visiting lecturer;
13. Visiting lecturer.

11.421: Self-help Housing, Squatters and Social Change

The course includes lectures and readings or research on the issues of autonomy vs. centralized authority in housing, and the problems of the urban accommodation of low-income sectors undergoing rapid geographic, social and economic change. Case material from Africa, Asia, Latin America, and the USA will be used in order to develop a methodology for analyzing housing systems, and as a comparative basis for the discussion of general models and of alternative government development policies.

11.422: Seminar in Self-help Housing, Squatters, and Social Change

The course is a continuation of 11.421. Students may work in teams on an in-depth analysis of development systems in a particular urban area or on specific aspects or problems in a context that they know through personal experience. Those so qualified may use both 11.421 and 11.422 for a unified program. A major paper is required on the basis of the research material obtained in 11.421.

15.223: International Business Environments

The course, divided into four sections, focuses on a different region--

Europe, Latin America, Japan, North America--in each section. Subject areas in each section include historical inputs; social-psychological dimensions; political and economic structure; characteristics of labor organizations, financial institutions, and market structure. It deals also with the relation of such environmental variables to company organization, managerial behavior, and corporate policy, and the treatment of important social issues confronting the business community. Sections meet separately for most sessions. Insofar as scheduling permits, students are allowed to move among sections following subjects of greatest personal interest on an inter-regional basis.

### 15.317 Comparative Studies of Organizations

This seminar examines studies of the management of organizations in various parts of the world. It attempts to determine which ways of managing are most appropriate in different countries and whether any general principles of management are valid internationally. Beginning with basic theoretical and empirical work in organization studies, the seminar continues with an examination of findings about organizations outside of the United States and concludes with an examination of cross-cultural aspects of technical assistance. Each student is encouraged to become an expert on organizational studies in a particular country. Topics to be covered include motivation of workers and managers, power and control, communications, the generality of participative approaches such as Theory Y or System IV, and organizational development.

### 16.752: Flight Transportation Seminar (International Air Transportation)

#### 1. The nature of the airline itself--

- types and implications of ownership;
- types of relationships with government agencies;
- types of direct and indirect subsidy;
- impact of non-civil aviation functions imposed on civil airlines, such as--
  - military support (CRAF and otherwise),
  - espionage,
  - support of indigenous aircraft industries,
  - foreign policy needs, and
  - balance of payments factor.

#### 2. Survey of international airline operations; one session will be devoted to the carriers and the nature of international airline operations in

- prewar period, including the colonial carriers and Lufthansa "airline imperialism";

- United States, including discussion of the manner in which international routes were distributed among the different U.S. carriers, Canada, Central and South America;
  - Western Europe, including a discussion of KSSU and ATLAS;
  - developing countries of Africa and Asia, including discussions of Air Afrique, East African Airways, AACO and the Arab airlines;
  - Japan and Australasia; and
  - Eastern Europe, the Soviet Union, and China.
3. Discussion of the five freedoms, and the sixth freedom--sabotage; implications, common practice.
  4. The route--
    - discussion of major worldwide route patterns;
    - types of routes;
    - islands, no other access, or poor land connections;
    - strategic, strategic-political;
    - military/defense-related;
    - colonial or vestigial colonial; and
    - symbolic or prestige.
  5. Bilateral negotiations.
  6. Restrictive practices on foreign airlines by governments--
    - discriminatory airport user charges and airway/enroute charges;
    - marketing and sales restrictions;
    - foreign exchange regulations;
    - discriminatory taxation on foreign carrier revenues;
    - pressure, subtle and otherwise, on civic and fraternal groups, shippers, other businesses to use national carrier; and
    - capacity restrictions, including those intended to reduce impact of more modern equipment used by a foreign carrier, reduce schedule flexibility of a foreign carrier.
  7. Restrictive practices on foreign airlines by home airlines--
    - illegal discounting; and
    - discriminatory liaison with domestic carriers.
  8. International air transport organizations (primarily IATA and ICAO, but also including IFALPA, ITA, others)--
    - history of the organizations;
    - politicization of the organizations; and
    - role played in organizations by different governments and airlines.
  9. Issue of unlawful interference with aircraft--
    - attempts to construct enforceable conventions;
    - responses of different governments, politicization of issue, and "confrontation" between certain governments and foreign airlines over related problems.

10. Air transport in developing countries--

- special problems; and
- technical assistance pacts.

11. Airline-allied operations--

- hotels, rental car agencies, etc.; and
- technical assistance agreements from point of view of Western airlines.

Other

Professor Willard Johnson's Business Management for Economic Development Project generated a new course for the Community Fellows Program at MIT, based largely on project materials and experiences. This Program brings local community leaders from across the country to MIT in order to develop new programs for local implementation. The course is concerned with economic development programs that could be organized at the community level, and three of the Fellows worked on such projects for their local communities.

Material from project-related sources was also included in several other courses. Professor Johnson participated in Professor Robinson's course on "International Business" in the Sloan School of Industrial Management; Professor Johnson's presentation concerned the Zambian experience with copper mining companies. Project materials and experiences were included in the course on "Community Development in Urban Ghettos," which Professor Johnson normally teaches, and in the course on "Comparative African Politics," which he teaches at the Fletcher School of Law and Diplomacy as well as at MIT. The latter course included material particularly concerned with management development.

The main thrust of Professor Stanley Backer's project on "Technology Adaptation in the Textile Industries of LDCs" was the development of material dealing with the technological problems of both developed and developing countries in the area of textile use and production for inclusion in existing courses; benefiting from the inclusion of such material were the division course, one undergraduate subject, and four graduate seminars. The lectures were presented mainly by Dr. Stelios Arghyros, but the project and courses benefited from the presence of two visiting professors and a guest lecturer, Professor John Thwaites of Cambridge University, England; Professor Ronald Postle of the University of New South Wales, Australia; and Dr. Leland Liang, Textile Marketing Associates, New York. The courses in which these lectures were presented were

2.903: Elements of Textile Materials and Processes (undergraduate)

2.913: Fibers and Polymers Seminar (graduate)

2.914: Fibers and Polymers Seminar (graduate)

2.915: Clothing and Design and Comfort (graduate)

2.916: Industrial Technology (graduate)

The subject matter varied depending upon the course, but the lectures covered, among many topics, the following subjects, in an attempt to relate the problems of textile manufacturing and use in both developed and developing countries to the adaptation of technology in the textile industry in developing countries:

- (1) quality control in the textile industries of developing countries;
- (2) new yard processing methods for developing countries;
- (3) vegetable fibers and their significance in the economics of developing countries;
- (4) fiber production and consumption forecasting on a world-wide basis;
- (5) the significance of textile research institutes in developing countries;
- (6) textiles in Asia;
- (7) cost/benefit analysis relevant to textile industries;
- (8) textile marketing on a global basis;
- (9) comparison between modern techniques and those in use in developing nations.

