

AGENCY FOR INTERNATIONAL DEVELOPMENT  
WASHINGTON, D. C. 20523  
BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY

Batal 35

1. SUBJECT CLASSIFICATION	A. PRIMARY	TEMPORARY
	B. SECONDARY	

2. TITLE AND SUBTITLE  
Technology adaptation program, mid-term report, August, 1975

3. AUTHOR(S)  
(101) MIT

4. DOCUMENT DATE 1972	5. NUMBER OF PAGES 110p.	6. ARC NUMBER ARC
--------------------------	-----------------------------	----------------------

7. REFERENCE ORGANIZATION NAME AND ADDRESS  
MIT

8. SUPPLEMENTARY NOTES (Sponsoring Organization, Publishers, Availability)

9. ABSTRACT

Science and technology R&D

10. CONTROL NUMBER PN-AAB-925	11. PRICE OF DOCUMENT
12. DESCRIPTORS	13. PROJECT NUMBER
	14. CONTRACT NUMBER CSD-3360 211(d)
	15. TYPE OF DOCUMENT

**TECHNOLOGY ADAPTATION PROGRAM**

**MID-TERM REPORT**

**AUGUST 1975**

**to**

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

**Massachusetts Institute of Technology  
Cambridge, Massachusetts**



## TABLE OF CONTENTS

	<u>Page</u>
I. Statistical Summary	1
II. Narrative Summary	2
III. Accomplishments of the Program to Date	3
A. General Background and Purpose of the Grant	3
B. Organization and Management of the Program	4
C. Objectives of the Grant	5
D. Responses to Objectives	6
1. Research	7
2. Institution Building	8
a. At MIT	8
b. Overseas	9
IV. Current Technology Adaptation Program at MIT	10
A. Revised Guidelines	10
B. Current Focus	12
C. Specific Programs	14
1. Colombia	14
2. Egypt	20
V. Proposed Continuation of the Technology Adaptation Program at MIT	21
A. General Background	21
B. Principal Objectives	23
C. Program Elements	24
1. Research	24
2. Education	25

Table of Contents, continued

	<u>Page</u>
Appendix 1: Individual Research Projects	29
Appendix 2: Institution Building: Meetings, Workshops, Seminars	51
Appendix 3: Institution Building: Course Development	71
Appendix 4: List of Publications	83
Appendix 5: Activities Related to the Technology Adaptation Program	91

MID-TERM REPORT

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

Grantee: Massachusetts Institute of Technology  
Cambridge, Massachusetts

Chairman, Program Steering Committee: Fred Moavenzadeh  
Professor of Civil Engineering

I. STATISTICAL SUMMARY

Period of the Grant: December 1, 1971 to December 1, 1976

Amount of the Grant: \$900,000

Expenditures for Past Fiscal Year: \$123,932.13  
(July 1, 1974 to June 30, 1975)

Accumulated Expenditures: \$536,644.51 (As of June 30, 1975)

Anticipated Expenditures for Coming Year: \$225,000.00

## II. NARRATIVE SUMMARY

The Technology Adaptation Program at MIT is designed to strengthen the Institute's ability to carry out research, analysis, education, and training relating to the various problems of adapting industrial and public works technology to the conditions of emerging nations.

During the past three years the Program has provided funding for numerous projects dealing with various problem areas related to one or another aspect of adapting technologies to the developmental process of less industrialized countries. Faculty and students in several departments have participated in investigations covering a wide range of research activities, from creating evaluation frameworks for multi-modal transportation infrastructures to considering the adaptation of capital-intensive construction methods to labor-intensive environments; from developing a technique for using electromagnetism to prospect for subsurface water in arid regions to a study of the efficient use of natural fibers for manufacturing purposes in both developed and developing nations.

The Institute has attempted to fund projects which will build upon its already substantial ties with emerging nations; we have tried to 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 an ongoing research program concerned with creating and adapting industrial and public works technologies which will help meet various needs of emerging nations.

Some of the projects have been more "successful" than others; some have resulted in numerous research reports and professional papers; others have generated additional funding from external sources. The enthusiasm generated by the Program, the increased sensitivity of the MIT community to the needs of developing nations, and our enhanced awareness of the various social, economic, and political trade-offs inherent in any transfer or adaptation of technology testify to the success of the Program as a whole.

Based on our past experience and on the new guidelines outlined by the Agency for International Development for 211(d) grant institutions, we believe that the Program will be more productive if, in the future, it emphasizes research on the implementation of appropriate technologies rather than on "hardware" solutions to the problems of technology transfer and adaptation. This new orientation calls both for more narrowly focused research on the part of MIT and for a more formal cooperative working relationship with certain institutions in a few selected countries. Colombia and Egypt, as nations which have already achieved substantial infrastructures and are seeking specific advanced technological cooperation, appear to be the best choices for collaborative research efforts of mutual interest to MIT, the individual country, and AID. Those areas of most interest to the various groups involved have been identified tentatively as public works and industrial development, with specific sectors of technological interest including mechanical engineering systems, transportation, water resources, materials, and technology in public systems.

### III. ACCOMPLISHMENTS OF THE PROGRAM TO DATE

#### 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 programs 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 25 percent of the student body at the Institute is foreign, many from various developing countries, we feel we have a special incentive to devote research and teaching efforts to discovering solutions to developmental problems in their home countries.

## B. Organization and Management of the Program

Management of the Technology Adaptation Program has resided in a Steering Committee reporting directly to the Provost of the Institute. During the first year of the Grant the Committee decided to begin activities by attempting to increase 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.

The Committee's principal function has been to select specific projects for 211(d) 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.

When the Committee members found projects which fulfilled these various criteria at a reasonable level of funding, the project was approved. The lack of sufficient funding for all worthwhile and potentially rewarding projects limited the amount of Grant-funded research, although a number of projects first inaugurated under the auspices of the Technology Adaptation Program have found continued financial support after the initial period of their grant has expired.