APPENDIX D

LIST OF PUBLICATIONS

## LIST OF PUBLICATIONS, 1972-1973

### 1. Reports and Published Papers

Ahmad, Athar, P., Ferro-cement Journal Bearing, May 1973.

Abtahi, H., A Reinforced Concrete Shell for the Conventional Single-Pass, Single or Multi-Pressure Steam Condensers, August 1973.

Ausrotas, Raymond A., Air Transportation in Developing Countries, Flight Transportation Laboratory Technical Memorandum 73-12, Massachusetts Institute of Technology, Technology Adaptation Program, July 1973.

"Basic Performance Standards for Urbanization in Latin America and East Africa," Massachusetts Institute of Technology, Urban Settlement Design Program, 1973.

"Identification of Dwelling Systems in Nairobi, Kenya," Massachusetts Institute of Technology, Urban Settlement Design Program. Twenty case studies of typical dwellings have been surveyed and analyzed.

"Interim Urbanization Project Dandora: A Progressive Development Proposal including a Site and Services Model," Massachusetts Institute of Technology, Urban Settlement Design Program, Spring 1973.

Kayansayan, Nuri, "An Estimate of Steam Condenser Needs for Less Developed Countries," Massachusetts Institute of Technology, Technology Adaptation Program, May 1973.

Major, David C., "Investment Criteria and Mathematical Modelling Techniques for Water Resources Planning in Argentina: The MIT Argentina Project," Proceedings, IFAC/IFORS Conference on Systems Approaches to Developing Countries, Algiers, May 1973.

Rashid, Iqbal, "Concrete Shell Heat Exchanger Protective Coatings," Massachusetts Institute of Technology, Technology Adaptation Program, May 1973.

Smith, Curtis, S. and Jan T. Taniguehi, "Material Adaptation for Developing Nations: Progress Evaluation," Massachusetts Institute of Technology, May 1973.

Stickney, R.E., P.C. Abbott, and J.G. Chamberlin, "Systems Approach to Nutrition Planning: Preliminary Considerations," in Proceedings of the Symposium on Systems Approaches to Developing Countries, Algeria, May 28-31, 1973. M.A. Cuenod and S. Kahne, editors, International Federation of Automatic Control, 1973, pp. 137-147.

## 2. Professional Papers

Major, David C., "Notes on the Program in Technology Adaptation at MIT," Presented at the Batelle Research Conference on Successes and Failures in Technology Transfer, Seattle, Oregon, November 1972.

Moavenzadeh, Fred, "Selection of Optimal Investment Strategies for Low Volume Roads," Presented at the Annual Meeting of the Planning, Transport, Research and Computation Company Ltd., University of Sussex, June 1973.

Moavenzadeh, Fred, "Transfer and Adaptation of Technology in the Construction Industry," Presented at the AID Symposium on Bilateral Aid Strategies and Programs in Selected Areas of Science and Technology, Cornell University, May 7-8, 1973.

Terner, Ian D., "Technology Assessment for Low-Cost Housing in Third World Countries," Presented at the International Congress on Technology Assessment, The Hague, Netherlands, May 27-June 2, 1973.

## 3. Theses

Cruz, Pedro, "A Preliminary Simulation Model of Factors Affecting the Nutritional and Health Status of Children in Low Income Families," M.S., Department of Mechanical Engineering, Massachusetts Institute of Technology, 1973.

Gattoni, George and Praful Patel, "Residential Land Utilization: Case Study/Nairobi, Kenya," M. Arch. A.S. degree, Department of Architecture, Massachusetts Institute of Technology, 1973.

Gruber, Jerome M., "Formulation of a Least-Cost Diet Supplement for Pre-School Children of El Salvador," M.S., Department of Mechanical Engineering, Massachusetts Institute of Technology, 1973.

Guerrero, Mario Alfredo, "A Systems Analysis of Government Policies for Improving the Nutritional Status of Low-Income Families in El Salvador: Preliminary Considerations," M.S., Department of Mechanical Engineering, Massachusetts Institute of Technology, 1973.

Sarris, Kyriakos H., "An Approximate Analytical Model for Estimating the Effectiveness of a Food Supplementation Program for Children in El Salvador," M.S., Department of Mechanical Engineering, Massachusetts Institute of Technology, 1973.

## LIST OF PUBLICATIONS, 1973-1974

### I. Reports and Published Papers

- Bloomberg, Carol A., The Transfer of Management Technology in the Commonwealth Development Corporation, Business Management for Economic Development Project, Center for International Studies, Massachusetts Institute of Technology, July 1974.
- Johnson, Willard R., Training Business Managers to Promote Economic Development, Business Management for Economic Development Project, Center for International Studies, Massachusetts Institute of Technology, July 1974.
- Karuga, James Gatanyu, Africanization and Management Development in Kenya, Business Management for Economic Development Project, Center for International Studies, Massachusetts Institute of Technology, July 1974.
- LaTorraca, Gerald A., and Lawrence H. Bannister, "Feasibility Study of a Swept Frequency Electromagnetic Probe (SWEEP) Using Inductive Coupling for the Determination of Subsurface Conductivity of the Earth and Water Prospecting in Arid Regions," Center for Space Research TR 74-3, Massachusetts Institute of Technology, September 1974.
- Moavenzadeh, Fred, "The Role of the Construction Industry in the Development Process," Public Policy, Volume XXII, Spring 1974, Number 2, Harvard University Press, 1974.
- Moavenzadeh, Fred, and Janet Koch Rossow, The Construction Industry: A Review of the Major Issues Facing the Industry in the United States, Department of Civil Engineering Research Report Number R74-44, Massachusetts Institute of Technology, Summer 1974.
- Proceedings of the M.I.T. Symposium on Strategies for A.I.D. Programs in Selected Areas of Science and Technology, ed. J.P. Ruina, Technology Adaptation Program, Massachusetts Institute of Technology, 4 vols., Winter 1974.
- Simpson, Robert W., and Raymond A. Ausrotas, Air Transportation in Ethiopia, 1974, Flight Transportation Laboratory, Department of Aeronautics and Astronautics, Massachusetts Institute of Technology, February 1974.
- \_\_\_\_\_, Air Transportation in the Sudan, 1974, Flight Transportation Laboratory, Department of Aeronautics and Astronautics, Massachusetts Institute of Technology, March 1974.

Stickney, R.E., and K. Sarris, "Approximate Model for Estimating the Potential Reduction of Malnutrition and Mortality by Various Intervention," Draft Paper, Department of Mechanical Engineering, Massachusetts of Technology, Fall 1974.

## 2. Professional Papers

Ausrotas, R.A., "Low Density Air Transportation in Developing Countries," Presented at the 15th Annual Meeting of the Transportation Research Forum, October 1974.

Johnson, Willard R., "International Investment and Transfer of Power; Perspectives on Africanization of Management," Paper presented to the Seminar on International Organizations and the Political Self Assertion and Strengthening of Africa Continentally, University of Yaounde, September 1974.

Stickney, R.E., et al., "Systems Analysis in Nutrition and Health Planning: Approximate Model Relating Birth Weight and Age to Risk of Malnutrition," Paper presented at the Western Hemisphere Nutrition Congress IV, Bal Harbour, Florida, August 19-22, 1974.

## 3. Theses

Baldwin, John, "Guide to Survey-Evaluation of Dwelling Environments," M.S., Department of Architecture, Massachusetts Institute of Technology, Spring 1974.

Bazant, Jan, Enrique, Espinosa, Jose Luis Cortes and Ramiro Davila, "Urban Dwelling Environments: Mexico City," M.S., Department of Architecture, Massachusetts Institute of Technology, Spring 1974.

Castaline, Alan H., "An Analysis of Urban Public Transport in the Developing Country Context," M.S., Department of Civil Engineering, Massachusetts Institute of Technology, August 1974.

Chana, Amrik, S., "Prototype Development for Low Income Settlements," M.S., Department of Architecture, Massachusetts Institute of Technology, Spring 1974.

Chana, Tara Sing Lachman S., "Dwellings and Land Models: Nairobi, Kenya," M.S., Department of Architecture, June 1974.

Motomura, Yuichiro, "Policy Alternatives for Financing Urban Transport in Developing Countries," M.S., Department of Civil Engineering, Massachusetts Institute of Technology, May 1974.

Mulumba, Stanley, "Urbanization in Developing Countries, Case Study: Kampala, Uganda," M.S., Department of Architecture, Massachusetts Institute of Technology, Spring 1974.

- Ocharoen, Pia, "Urban Dwelling Environments: Bangkok, Thailand," M.S., Department Architecture, MIT, Spring 1974.
- Samizay, Rafi, "Urban Growth and Residential Prototypes in Kabul, Afghanistan," M.S., Department of Architecture, Massachusetts Institute of Technology, Spring 1974.
- Tsai, Hsung-Hsiung, "A Methodology for Evaluating a National Housing Plan: The Case of Taiwan," M.S., Department of Urban Studies and Planning, Massachusetts Institute of Technology, September 1974.
- Valenzuela, Maria, "Philippine Squatter-Housing Policy and National Development," M.C.P. Department of Urban Studies and Planning, Massachusetts Institute of Technology, May 1974.
- Vaidya, Ramesh, "The Choice of Technology in Highway Construction Industry: A Case Study of Nepal," M.S., Department of Civil Engineering, Massachusetts Institute of Technology, June 1974.

## LIST OF PUBLICATIONS, 1975-1977

### 1. Reports and Published Papers

- Bhandari, Anil and Fredric Berger, The Highway Cost Model: Evaluation of the Dar-es-Salaam Morogoro Section of the Tanzania-Zambia Highway, Technology Adaptation Program, Report 75-5, Massachusetts Institute of Technology, September 1975.
- Dietz, Albert G. H. and Fred Moavenzadeh, "Innovative Uses of Materials for Housing in Developing Areas," International Journal for Housing Science and its Applications, Vol. 1, No. 2, October 1977.
- Durali, Mohammad, Design of Small Water Turbines for Farms and Small Communities, Technology Adaptation Program, Report 76-1, Massachusetts Institute of Technology, Spring 1976.
- Eckaus, Richard S. and John Potter, Limits to Labor-Capital Substitution, Some Generalizations and a Case Study of Irrigation Pumps, Technology Adaptation Program, Report 77-3, Massachusetts Institute of Technology, Winter 1977.
- Grossman, Donald, et al., Capacity Expansion for Urban Water Supply in Colombia, OKSA/TMS, Fall 1976.
- Moavenzadeh, Fred and Janet A.K. Rossow, The Construction Industry in Developing Countries, Technology Adaptation Program, Report 75-4a, Massachusetts Institute of Technology, Spring 1975.
- Moavenzadeh, Fred, "A Framework for Road Evaluation in Venezuela," Proceedings, III Pan-American Conference on Materials Technology, July 1975.
- Moavenzadeh, Fred, Fredric Berger, Brian Brademeyer, and Robert Wyatt, The Highway Cost Model: General Framework, Technology Adaptation Program, Report 77-1, Massachusetts Institute of Technology, September 1975.
- Potter, John, Foundry Design and Equipment Selection in Developing Countries, Technology Adaptation Program, Report 76-2, Massachusetts Institute of Technology, December 1976.
- Rossow, Janet A.K., and Fred Moavenzadeh, Technology and Productivity in Highway Construction, Technology Adaptation Program, Report 77-1, Massachusetts Institute of Technology, Spring 1977.
- Sloss, James and Laurence Michaels, eds., An Assessment of the National Railway's Performance and Potential Role in Meeting the Commodity Transport Requirements of the Republic of Colombia, Technology Adaptation Program, Report 77-2, Massachusetts Institute of Technology, July 1977.