### C. Objectives of the Grant

"A long-term aim of MIT, which this Grant supports, is to develop a broadly-based body of expertise at the Institute concerned with the exploitation of technology for public works and industrial development in developing countries. 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. Examples where MIT's engineering competence seem particularly applicable are chemical processing, materials and metallurgy, power generation and transmission, machine tools and materials processing, construction, water resource development, communications and data processing, and transportation....These fields constitute much of the basis for the industrialization that is emerging in the developing countries."\*

#### D. Responses to Objectives

The original long-term objective of the Technology Adaptation Program at MIT was to develop a body of expertise concerned with the problems of utilizing public works and industrial technologies in developing countries, and to employ this expertise to maintain a continuing program of investigation and training. In the Proposal of August 1971, the Institute indicated that it 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.

For this report we have divided the Program Elements into two broad categories, research activities and activities concerned with institution building both

---

\*From the Proposal for Support by the Agency for International Development Institutional Grant Program, "Adaptation of Industrial and Public Works Technology to the Conditions of the Developing Countries," August 1971, Section II, pp.6-7.

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. Within the area of institution building we have included course and curriculum development, workshops, seminars, and conferences, and the acquisition of library and resource materials.

### 1. Research

The bulk of the Technology Adaptation Program's efforts to date have concentrated primarily on individual research projects. Each project, described briefly in Appendix 1, has its own emphasis, is directed by an individual faculty member with his or her own specific research interests and goals, and devotes a different fraction of its resources to the Program Elements listed above. Some projects concentrate 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. We can draw some conclusions, however, about the overall thrust of the Grant-supported research:

A large number of papers and reports have been generated by individual projects; a complete listing of such publications is included in Appendix 4. 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.

Faculty and student development cannot be measured quantitatively, except perhaps in terms of papers and reports generated by individual projects. What is notable, however, is an increased awareness of the problems involved in the transfer and adaptation of technology to the conditions of emerging countries

on the part of the MIT community as a whole. This increased sensitivity becomes apparent when one examines the concomitant increase in the number of courses given in the Engineering School which include material devoted to the developmental problems of less economically and industrially advanced nations.

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 4 for a list of TAP-sponsored theses).

Most senior investigators, aided by the Program's travel budget, have developed informal working relationships with individuals, institutions, and research groups in various emerging nations. Although initially less emphasis was placed upon developing formal institution-to-institution ties, such linkages currently are being established as a result of our past experiences and new directives as discussed in Section IV.

## 2. Institution Building

### a. Institution Building at MIT

According to the original Proposal accepted by AID in 1971, the first 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" (p.8). 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 3; several of these have been offered by faculty members who have participated in TAP research efforts.

The MIT community has held a number of seminars, workshops, and conferences dealing with various aspects of the social, economic, political, and technological problems associated with the transfer and adaptation of advanced technologies to the conditions of emerging nations. 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 2 contains more details on this Program Element.

Most library and resource material acquisition has depended upon the Institute's general library funds and facilities. Individual projects have of course collected highly specialized material relating to individual needs, but the acquisition of a complete centralized document collection was considered too costly since such a collection would divert funds from other parts of the Program.

#### 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 developmental 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, establish

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.

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 2 for further details).

#### IV. CURRENT TECHNOLOGY ADAPTATION PROGRAM AT MIT

##### A. Revised Guidelines

During the coming years the Steering Committee proposes to focus the research which it sponsors mainly in two countries, Colombia and perhaps Egypt. We believe that our abilities and resources can be most usefully employed in countries which have already created a sound technological base and are in the process of developing more sophisticated technical capabilities, and that these countries still require a certain amount of assistance from and cooperation with institutions in the United States, such as MIT, in order to attain such advanced capabilities. We plan to focus only on those technological areas for which we can find mutual interests both at MIT and in the developing countries, and to emphasize "soft-" rather than "hardware" solutions to problems of technology transfer and adaptation. The problems of implementing appropriate technologies will be stressed, although research will be sponsored on purely technical problems when promising opportunities arise.

This approach is 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.\*

By concentrating on two countries it is expected that the various projects undertaken will become mutually supporting to a much greater degree than has previously been the case. There will be more opportunities to identify common problems of finding and implementing appropriate technologies and common elements in solutions. Greater expertise can be developed and shared in understanding the cultural and social factors which mediate technological adaptation, and closer ties established with cooperating institutions abroad through a broader range of interactions. Whatever emerges from our concentration on two countries might further be examined with regard to its applicability to other countries, particularly those at similar levels of development with similar conditions.

The increased emphasis on developing formal linkages with educational and research institutions in Colombia and Egypt, and the narrowing of the focus of research in areas of technology of mutual interest to all groups involved

\*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

in this collaborative work will not substantially change the basic Program Elements of MIT's 211(d) grant. The Institute also will continue to support student and faculty development, grant-related travel, course and curriculum development, workshops, seminars, and conferences, and the acquisition of library and resource materials.

#### B. Current Focus

Some degree of modification in the scope of the Technology Adaptation Program appears to be in order as a result both of the new AID guidelines and of MIT's intention of focusing on "soft-" rather than "hardware" solutions to the problems of technology adaptation and transfer. The guidelines' increased emphasis on identifying shortages of trained personnel as well as specific gaps in knowledge and skills, combined with the establishment of formal linkages with agencies and personnel in selected nations, is also in accord with MIT's efforts to provide a multidisciplinary approach to the practical solution of developmental problems in less industrialized countries.

In order to most effectively carry out research useful to the Institute, less industrially advanced nations, and AID, the Program requires the development of active ties with specific institutions in a few selected countries. The Institute's capabilities in both the areas of public works and industrial development can best be utilized if the countries selected for collaborative research efforts have already achieved significant infrastructures and a reasonably sophisticated technological base and are seeking explicit advanced technological cooperation.

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 projected 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.

There are several of the less developed countries which are substantially advanced in the scientific and technological fields, particularly in public works technology, and which are currently concerned with the development and application of sophisticated analytic management, planning, design, or control techniques. At this point their greatest needs, in other words, seem to be mainly in the area of effective implementation of technological decisions rather than in making the decisions themselves. Colombia, Venezuela, and Brazil in Latin America, Korea and Thailand in Southeast Asia, and Egypt and Turkey in the Near East are examples of such countries.

The basis for the selection of appropriate countries includes 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 two investigative trips to visit various agencies and institutions by the Chairman of the program, it was concluded that Colombia met all the requirements for establishing collaborative working relationships with TAP-funded projects at the Institute. Ties with specific groups, institutions, and agencies in Colombia have now been established and will be discussed below. The establishment of a comparable collaborative program with Egyptian institutions is still in the early stages of development; the progress to date in this area is also discussed in the following section.

It is proposed that the Technology Adaptation Program will concentrate in the future on a few areas of technology of interest to Colombia and Egypt, to MIT, and to AID. Primary fields have been identified tentatively 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 modelling. Specific sectors of technical interest include mechanical engineering systems, transportation, water resources, materials, and technology in public systems.

### C. Specific Programs

#### 1. Colombia

Colombia seems particularly appropriate as a country with which MIT's Technology Adaptation Program might establish collaborative working relationships. Not only does it fully meet the requirements set forth by AID and TAP, but its government also appears firmly committed to a wide range of programs designed to broaden the benefits of development, including specifically rural development. The rural development program, integrated on both public and private levels, is to be funded both by major foreign loans and by government grants up to a total of 300 million dollars; preliminary loan negotiations apparently have been successfully completed with the World Bank, the Inter-American Development Bank, and AID.

In addition to the conventional problems of agriculture and migration, the program deals with rural energy development, nutrition, health care delivery systems, transportation, municipal services, rural industrialization, education, communication, and housing. The programs in some of these sub-sectors are still in the process of initial formulation, while others are being implemented on a limited scale. Several of the groups with which we will be collaborating such as the Mechanical Engineering Department at Los Andes University, FICITEC, and Fondo Nacional de Caminos Vecinales are involved in the program. The Colombian AID Mission also has a continuing interest in several of these areas; AID has provided partial support, for example, for the rural road and health care delivery programs.

The future program of collaboration between TAP and Colombia has been defined in a series of discussions and will be implemented in particular research

agreements. The universities, primarily Los Andes University, 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) will provide research teams on the host country side. Fondo Colombiano de Investigaciones Cientificas (COLCIENCIAS), Colombia's equivalent of our NSF, will act as the primary liaison, providing the management, administration, and funding for the Colombian component of our joint research program. Dr. Efraim Otero, Director of COLCIENCIAS, suggested that a four or five member Steering Committee composed of individuals from COLCIENCIAS, the University, and one or two private research institutes and/or government agencies be formed to oversee the progress of the Colombian research. An annual or semi-annual joint meeting of both Steering Committees could then be held to review continuing and approve new projects. To date, five basic areas of collaborative research have been defined, and within each of these the specific topics, the Colombian individuals or groups tentatively interested in participating, and their potential MIT counterparts have been identified as discussed below.

Mechanical engineering systems is the first area of joint research to be undertaken in Colombia, and within this there will be two sections. The first is concerned with developing small systems and tools for use primarily in rural regions. A program in this area, entitled "Development of Appropriate Technologies", is currently in progress in the Mechanical Engineering group at Los Andes University; more specifically, it is concerned with the development of (1) an efficient rural electrification system, (2) the use of water turbines for energy generation, (3) efficient induction pumps, and (4) solid waste disposal systems for small towns. Ing. Rodriguez Urrego, Vice Dean of the Engineering School, directs the program; which has been, and probably will continue to be, funded by COLCIENCIAS.

Ing. Jorge Zapp Glanser, Head of the Mechanical Engineering Department, and Ing. Jaime Lobo Guerreru, a faculty member with primary interest in hydraulic machinery, assist Ing. Rodriguez Urrego. At MIT Professor David Wilson of the Mechanical Engineering Department is interested in the research and has met with this group to develop a working program.

The second section in mechanical engineering systems is concerned with rural industrialization, particularly textile and food technologies. Interest in this is located primarily at FICITEC. In the field of textile technology a state-of-the-art review of the textile industry, appraisal of its potential local and foreign markets, and establishment of guidelines for the development of a viable indigenous industry are of interest; research in food technology deals with similar concerns. Sr. Guillermo Llinas, Director of FICITEC, heads the research group. Professors Stanley Backer and Giuliana Tesoro of the Textile Engineering group in MIT's Mechanical Engineering Department are interested in pursuing the possibilities available for collaboration in the textile area. As for food technology, Professor Lance Taylor met briefly with Sr. Llinas, and he and others in MIT's International Nutrition Planning Program may be interested in establishing a collaborative program.

The second area of research is water resources, in which there are currently two specific projects underway at the Center for Hydraulic Research at Los Andes University. The first, a collaborative project among the Center, the Water Resources Division of Simon Bolivar University in Caracas, and our Water Resources group at MIT, is concerned with planning for water resource development in remote and mountainous regions. Seeking quantitative links between climate and weather and developing measures of stream-channel network structure are currently of interest, as success in these efforts presumably would allow one to infer precipitation and/or streamflow statistics from aerial observations of

landforms, thus bypassing the conventional process of gathering field data. The principal investigators include Dr. Jose Manuel Mejia of the Center for Hydraulic Research, Professor Ignacio Rodriguez-Iturbe in Venezuela, and Professor P. S. Eagleson at MIT. COLCIENCIAS is interested in funding the program in Colombia for the next academic year, while CONICIT, the Venezuelan equivalent of COLCIENCIAS, will fund Professor Rodriguez-Iturbe. A meeting of the principal investigators is scheduled for early fall in Bogota.