Sloss, James, Forrest N. Krutter, and Luis Claudio Garcia de Souza, Intercity Freight Transportation in Developing Countries, Technology Adaptation Program, Report 75-3, Massachusetts Institute of Technology, September 1975.

## 2. Professional Papers

Moavenzadeh, Fred, "Building Operation and the Choice of Appropriate Technology for Conditions Prevailing in Developing Countries," presented at United Nations Inter-Regional Seminar on Building Operation in Low-Cost Housing Construction, Rotterdam, April 1976.

Moavenzadeh, Fred, "The Highway Cost Model: General Framework," presented at III African Highway Conference, International Road Federation, Abidjan, October 1976.

Moavenzadeh, Fred, "Industrialization of Production and Assembly of Prefabricated Elements and Components," presented at UNIDO Joint Consultation on Prefabrication for Industrial Construction, Poland, September/October 1975.

Moavenzadeh, Fred, "Shelter: Experiences, Problems and Solutions Related to 'Formal' Building Industry," presented at Habitat: United Nations Conference on Human Settlements, Vancouver, May/June 1976.

Rossow, Janet A.K., "Labor-Capital Substitution in Highway Construction - A Review of Some Case Studies," presented at the First Conference on Highway Planning and Project Evaluation, Addis Ababa, Ethiopia, January 1976.

## 3. Theses

Al-Hussayen, Mohammed Abdulrahman, "Urban Land Utilization: Case Study - Riyadh, Saudi Arabia," M.A.A., Department of Architecture, Massachusetts Institute of Technology, June 1975.

Aylward, Anne D., "Housing is a Red Herring: The Need for Alternative Water Supply and Waste Disposal Technology for Use in Squatter Settlements," M.S., Department of Urban Studies and Planning, Massachusetts Institute of Technology, February 1975.

De Souza, Luis Claudio Garcia, "Analysis and Evaluation of the Brazilian Railway System," M.S., Department of Civil Engineering, Massachusetts Institute of Technology, September 1975.

Durali, Mohammad, "Design of Small Water Turbines for Farms and Small Communities," M.S., Department of Mechanical Engineering, Massachusetts Institute of Technology, 1976.

Gilani, Ijaz, "From Khartoum to Rabat; the Development of Pragmatic Arabism in Inter-Arab Relations (1967-74)," Ph.D., Department of Political Science, Massachusetts Institute of Technology, January 1977.

- Grossman, Donald S., "Capacity Expansion for Water and Wastewater Services," Ph.D., Department of Civil Engineering, Massachusetts Institute of Technology, January 1977.
- Krutter, Forrest Nathan, "The Standardization of Gauges on Rail Lines," M.S., Department of Civil Engineering, Massachusetts Institute of Technology, 1975.
- Millan, Jairo Armando, "Urban Dwelling Environments: Cali, Colombia Case Studies and Model," M.A.A., Department of Architecture, Massachusetts Institute of Technology, June 1975.
- Phisuthikul, Chakorn, "Housing/Community Prototype for Nakhon, Ratchasima, Thailand," M.A.A., Department of Architecture, Massachusetts Institute of Technology, June 1975.
- Potter, John R., "A Model for Foundry Molding Equipment Selection in Developing Countries," M.S., Department of Mechanical Engineering, Massachusetts Institute of Technology, September 1976.
- Rosenberg, Myron, "The Transfer of River Basin Planning Technology to Less Developed Countries," Ph.D., Department of Civil Engineering, Massachusetts Institute of Technology, 1977.
- Rossow, Janet A.K., "Technology and Productivity in Highway Construction," Ph.D., Department of Civil Engineering, Massachusetts Institute of Technology, January 1977.
- Tokman, Kemal Bulent, "Urban Dwelling Environments: Ankara, Turkey", M.A.A., Department of Architecture, Massachusetts Institute of Technology, June 1975.

APPENDIX E

ACTIVITIES RELATED TO THE TECHNOLOGY ADAPTATION PROGRAM

## ACTIVITIES RELATED TO THE TECHNOLOGY ADAPTATION PROGRAM

### The Center for Advanced Engineering Study

The MIT Center for Advanced Engineering Study was established to help experienced men and women maintain the high level of competence needed for continued leadership in an age of unparalleled technological change. The Advanced Study Program provides these men and women with the opportunity to study new developments in fields in which they are already expert, to learn about emerging fields, to broaden themselves or to pursue a combination of these objectives.

The Advanced Study Program of the MIT Center for Advanced Engineering Study is designed for men and women who have supplied and will continue to supply the initiative, leadership, and accomplishment that catalyze technical progress. The Program provides an opportunity for such people to spend one or more academic terms on the MIT campus participating in whatever academic, research, and other special activities seem most relevant to their present and future needs.

Past participants have varied in age from mid-twenties to late fifties. The median age is about forty. Countries, in addition to the United States, represented by past participants have included Argentina, Belgium, Bolivia, Brazil, Canada, Czechoslovakia, France, Great Britain, India, Iran, Israel, Italy, Japan, Mexico, New Guinea, Norway, Poland, Switzerland, and Venezuela. Participants have come from industry, government agencies, and academic institutions. Most Fellows have Bachelor's or Master's degrees. Most participants receive financial support from their employers; some participants are supported by government fellowships or fellowships from foundations and international organizations.

The format of the Program is one of great flexibility. The program of each Fellow is individually tailored to his or her background and objectives and normally combines formal classroom study, seminars, research, and studies guided by one or more members of the MIT faculty. The entire spectrum of MIT activities is made available: undergraduate and graduate subjects, seminars, colloquia, and research.

Each Fellow works out an individualized program in consultation with MIT faculty. The aim is to match the background and objective of the Fellow and his or her sponsoring organization with the opportunities available at MIT. Some participants carry a substantial load of formal classroom subjects, while others delve deeply into research frontiers following and digesting emerging technology and evaluating its relevance to their home organizations. Fellows may combine studies in science, management, architecture, urban studies, humanities, economics, political science or any other field available at MIT.

The Center's programs prepare men and women for future roles which envisage

1. Technical management: The Program would combine work in key technical fields with work in relevant management areas.
2. Creative leadership in an area that requires the applications of knowledge from several disciplines; the Program would add new areas to the Fellow's current background.