The second program in water resources concerns the evaluation of the 250 million dollar multi-purpose Rio Cauca project in Colombia. The Center for Hydraulic Research has been studying this project for the past two years under a grant from the Resources for the Future, Inc., and COLCIENCIAS. Project evaluation methodologies such as those of UNIDO and OECD have been applied, and as a result of their preliminary findings, the initial project design has undergone major revisions. Work on this is expected to be completed within the next eighteen months. Dr. Mejia and Dr. Jaime Millan, also of the Center, head the research effort and expect Dr. Alejandro Deeb, who recently completed his doctorate in water resources at Harvard, to join them this summer. Professors Richard Eckaus and Lance Taylor of MIT's Economics Department and Professors Frank Perkins and David Marks of MIT's Civil Engineering Department have expressed interest in collaborating on both economic and technical aspects of this project.

Transportation, the third research area, is also composed of two projects. In the field of commodity transport interest is in the development of methodologies for evaluating transport technologies available for moving bulk goods. Colombia's topography and spatial distribution of population, resources, and port facilities have so far limited the development and implementation of an intermodal transport model. The current issue of primary concern is evaluating certain available transport technologies within the context of a specific

commodity such as coal or cattle or in a specific region or corridor. Dr. Ulpiano Ayala, who recently received his Ph.D. in Transportation from MIT and is now at Los Andes University, is interested in exploring such research opportunities. Professors Joseph Sussman and James Sloss of MIT's Transportation group, who have been involved for the past year in freight transportation research in Latin America, are in contact with Dr. Ayala; Mr. Sloss is planning to visit Bogota during August to develop a research program. Professor Joseph Vittek of MIT's Aeronautics and Astronautics Department may also take part in the program.

The second transportation project area, rural road programs, is one to which the Colombian government is strongly committed on a rather large scale. The Fondo Nacional de Caminos Vecinales has been actively involved in the planning and construction of penetration and feeder roads, for which AID has been providing substantial financial support. There is, however, a growing need for the development and implementation of more comprehensive and systematic methods of analysis and evaluation of such projects, especially since attempts have been made to use the rural road program to generate employment; for example, highly labor-intensive construction methods have been used without knowing whether capital-intensive methods are more efficient and less costly or not. Ing. Manuel Baquero of Los Andes University, formerly head of the Planning Department of the Ministry of Public Works, has substantial knowledge of and experience with rural road programs and is interested in collaborative work. A comprehensive research program in this area requires the cooperation of Planeacion Nacional, M.O.P., Fondo Nacional de Caminos Vecinales, and AID. At MIT Professor Fred Moavenzadeh intends to pursue cooperative research in this area.

Materials is the fourth area of research and is a field, particularly the building materials segment, of great interest to COLCIENCIAS. An advisory panel

of representatives from the materials manufacturers associations, government agencies, and universities is currently collaborating with the staff of COLCIENCIAS in delineating research programs in materials engineering; an industrial survey of the building materials industry is currently underway. Academic research in this area is distributed among several universities, with primary emphasis upon identifying and classifying local building materials. In order to provide a better focus for overall research efforts and for MIT's involvement in this field, it has been suggested that COLCIENCIAS sponsor a meeting in Bogota or Cali, inviting personnel from various universities and research institutions. At MIT Professors John Elliott and Fred McGarry of the Materials Science and Engineering Department and Professor Stamatia Frondistou-Yannas of the Civil Engineering Department have agreed to participate if research areas of interest to them can thus be identified.

Technology in public systems, the fifth and final collaborative research area, encompasses the role of advanced technology in education, communications, health care delivery, and other public systems. Due primarily to its importance in the government's Integrated Rural Development Program, it is currently receiving considerable attention in Colombia, and any collaborative work in the area will have to be coordinated with several government agencies, particularly Planeacion Nacional. Dr. Eduardo Aldana, former Rector of Los Andes University and the current director of SER, is now developing research efforts in the public systems technology area. He is informed of our interest in this field, and once more is known about the government's plans, it should be possible to develop specific collaborative works, probably initially with an operations research orientation.

In order to provide a forum for discussion and to exchange information on MIT/TAP and Colombia, Dr. Otero of COLCIENCIAS suggested that a three-to-four

day meeting attended by several MIT faculty members and Colombian government and university officials be held in Bogota sometime this fall. The participants would have an opportunity not only to discuss the general area of technological cooperation, but also to develop an understanding of how MIT's resources might be utilized most effectively in Colombia.

## 2. Egypt

In June of this year 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. According to Dr. Ismail, the various Egyptian universities are presently concerned with delineating specific areas of research of interest both to the U.A.R.E. and to U.S. groups and individuals working in the fields of economics, health, education, and science and technology.

Dr. Ismail and his colleagues are concerned particularly with the development of five specific industrial technological infrastructures--metallurgy, including the production of special steel, high pressure pipes, and construction tools; engineering and electronics, ranging from the production of small electric appliances to tractors; textiles, including the development of flax production as well as man-made fibers; chemicals, including the production of paper products,

leather goods, phosphoric acid, recycled rubber and paint; and building materials, particularly heat resistant glass, sand bricks and hollow concrete blocks, and prefabricated housing. The Egyptians are interested also in research on a number of aspects of developmental economics, technology transfer and adaptation, nutrition and food planning, water resources, and population studies.