3. In-depth accomplishment in one discipline: The Program would lead to capability at the frontier of a discipline.

Special Center Subjects: In addition to the regular MIT subjects, the Center offers a number of special subjects. These are designed to meet the particular needs of the Fellows.

Computer Systems: Basic components of a computer system. Programming, including the organization and planning of programs and the key features of alternate languages. Design and use of problem-oriented languages. The role of man-machine communications, time sharing, graphical input-output, dynamic memory allocation. Features of operating systems and comparison of systems. Present and future impact of the computer; its use as an information processor. Extensive "hands on" use of high-speed digital machines.

Simulation Methods: Basic simulation methodology as applied to discrete stochastic systems. Role of simulation in systems analysis. Comparison of various time-flow mechanisms. Use of several computer languages to program simulation models. Computer system requirements for simulation modeling. A survey of simulation applications including the study of several in depth. Random number generation and testing. Statistical aspects of simulation analysis including validation, variance reduction, experiment design, validity of results, run-length considerations, model initialization, analysis of autocorrelated data.

Introduction to Systems Analysis: Introduction to the approaches, concepts, and techniques employed in the analysis of policy problems. Main focus on cost-effectiveness as a means of choosing between major policy alternatives. Application of principles to case-study problems for illustrative purposes.

The Federal Budget and National Priorities: Functions and roles of the federal budget; its composition as reflected in revenues, outlays, and the allocation of resources; and projections of future budgets. Major program areas such as defense, income maintenance, health, education, and environmental control, emphasis on current issues. Review proposals for alternative federal budgets in terms of their objectives, revenues, outlays, and allocation of resources.

Quantitative Techniques and Systematic Analysis: Introduction to the concepts and quantitative techniques relevant to the systematic analysis of policy decisions. Principles of supply and demand, production possibility and indifference curves, marginal utility, costs. The application of these principles and the techniques of discounting, depreciation, regression analysis, break-even analysis in the analysis of case-study situations.

Probability Theory: An introduction to the theory of probability and random processes with engineering applications. Probability as a model for empirical averages. Random variables and probability distribution functions. Statistical averages. Elements of estimation and sampling theory. Correlation and characteristic functions.

Random Processes: Basic properties of the simple random walk, Markov chains, and the Poisson and Gaussian random processes through linear systems, definition of spectra, and an introduction to the theory of optimum linear systems. Various additional applications at the discretion of the instructor.

Introduction to Operations Research: A two-term introduction to some important techniques of operations research, including linear programming, network analysis, dynamic programming, statistical inference and decision theory. Markov models, queueing theory, inventory theory, and simulation. Emphasis on decision-making applications. Several recently published studies critically reviewed. Oral and written presentation of a course project required.

System Dynamics: Introduction to modeling of social systems, emphasizing the study of feedback structures and their behavior. Development of concepts that allow one to understand the mechanisms underlying growth, stagnation and cyclical fluctuation. Examples and practice at formulating models of industrial, economic, social, and ecological systems.

Introduction to Statistics and Probability: Introduction to probabilistic concepts and statistical methods with strong emphasis on applications to management, engineering and administrative problems. Elements of probability rules and the use of binomial, hypothesis testing and regression analysis. Other topics will include introduction to statistical decision-making under uncertainty, statistical data analysis and elementary econometrics.

Applications of Statistical Analysis: This course will contain a presentation of several statistical techniques which are useful in the analysis of statistical data emphasizing applications to modern managerial analysis and engineering systems. Focus upon developing skills for identifying and dealing with practical data analysis problems. Topics will include intermediate regression analysis, analysis of variance, discriminant analysis, factor analysis, maximum likelihood estimation, elements of time-series analysis, forecasting models, nonparametric statistics and decision making under uncertainty. While some of the techniques will make use of available computer-based systems, the students are not expected to write their own programs. Elementary knowledge of probability and statistics will be required.

The Center also conducts weekly seminars during the fall and spring terms. These seminars are planned especially for the Fellows and are designed to acquaint them with important emerging fields or new developments. Past topics have included The Dynamics of Social Systems; Artificial Foods; Technology and Public Policy; Race and Poverty in America; Management of Research and Development; Economics of Marine Systems; An Economic View of Congestion; Solid Waste Disposal; Changing Policies Regarding Science and Technology; The Limitation of Strategic Arms; Women and Men and Work; New Developments in Public Investment Planning; and Transportation Constraints.

A certificate is awarded following satisfactory completion of the Program; grades will be recorded for those MIT subjects that are taken for credit. Fellows may apply for admission to the MIT Graduate School; those who are accepted and who fulfill all the requirements of the Graduate School are eligible for advanced degrees.

## Center for Policy Alternatives

The Center for Policy Alternatives, a part of the Massachusetts Institute of Technology's School of Engineering, was founded in 1972 in response to the need for policy analysis of the alternatives available to governments, industry, education and individuals in meeting complex societal problems throughout the world.

The Center was initially funded by a grant from M.I.T and the Alfred P. Sloan Foundation and currently has project grants or contracts from the National Science Foundation, the Department of Commerce, the State Department's Agency for International Development, and the Ford Foundation, and several foreign governments.

Its scope and activity require expertise in a wide range of interrelated disciplines, particularly from specialists who are knowledgeable about technology and its relation to industry, the legislative and governmental processes, economics and public policy issues. Project participants include staff researchers, faculty from M.I.T. and other universities, and students. A post-doctoral and research fellow program draws specialists from other universities, government and industry, both from the United States and world-wide.

Additionally, through its relationship with the Institute, the Center serves to involve faculty and students in the application of applied science and engineering to societal problems. The Center not only undertakes rational study and analyses of issues so as to beneficially connect technology and economic welfare but also encourages studies within the Institute related to the issues.

Drawing on the personnel and resources of a major scientific and engineering institution, the Center is committed to a twofold objective--

1. to mount in-depth studies of substantive societal issues and problems, particularly those in which technology and engineering could play significant roles; and
2. to assess the consequences of established policies and programs and suggest alternatives to modify those consequences.

The results of the Center's studies and assessments are made available to key decision makers in government, industry, education, and other institutions.

The major areas in which the Center is now or intends to become involved include

Science, Technology and Public Policy: The impact of governmental activities on industrial and economic development, and the use of technology for social purposes in both developed and developing nations.