We have been in contact with Dr. Ismail to discuss the possibility of establishing some form of collaborative research relationship with MIT under the auspices of the Technology Adaptation Program. Professor Fred Moavenzadeh has suggested that he, Professor Richard Eckaus of the Economics Department, and Professor Nazli Choucri of the Political Science Department visit Dr. Ismail in Cairo sometime during the fall in order to explore avenues for joint research and development efforts. The MIT group would meet not only with individuals from the Departments of Economics and Engineering at Cairo University, but also with the Ministers of Finance, Planning, Economics, Public Works, the High Dan, and Social Affairs; in addition, they would establish contact with other individuals and government agencies such as the Suez Canal Authority, the Supreme Council for Population Planning, and the Governor of the new province of Al Wadi El Guidid.

Although the MIT-Egyptian relationship is still in the early stages of development, members of the Technology Adaptation Program Steering Committee feel that a strong potential for productive collaborative efforts does exist and should be pursued.

## V. PROPOSED CONTINUATION OF THE TECHNOLOGY ADAPTATION PROGRAM AT MIT

### A. General Background

As a result of our recent experiences with transferring and adapting technology to the current needs and conditions of emerging nations, we have noted that for many of these countries the patterns of their development depend in part on

their ability to borrow technical expertise from the industrialized countries. This accelerated rate of change has created a variety of new situations with social, economic, and political consequences which are as yet not clearly understood. What is apparent is that the technologies most useful and appropriate to the conditions of developing countries are not necessarily those inherently shaped by mass production, capital-intensive practices, inexpensive energy, and so on.

Since social and political realities tend to mold the nature and course of technological change and of the diffusion of technology as much as do practical questions of "hardware", industrialization is concerned with these former factors as much as with "purely" technical processes. This fact certainly does not mean that emerging nations either can or should ignore the advantages of technologies available from more industrialized countries. It does appear to indicate, however, that any development strategy must take into account a variety of factors in deciding how, when, and in what manner to transfer and adapt technical knowledge to the special conditions and needs of the recipient nation.

Although we lack a complete understanding of the industrialization process itself and of the technical inputs most useful at various stages of technological development, many people both in the developed and the developing world have valuable insights about one or another aspect of such problems. At MIT there is a particularly rich body of institutionalized and individual knowledge which provides the basis for further work in this area. There are formal research programs such as the Energy Laboratory, the Center for Transportation Studies, the Center for International Studies, the Center for Policy Alternatives, and the International Nutrition Planning Program. There are also a number of individuals involved in areas of research related to TAP interests, ranging from activities in transportation, energy, and water resources to development economics, the

politics of population, and foreign policy concerns.

## B. Principal Objectives

The long-term objective of the proposed continuation of the Program remains basically the same, "to develop a broadly-based body of expertise at MIT concerned with the exploitation of technology for public works and industrial development in developing countries". In order to better understand the processes that enable technology to contribute to industrialization in these countries, the Program will focus on

- (1) developing analytic techniques for determining the appropriateness of certain technologies to the environments of specific countries;
- (2) identifying the factors which inhibit the transfer and adaptation of technologies appropriate for economic and social development in emerging nations;
- (3) understanding the processes by which technological and managerial skills can be introduced, disseminated, and used effectively in developing countries; and
- (4) finding efficient technical solutions to problems of concern to specific emerging nations on a case study basis, enabling MIT not only to expand abilities useful in knowledge transfer, but also to create joint problem-solving capabilities with institutions in these countries.

To meet these objectives we propose to perform research in specific problem areas, foster joint collaborative working relationships with institutions in selected developing countries, develop special curricula, and train both American and foreign graduate students. The Institute will draw upon its engineering, economic, managerial, and political science skills in order to create a multi-

disciplinary approach to the solution of development problems. In selecting specific countries and problem areas for collaborative research we will consider not only MIT's specialized expertise but also the individual country's developmental priorities and those of AID.

### C. Program Elements

Extending the grant period of the Technology Adaptation Program would not only assist in maintaining and strengthening the body of expertise already developed at MIT in the fields of technology, economic development, and international affairs, but would also expand the knowledge bases relating to these areas. An extension would make it possible to create a more coherent educational program for interested students; it would also provide a focus within the Institute for more effective interaction between faculty and students and members of both the national and international development communities.

The proposed Program will consist of two broad categories of activities, research and education.

#### 1. Research

Extending the Grant will make a critical contribution to our current research by providing both a continuity of effort and the time necessary for the maturing of specific programs. By continuing to make resources available for research, we will strengthen the interest of the MIT faculty in the problems of developing countries, broaden specific areas of competence, and increase the applicability and utility of both individual and group efforts.

The proposed program of continuing research will include those elements identified in Section IV for our collaborative working relationships. While we intend to focus primarily on programs dealing with technical research, we will also attempt to recognize and account for the economic and socio-political

constraints which often play a large role in determining the actual success or failure of technological advances.

Depending upon available funding, the Program will select additional countries for developing collaborative research programs emphasizing both immediate and long-term solutions to specific technological problems. The criteria for selecting these additional countries will remain the same as those applied to the selection of Colombia and Egypt for our current program. These include the presence of suitable, well-staffed research and educational agencies in the country, the willingness of such groups to cooperate on mutually acceptable areas of interest, and the agreement of the AID Office of Science and Technology and the local AID Mission on the appropriateness both of the chosen country and the problem area.

Two countries which appear suitable for potential joint collaborative efforts are Brazil and Turkey. Both have already developed strong technological infrastructures and are seeking specific advanced technical cooperation, particularly in the areas of analytic management, planning, design, and control techniques.

## 2. Education

The proposed Program will provide for the following educational activities at MIT:

(1) Graduate Student Fellowships: The Grant will provide a limited number of Fellowships (5-10) for qualified American and foreign graduate students already admitted to MIT's regular departments. A TAP Fellow will be required to take a certain number of subjects in fields related to the process of development and write a thesis dealing with some aspect of technology transfer and adaptation in developing countries. The candidates will be selected and reviewed once a year by the Program Steering Committee.