Educational Manpower: The influence of government and education policy on the supply, demand and character of professional, managerial, and technical manpower.

The Service Sector: The influence of institutional interrelationships and the application of technology on the delivery of health, education, and local government services.

Manufacturing, Productivity, and the Workplace: The identification of new telecommunications transmission systems and the distribution of information on public attitudes, urban and rural life, and education.

121

## The Energy Laboratory

In recognition of its potential for public service in the energy field, MIT established the Energy Laboratory in November 1972. Five broad objectives were adopted. The Laboratory would

1. undertake a broad-based, intensive program of interdisciplinary and mission-oriented energy research;
2. conduct comprehensive and objective policy studies and assessments of alternate energy strategies;
3. communicate research results to potential users and promote the transfer of new technologies and methodologies into practice;
4. expand educational and training opportunities in energy areas at MIT and develop the manpower with the skills and experience necessary to deal with energy problems; and
5. contribute to public dissemination of energy-related data and the furtherance of informed dialogue on key energy issues.

The Energy Laboratory attempts to meet these objectives through programs in seven major research areas--Energy Management and Economics; Fossil Fuel Technology; Nuclear Technology; Environmental Technology; Electric Power Technology; End Use Technology; and Alternate Energy Technology.

Energy Management and Economics: Programs in this area involve the following types of activities: (a) formulation, implementation, and application of analytical models of energy production and utilization behavior using techniques of applied economics, econometrics, mathematical modeling, and engineering cost estimation; (b) conducting of energy policy studies and evaluations, including evaluation of specific technological choices; (c) development of improved computational methods for the estimation and solution of analytical energy models, as well as the assimilation and management of energy data bases.

Fossil Fuel Technology: Programs in this area involve the following activities: (a) basic research relating to fossil fuel processing, conversion, combustion, and separation or cleaning of emission products; (b) use of results of basic research to develop improved analytical models for predicting performance of components and systems associated with chemical and fuel processing plants, electric power plants, boilers, gas turbines and automotive engines; and (c) use of improved analytical models in conjunction with data from experiments carried out on pilot or demonstration plants, to determine scaling laws and obtain engineering information that can be used in the development of new systems or new models of presently operating systems. Such models can be used for systems simulation, economic evaluation, optimization and estimation of materials requirements relating to fossil fuel utilization.

Nuclear Technology: Programs in this area are aimed at technical, environmental and economic problems relating to development and utilization of nuclear power.

Principal activities include: (a) development of improved methods of design and safety evaluation relating to contemporary fission reactors; (b) basic research and technology development relating to advanced fission reactor concepts; and (c) basic research and technology development relating to nuclear fusion.

Environmental Technology: Programs in this area include experimental and analytical work aimed at developing improved methods for prediction, monitoring, and control of environmental and health effects of waste products associated with the production and utilization of energy.

Electric Power Technology: Programs in this area involve both experimental and analytical work aimed at: (1) development of improved electrical component design; and (2) development of improved methodology for planning, design and operation of large interconnected systems.

End Use Technology: Programs in this area include experimental and analytical work aimed at: (a) improvement of energy efficiency in buildings; (b) reduction of energy consumption in industry processes; (c) increasing energy efficiency of transportation systems; and (d) determination of efficiencies to be derived from integrated energy systems.

Alternate Energy Technology: Programs in this area include work on: (a) solar-energy technology, with special emphasis on electric power and hydrogen generation; (b) energy storage; and (c) energy conversion, including a topping cycle involving high temperature (1500°F) electrolysis and a medium-temperature fuel cell.

The Energy Laboratory is modeled in principle after such highly successful Institute organizations as the Charles Stark Draper Laboratory, the Lincoln Laboratory, and the Research Laboratory of Electronics. Like both Draper and Lincoln Laboratories, the Energy Laboratory is organized as a "special" facility under the Vice President for Research rather than under the direction of a particular School or academic department. This enables the Energy Laboratory to move across traditional disciplinary lines and integrate diverse programs and synthesize approaches not conceived by narrower, more specialized research groups.

One major difference between the Energy Laboratory and its predecessors is that issues of management, economics, and public policy--and the intersection of these matters with the details of science and technology--loom much larger in the energy picture than they did in the primarily defense-related research undertaken earlier.

In order to maintain a program responsive to both MIT and national needs, several internal and external committees exist which provide guidance to the laboratory as it formulates and carries out energy research activities. General research guidance and month-to-month coordination of the Laboratory's efforts with those of the academic departments within the Institute are provided by an Energy Laboratory Steering Committee. Larger issues of policy regarding the Lab's development are the responsibility of the Policy Committee consisting of Academic Deans and other administrative staff of the Institute. An Advisory Board of energy experts from outside MIT reviews the work of the Laboratory on a periodic basis and brings close working knowledge of energy problems to bear in advising the Lab on its current programs and future plans.

In carrying out current programs, the Laboratory employs a full-time research staff and draws extensively on personnel and resources available through various departments and research facilities at the Institute. The research volume of the Laboratory currently exceeds \$3.5 million annually, with specialists in science, engineering, economics, and management involved in a range of applied research projects funded by government, industry, and the Institute. In all, over 60 faculty members, 100 students, and 30 professional staff--including specialists from industries and utilities--participate in Laboratory programs.

Typical activities now underway at the Laboratory include (1) national energy policy analysis involving supply, demand, and new technology projections; (2) on-line weather predicting and monitoring systems for improving environmental quality nationally by fuel shifting and load shifting of electric power plants on an operating utility system; (3) modeling, instrumentation, and materials development for MHD, combined cycle, and advanced combustion systems; and (4) environmental management, monitoring and safety analysis for electric power plants as a regional cooperative program with the New England utilities.

## Center for Transportation Studies

The Center for Transportation Studies has been established to promote cooperation in interdepartmental and intermodal matters, to facilitate innovative research in transportation, and to provide a focal point for educational programs within the Institute. The Center's research emphasis is on problem-oriented, interdepartmental, multi-modal research. It covers a wide spectrum ranging from broad conceptual planning through operation and management of transportation problems to new methods of transportation analysis, planning and decision making.

The Center has developed a structure which promotes interaction among faculty members from all schools at M.I.T. as well as other universities and organizations concerned with transportation. Interdepartmental cooperation is essential in dealing with the complex problems found in this area since their solution requires close ties between technological possibilities and their social, economic, ecological, and political ramifications. The Center has developed a sense of community that promotes cooperation, the exchange of ideas, a wider perception of the opportunities, and a common purpose.

The research program of the Center is broadly based, incorporating both interdepartmental and intermodal elements. Research capability extends from the areas of social science and management to the technological research associated with the development of new modes of transportation. Recent research projects have concerned application of new methods to transportation planning, transportation and community values, railroad reliability and network planning, innovative urban transportation, transportation in developing countries, transportation demand models, urban freight movements, airport planning and development, commodity movement, industry location, freight terminal simulation, energy transport, superport location, air traffic control, dual mode transportation, assessment of STOL/VTOL air service potential, local service air carriers, and the logistics of freight modal choice and inventory control. Research sponsorship includes a range of government and industry organizations affording students wide opportunities to be involved in newly evolving research frontiers.

The academic program includes subjects in the areas of transportation systems analysis, economics, social and environmental effects, management, public policy, and technology. The core subjects of the program emphasize the fundamental disciplines underlying analysis, planning, and problem solving in transportation. Although most students will take the core subjects, programs are flexible to allow an individual the latitude to pursue a particular area of specialization.

## Center for International Studies

The Center for International Studies, one of MIT's interdisciplinary research centers, emphasizes in its program the international issues arising from unprecedented global interdependence. Many of those issues involve technological as well as social, political, and economic aspects, so that the Center's research often requires collaboration across the disciplinary boundaries of engineering and the social sciences. MIT provides a unique setting for such research, given the high quality of its faculties in both technology and the social sciences and the flexible, receptive climate that encourages cross-disciplinary collaboration.

The Center was founded in 1951, one of the first major university research centers in the international field. The program in succeeding years centered largely in the social sciences and more specifically on the study of economic and political development, the communist world, defense and arms control, and political communications. Many of the Center's members are continuing to pursue these interests, while others have launched new projects with more explicit technological dimensions in such areas as food, space, energy, trade, transfer of technology, arms, and the environment. Much of the research is strongly policy-oriented. Our goal is to help illuminate new international issues and to assist in the increasingly difficult task of making policy to deal with complex social problems.

The primary business of the Center is research, although it plays an auxiliary role in graduate and undergraduate teaching at the Institute through faculty and student participation in research projects and through seminar and lecture programs. As a research center, it responds to and stimulates interest in important international questions for which MIT faculty members have relevant competence. The initiative for research projects may come from members of the faculty, from the Center, or from outside sources. In all cases, the faculty and students associated with the projects retain their primary Departmental affiliations, while carrying out research under Center auspices.

The theme for the Center's research program is now global interdependence, with special attention to the consequences of technological change, social control of the effects of technology, use of scientific and technological knowledge, problems of accelerating growth, and problems of policy-making in this changing international environment.

Major projects or programs that have been developed under this new theme include:

- international nutrition planning
- arms control
- common problems of advanced industrial countries
- nuclear power regulation
- communications policy
- long-term resource availability
- impact of technology on the international political system

- foreign policy planning
- consequences of migration within and between developing and industrialized countries
- changing climate for international business

Special seminars, related research, and planning for possible future programs are being conducted on other subjects related to the new theme of Center research, including:

- comparative environmental policy
- technical analysis for policy-making
- international institutions
- international energy issues
- comparative study of national and international regulatory mechanisms
- transfer of technology
- food/population

Several other research programs continue at the Center, and new ones have been initiated in response to faculty initiative, that reflect longer-standing research interests. These include projects or programs on subjects such as:

- group identity and political change
- Asian political cultures
- information management
- international economic system
- communism, revisionism, and revolution
- comparative analysis of internal social conflict
- policy-making for local conflict situations

In addition to these programs, there is close collaboration with research based at other locations at the Institute. For example, the extensive energy policy studies of the Energy Laboratory, the research of the Technology Adaptation Program, and some of the projects at the Center for Policy Alternatives are conducted with substantial interaction with the Center.

The Center is the only Institute-wide body devoted principally to international affairs. However, other internationally related activities and research projects proceed elsewhere in the Institute, either within individual departments or in other research centers. There is no attempt to collect these under one umbrella, though the Center for International Studies seeks to keep abreast of related work. In many cases, projects are carried out jointly between the Center and other departments, Schools, or centers at the Institute.

The relatively small size of MIT (8,000 students, graduate and undergraduate) and a long history of interaction among disciplines greatly aids the development

of genuine multidisciplinary research projects. The growing interest and concern of engineering faculty and students in the social implications of technology and in the policy issues raised by technology are crucial assets to the Center's work.

Aside from its research projects, the Center has other important roles at MIT. An extensive program of seminars and lectures deals with special issues of interest, usually in connection with specific projects or to initiate new research areas. The Center receives many short-term visitors from the United States and abroad and is also host to a small number of visitors for a semester or a year. Occasionally, the Center undertakes special educational or training programs in conjunction with one of its research projects.

The Center cooperates closely with other institutions in the area, particularly at Harvard with the Center for International Affairs, the Center for European Studies, the Program for Science and International Affairs, and the Population Center. Several projects and programs are jointly sponsored with Harvard; with others there is close, informal collaboration.

The Center sponsors the publication of books resulting from research conducted under its auspices and publishes research reports and policy articles under its own imprint. Nearly 250 books and a large number of articles and policy papers have been published.

Funding for Center programs is derived from a variety of public and private sources. The Ford Foundation figures prominently in support for individual programs and in the past for general Center support. Other foundations, industry, and U.S. government agencies--notably the Agency for International Development and the National Science Foundation--are current program sponsors.

## International Nutrition Planning Program

Malnutrition, once considered solely a serious humanitarian concern, now is acknowledged as having important implications for the larger economic growth process. Despite growing awareness of this fact by governments of both the developed and the developing nations, nutrition intervention programs to date have been limited both in scope and effectiveness. The inadequacy of traditional approaches alone and a clearer understanding of the magnitude and complexity of the malnutrition problem make it apparent that a broader approach is necessary. Such an approach implies a need (1) to relate nutrition programs to the larger processes of economic growth, requiring an understanding of vital interrelationships between nutrition and rural development, agricultural policy, public health, and population problems, and (2) to address explicitly the matter of integrated nutrition planning.