(2) Graduate Student Research Assistantships: Each project funded by the Program generally will have one or more graduate assistants performing various research duties for a senior investigator. Since such students are encouraged to use these research materials in their individual theses, their financial support by the Program contributes not only to furthering the project itself, but also to helping provide a graduate-level education to students interested specifically in the problems of development.

(3) Graduate Program: We intend to develop an interdisciplinary graduate program, at the Master's level, designed for those students interested in developmental issues in fields of engineering such as energy, transportation, water resources, mechanical design, metal processing, food, and textile technology. In addition to fulfilling the regular requirements in their respective engineering disciplines, students will take a core program consisting of several subjects oriented toward developing countries in areas of specialized engineering, economics, political science, and management. Their theses will be on subjects related to developmental problems of emerging nations. The graduates of this program will be highly specialized engineers with a background in and a knowledge of developmental issues related to their own respective areas of expertise.

(4) Course Development: Funds in the form of salary support and/or teaching assistant support will be made available to faculty members for the creation of graduate or undergraduate subjects related to issues of development; we expect to provide support for a minimum of two subjects during each year of the Grant. We are interested primarily in locating these subjects in engineering departments where technological analysis will be focused on problems of development.

(5) Foreign Scholars and Research Workers: Through options currently available at MIT's Center for Advanced Engineering Study the Program will invite a limited number of foreign visitors to attend the Institute for a specified length

of time in order to participate in research and educational activities concerned with technology transfer and adaptation.

(6) Workshops and Conferences: The Program will continue to develop workshops and seminars dealing with problems of technical assistance. Such gatherings aid in establishing paths of communication between academic researchers and professionals from other institutions and agencies; whether the meeting is a small informal workshop or a larger, more formal conference or symposium, we will seek full participation from groups and individuals in emerging nations.

(7) Library and Resource Materials: As in the past, Grant funds will be used to supplement the resource materials of individual research projects. Since acquiring a complete centralized document collection is considered too costly, diverting funds from other parts of the Program, most library and resource material acquisition will continue to depend upon the Institute's general library funds and facilities.

(8) Linkages with LDC Institutions: To be successful the Program requires effective contacts, including exchanges of faculty and students, with institutions in emerging nations that can contribute to our understanding of developmental problems. MIT intends to 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. These efforts will include such joint research collaborations as that currently underway between the MIT Technology Adaptation Program and Colombia's COLCIENCIAS.

(9) Travel: Funds from the Grant will continue to finance both domestic and international travel in connection with TAP-sponsored research. Such travel will serve not only to seek out and establish linkages with specific research groups and individuals, but also will provide MIT faculty and students with the

opportunity of observing the developmental problems of less industrialized nations in "real life" situations. In addition, foreign and domestic travel will give MIT researchers an opportunity to consult with experienced scholars and other professionals, to establish contact with governmental agencies in emerging nations whose cooperation is essential for successful collaborative research, and to bring together individuals from both the developed and the developing countries in workshops, conferences, and other Program activities.

**APPENDIX 1**

**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 capabilities of the model. Through cooperative work with the appropriate agencies in Venezuela, Brazil, and Colombia, field data was collected for calibration purposes, and the capabilities 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 resource 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 Systems

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 faced by 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 Technologies  
to the Needs of Developing Areas

Principal  
Investigators

Professors John F. C. Turner and Ian Donald Turner  
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  
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. 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 aimed at formulating tentative performance standards for comparison with U.S. and Latin American references. Models were prepared to test the standards during 1972-1973.

Title: Organizational Studies and Development

Principal  
Investigators: Professors George Farris and Anthony Butterfield  
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 types of 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. The center ideally 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: Water Resources Technology Adaptation

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

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 multidisciplinary 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 Investigators:** 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 medium of the work was field studies, workshops, and seminars held in collaboration with the University of Nairobi and the Nairobi City Council. Appendix 2.B contains more information on this field work; Appendix 4 lists the reports and papers published as a result of the research sponsored by this project.

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 involved potentially 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 Research and Development by Industrial Firms in India (Research for a Doctoral Thesis)

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 decision 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 simulation of both surface and subsurface conditions in Mali and Senegal was excellent. The first El Paso tests thus were intended to demonstrate the validity of the theoretical concepts and to debug 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 Investigators: Professor Stanley Backer and Dr. Stelios Arghyros  
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 development 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: Water Resources Technology Adaptation

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 Investigator: 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 are 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 of 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. During 1973-1974 the text was

revised and edited based on reactions from this trial usage, and publication by D.C. Heath is expected during the summer of 1975. The book has 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. The book, provisionally titled Housing Low Income Families: An International Perspective, will be ready for use in the academic year 1975-1976.

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

Principal Investigator: 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--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 on 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, and 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.

The Colloquium was extremely successful. A detailed description of its activities and results is included in Appendix 2.A.

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 course 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 the 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 assist 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.

**APPENDIX 2**

**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 of 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. Freeley 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, 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 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 mission 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 in 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 Nacional 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, an examination of river basin planning models, and a 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:

- |                  |   |
|------------------|---|
| <b>Caracas</b>   | Oficina Ministerial de Transporte, Metro de Caracas<br>Direccion de Planeamiento Urbano, Ministry of Public Works<br>Planning Department of the Distrito Federal<br>Comision del Desarrollo Urbano del Pais<br>Consejo Nacional de Vialidad |
| <b>Bogota</b>    | Universidad de Los Andes<br>Oficina de Planeacion Socio-Economica, Distrito Especial<br>Planeacion Nacional   |
| <b>Sao Paulo</b> | Economic and Planning Department, State of Sao Paulo<br>Companhia do Metropolitano de Sao Paulo   |

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 visit (1) 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 conference 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 were 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 discussion 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 Kutnik 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.

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, those 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 as well as consolidating 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.