Recognizing this need for a broader perspective and for a broader range of disciplines--e.g., economics, political science, anthropology, demography, social psychology, epidemiology, and management as well as nutrition and food science--the Department of Nutrition and Food Science and the Center for International Studies established an International Nutrition Planning (INP) Program at MIT in 1972. Individuals involved in operations of the INP Program are drawn from the Nutrition Department and the Center plus the Sloan School of Management, the Center for Advanced Engineering Study, and the Departments of Economics, Political Science, Urban Studies, Mechanical Engineering, and Ocean Engineering. In addition, the Program has the cooperation of individuals at Harvard University in the Development Advisory Service, the School of Public Health, the Center for Population Studies, and the Graduate School of Business Administration. The INP Program has received core support from the Rockefeller Foundation and the US Agency for International Development.

Activities of the INP Program are concentrated in three basic areas:

1. applied, operational research to determine and refine effective integrated approaches to national and regional nutrition planning, and implementation and evaluation of programs to combat problems of malnutrition among target populations;
2. provision of advisory services to governments and to multilateral and bilateral assistance agencies on specific aspects of nutrition planning and programming; and
3. education and training pertaining to these approaches, and designed for students, concerned persons, and institutions involved in various facets of the problem.

At the request of several governments, the INP Program has become involved in the planning of programs designed to combat malnutrition in ways which are integrated with rural development, public health, population, agricultural, and employment objectives of these countries.

In addressing the matter of nutrition planning the Program utilizes available relevant data and the full participation of national personnel. Planning activities necessarily are individualized according to country or regional needs but involve at least the following elements:

1. assessment of the nature and magnitude of the existing malnutrition problem, particularly with regard to young children among whom the consequences and implications of malnutrition are most critical;
2. analysis aimed at the identification of the relative importance and interactions of the determinants of the malnutrition found;
3. determination of effective technological or economic means of affecting the determinants or problems found most important in the first two steps.

The first step draws on expertise in the Department of Nutrition and Food Science, while the second and third steps utilize human resource economics, epidemiology, anthropology, and specific inputs from specialists in communications, demography, engineering, urban planning, and ocean resources depending upon the problem identified. Inputs from development economics and political science are employed at all stages to assure integration of this planning into the broader development process.

Although the primary thrust is oriented toward planning, the INP Program realizes that planning, if it is to be effective, does not terminate with the initiation of a project. It must continue through the implementation process which involves continued decision making, goal revision, and the ability to take advantage of new targets of opportunity. Similarly the evaluation mechanism clearly is an indispensable tool in a broadly conceived planning process.

While recognition of the implications of malnutrition is increasing among governments of low income countries and among international agencies, these same times lack the personnel to translate this concern into effective programs. The INP Program is making available to these governments and agencies a pool of skilled persons capable of providing competent operational advice geared to the solution of malnutrition problems. Such advisory services can be obtained in the broad area of nutrition planning discussed separately above. They also are provided to aid in the solution of such specific elements of a nutrition strategy as (1) particular deficiencies among population subgroups; (2) the design or evaluation of supplemental feeding, food fortification, plant breeding, or information dissemination programs; (3) utilization of nutrition inputs as a means of strengthening health, family planning, or educational institutions; or (4) the nutrition implications of an agricultural price policy or production-incentive program.

Examples of such services which have been provided by the Program include:

Chile: work with the Government's Industrial Protein Group (CPI) to develop low cost, indigenous substitutes for imported milk powder;

El Salvador: participation with the Planning Commission and with the Institute of Nutrition of Central America and Panama (INCAP) in developing short and long run nutrition program proposals for the Government;

Indonesia: assistance to the Government in development of a plan for national nutrition program development;

Pakistan: Assistance in the initiation of a nutrition planning effort in the Planning Commission;

Thailand: participation with the Institute of Food Research and Product Development in efforts to develop and commercialize nutritious products from mung beans.

Agencies involved in the Program's advisory services have included UNICEF, the International Bank for Reconstruction and Development, the World Health Organization (WHO), and the US Agency for International Development (AID).

Success in program planning and implementation will depend in part on the existence of personnel with training and experience relevant to malnutrition problem solving in low income areas. In addition to the development of such a trained cadre of professionals, there is a need to provide planners with an understanding of malnutrition and the dynamics of nutrition intervention, and to acquaint nutrition and health personnel with planning tools and with the relationships of nutrition to the broader process of economic growth. Given these needs in international nutrition, MIT is offering the following programs of graduate study and training.

S.M. and Ph.D. candidates in related departments can undertake regular graduate study with a thesis focus on international nutrition, national development, and planning, or they can, with the approval of the departments involved, arrange for special interdepartmental programs to meet individual needs. Such interdepartmental programs are particularly relevant to students in the Departments of Nutrition and Food Science and Political Science but may also be applicable to students in economics, management, or engineering.

Seminars will be designed to help the student integrate and focus materials from these subject matter areas. The student also will be expected to write a thesis of a multidisciplinary nature relating to international nutrition and development.

A small number of individuals will be admitted each year into a nine-month Advanced Study Program as Fellows in International Nutrition Planning. This program, undertaken in collaboration with the MIT Center for Advanced Engineering Study, generally is limited to officials of governments and international agencies who are able to meet certain entrance requirements (including fluency in English) and who are sponsored and financed by their respective organization. Fellows will undertake a special program of course work, seminars, and in some cases field work developed in a way which most sensibly supplements existing talents and experience, whether in public health, finance and economics, or administration. Fellows successfully completing the program will receive a Certificate in International Nutrition Planning.

Periodically the International Nutrition Planning Program will carry out workshops of two to eight weeks in duration, focusing on specific questions or problems in international nutrition and usually pertaining to a specific geographic area. These workshops will be announced at least six months in advance and will, in some cases, be carried out in conjunction with international agencies.

The INP Program also is involved in multidisciplinary research activities, as noted above, and it sponsors a seminar series on nutrition policy. Together with Cornell University's Program on International Nutrition and Development Policy, the INP Program publishes the Cornell-MIT International Nutrition Policy Series of international case studies and planning efforts relating to nutrition policy. The INP Program also produces a Technical Report Series pertaining primarily to its field activities.