Significant potential exists for developing a continuing informal working relationship with some of the institutions which Professors Wilson and Roos contacted during the research and visits undertaken in connection with their project on "Urban Transportation in Developing Countries." In particular, the Universidad de los Andes, Bogota, Colombia, appeared to represent an excellent prospect

for close cooperation. Close working relationships were also developed with the following groups:

**Caracas, Venezuela:** 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, Colombia:** Oficina de Planeacion Socio-Economica, Distrito Especial

Planeacion Nacional

**Sao Paulo, Brazil:** Economic and Planning Department, State of Sao Paulo

Companhia do Metropolitano de Sao Paulo

**Rio de Janeiro, Brazil:** Grupo de Estados para Integracao da Politica de Transportes

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 Robert 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 gather information at the headquarters of the Commonwealth Development Corporation.

**APPENDIX 3**

**INSTITUTION BUILDING: COURSE DEVELOPMENT**

INSTITUTION BUILDING: COURSE DEVELOPMENT, 1972-1973

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.

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.

1.25: 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.

1.203: 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.

#### 1.60: 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.

#### 1.74: 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 expenditure. Federal benefit-cost practices are described and analyzed, computer and mathematical programming techniques are related to public expenditure analysis.

#### 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.

#### 1.45 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.

4.160: Urban Settlement Design in Developing Countries  
4.161: Urban Settlement Design in Developing Countries

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.

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.

Many research groups and individual faculty members at the Institute were involved in programs relating to the transfer and adaptation of technology to the conditions of developing countries. The following two ongoing projects were particularly relevant to the interests of the Technology Adaptation Program:

Title: Developmental Studies of the Sahel-Sudano Zone of Africa  
(To begin September 1, 1973)

Principal Investigator: Professor William W. Seifert  
Department of Civil Engineering

Title: Technical and Economic Factors in Telecommunications for Developing Countries

Principal Investigators: Professors George Rathjens and J. P. Ruina  
Departments of Political Science and Electrical Engineering

INSTITUTION BUILDING: COURSE DEVELOPMENT, 1973-1974

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 new 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 motivation 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.

#### 1.60: Introduction to Water Resources

Engineering, economic and political aspects of water resources management will be discussed. The course 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 include pollution, ecological aspects of water development, water management institutions, engineering and 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.

#### 1.74: Public Expenditure Theory

The course will deal with the presentation of the full range of benefit-cost criteria required for the optimal economic design of public expenditure projects. Emphasis is placed upon water resource systems as specific examples of such projects. The course provides the political science dealing with the choice of objectives for public expenditure. Federal benefit-cost practices will be described and analyzed, and computer and mathematical programming techniques will be related to public expenditure analysis.

#### 1.732: Water Resource Systems

The course will consider flood forecasting, flood routing, flood plain management, and flood control. River basin simulation will be studied, as will the synthesis of hydrologic inputs. The interactive use of simulation and mathematical programming models will be considered, and evaluations of long-term net benefit and short-run loss functions will be studied.

#### 1.262J: Transportation Policy Analysis

Transportation policy at the national, regional, state, and local levels will be studied. The role of the U.S. Department of Transportation, the Interstate Highway Program and the Urban Mass Transit Assistance Acts will be considered, as well as the mechanisms of achieving policy implementation. Comparisons will be made between U.S. transportation policy and policies in other countries.

Principle policy-making actors and interest groups at the metropolitan level will be studied, and local funding sources will be indentified.

1.25: Innovative Urban Transportation Systems

The course investigates the technical and institutional issues in innovative means of urban transportation. The ability of innovative urban transportation systems to meet present and future needs will be studied, as well as the roles of government, private industry, labor, and the transit industry in urban transportation innovation. Case study analysis of several new innovative systems including Dial-A-Bus, Personal Rapid Transit, and Dual Mode will be included.

16.752: Flight Transportation Seminar (International Air Transportation) (New Course, Department of Aeronautics and Astronautics)

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--cabotage; 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 "confront-  
ation" between certain governments and foreign airlines over related problem

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.

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

In 1973-74 Professor Stickney arranged to introduce new material gathered from the past year's research into this multi-disciplinary course offered jointly by the Departments of Mechanical Engineering, Civil Engineering, and Nutrition and Food Science. This course is an exploratory introduction to the application of the concepts and techniques of systems analysis to problems pertaining to regional and national development in both industrialized and less industrialized countries--e.g., nutrition and population, transportation and communication, energy and power, utilization and conservation of natural resources. Consideration will be given to the utility and potential, as well as to the limitations and restrictions, of the approach as an aid in planning studies involving evaluation of alternative programs, strategies, and systems. Emphasis is on the modelling of the technical and behavioral features of a system by employing production functions and causal modelling; the search for optimal system designs by use of marginal analysis, mathematical programming, and sensitivity analysis; and the evaluation of projects with respect to time, risk and uncertainty, and the preferences of different target groups. Concepts and techniques will be illustrated through case studies and applied in term projects.

**4.79: Urbanization in Developing Countries: Dwellings and Land Issues  
(New course, Department of Architecture)**

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 BALOON 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.

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 in the Fibers and Polymers Division of the Department of Mechanical Engineering. Five divisional courses benefited from the inclusion of such material, one undergraduate subject and four graduate seminars. The lectures were presented mainly by Dr. Stelios Arghyros, but the project and the 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 4**

**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

### Completed

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.

Fong, Albert, "The Air Permeability of a Commercial Concrete Pipe," B.Sc., 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.

Varekam, Carlos, "A Study on Ferro-Cement: Theories, Properties and Applications," B.Sc., Department of Mechanical Engineering, Massachusetts Institute of Technology, 1973.

In Progress

Castaline, Allan, "Comparison of Urban Transportation Systems for Developing Countries," M.S., Department of Civil Engineering, Massachusetts Institute of Technology.

Kutnick, Bruce, "The Nature of R & D by Industrial Firms in India," Ph.D., Department of Economics, Massachusetts Institute of Technology.

Motomura, Yui, "Benefits Associated with Urban Transportation Investment in Developing Countries," M.S., Department of Civil Engineering, Massachusetts Institute of Technology.

## 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.
- Moavenzadeh, Fred, and Janet Koch Rossow, The Construction Industry in Developing Countries, Technology Adaptation Program, Massachusetts Institute of Technology, Spring 1975.
- 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.

All the following papers are provisional background material prepared for delivery at the MIT Colloquium on "Assessing the Economic and Environmental Impacts of Alternative Urban Growth Strategies". THESE ARE DRAFT PAPERS; THEY ARE NOT FOR DISSEMINATION OR QUOTATION.

Dyckman, John W., "The Urban Environment of Americans: Environmental Protection and the Pattern of Preferences," February 1974.

Hall, Peter, "M.I.T. Comparative Analysis Seminar on Environment and Urban Growth Strategies (11.902)--Britain," March 1974.

Major, David C., "The Transfer of River Basin Planning Technology: Two Case Studies," March 1974.

Marris, Peter, "Environment and Urban Growth Strategies: Problems of Introducing Alien Know-how into Growing Societies," March 1974.

Meier, Richard L., "Prospects for Resource-Conserving Life Styles that Expedite Indonesian Development," March 1974.

Sachs, Ignacy, "Environment and Styles of Development," Originally written for the United Nations Environment Programme, Presented April 1974.

Terner, Donald Ian, et al., "Self-Help Infrastructure: Applications of Irregular, Small-Scale, Incremental Systems for Residential Utilities," April 1974.

### 3. Theses

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

The following students will complete their M.S. theses in the Department of Architecture in the spring of 1975; the theses will generally include an analysis of the housing subsystems of their respective countries following a method partially developed through AID funding.

Al-Hussamen, Moahmmmed (Saudi Arabia)

Bazant, Jan (Mexico)

Millan, Jairo (Colombia)

Patel, Nimish (India)

Phisuthikul, Chakorn (Thailand)

Shauaibi, Ali (Saudi Arabia)

Tokman, Bulent (Turkey)

**APPENDIX 5**

**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 of 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. Its activities are directed by Dr. J. Herbert Hollomon, an M.I.T. alumnus and former president of the University of Oklahoma.

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 requires 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.

## 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 was founded in April 1973 in order to provide a focus for graduate transportation studies at MIT. It includes an Academic Program, a Research Program, and a Communication and Coordination Program.

The Center, headed by Professor Paul O. Roberts of the Department of Civil Engineering, has grown substantially since its founding. The past year was particularly successful. The volume of research funded through the Center increased more than four hundred percent; two major interdisciplinary research proposals to the U.S. Department of Transportation's University Research Program won support against competition from twelve other universities; the Center began work on its Development Plan; and, in conjunction with the Legal Studies Program, a major grant was received from the Union Pacific Foundation.

In addition to the six CTS Reports published during the past year, the Center has now assembled copies of a large number of recent publications in the field of transportation. A Master publication list will be issued later this year.

The Center continued to hold its Luncheon/Seminar Series. In all, there were ten guest speakers over the fall and spring terms. The speakers included the new Secretary of Transportation and Construction for Massachusetts, Mr. Fred Salvucci, who talked on "Transportation and Politics: The Boston Scene." Mr. Robert Thompson, Counsel to the Boston Regional Environmental Protection Agency spoke on "Post Hearing Revisions to the Boston Air Quality Control Strategy." Mr. George Sceizo from Personal Rapid Transit Systems Corporation in Chicago talked on "Astroglide, the Slim Transit System." Professor Ann Friedlaender, newly appointed Professor of the Departments of Civil Engineering and Economics talked about "Regional Macroeconomic Modelling in Massachusetts." Mr. John C. Emery, Jr., President of Emery Air Freight Corporation spoke on "Air Freight in the 1970's." Mr. Charles Foreman, Vice President and Director of United Parcel Service, discussed "Transportation Policy and Small Package Movement."

During the year some thirty proposals were submitted under the auspices of the Center's Research Program. Of these, sixteen were successful and have been awarded. Their contract value sums more than 3.2 million dollars.

The Center does not have an individual academic program. It does, however, coordinate transportation courses throughout the Institute. Requirements for a new degree "Transportation Engineer" have been drafted and are now being circulated for comment and review.

During this coming summer (1975) there will be four courses offered in transportation at the Institute. They are

"Air Transportation Systems Analysis, Part 1 to be given June 16-20 and Part 2 from June 23-27. This program will be presented by the faculty and staff of the Flight Transportation Laboratory, Department of Aeronautics and Astronautics.

"Analysis of Urban Service Systems," which will be given July 7-11. The program is under the direction of Professor Richard G. Larson of the Department of

Urban Studies and Planning. In all, there will be three other guest lecturers complementing Professor Larson.

"Analysis and Design of Transportation Systems," Part 1 to be given August 4-8 and Part 2 from August 11-15. This program is to be directed by Professor Marvin L. Manheim of the Department of Civil Engineering and assisted by M.I.T. faculty from the Departments of Civil Engineering, Ocean Engineering, and Aeronautic and Astronautics.

"Decision Making under Uncertainty: Methods and Applications of Decision Analysis," which will be given August 18-29. This program is directed and presented by Professor A.W. Drake, M.I.T. Operations Research Center, and Professor of Electrical Engineering; and Dr. R.L. Keeney, who has been Associate Professor of Operations Research and Management at M.I.T. He is currently a Research Scholar at the International Institute for Applied Systems Analysis, Laxenburg, Austria.

## 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 in 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 in 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 of the School of Engineering, 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, they sometimes 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 the 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.