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QUARTERLY PROGRESS REPORT

Evaluation Framework for Transportation Planning in Developing Countries

Prepared for

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

by

Fred Moavenzadeh, Principal Investigator
Department of Civil Engineering

Massachusetts Institute of Technology
Cambridge, Massachusetts

March 4, 1975

QUARTERLY PROGRESS REPORT

Table of Contents

	Page
Statistical Summary	1
Narritave Summary	2
Summary of Goals	2
Summary of Progress	2
Summary of the Report	3
I. Joint Program in Highway Planning with the Ethiopian Highway Authority	5
II. Model Development and Project Evaluation	8
Limitations	11
Advantages	12
III. Selected Case Studies	13
IV. Evaluation of Network Improvements	16
V. Future Work	18
Table 1: Projects	21
Appendix A: List of Participants	23
Appendix B: List of Contacts	25
Ethiopia	25
Kenya	27
Tanzania	28
United Kingdom	29
Appendix C: Agreement Between MIT and the EHA	31
Appendix D: Data Requirements for the Highway Cost Model	35
Appendix E: Current Case Studies	40
Asela-Dodola	40
Morogoro - Dar Es Salaam	42

Quarterly Progress Report

STATISTICAL SUMMARY

Title:	Evaluation Framework for Transportation Planning in Developing Countries
Contractor:	Massachusetts Institute of Technology 77 Massachusetts Avenue Cambridge, Massachusetts 02139
Principal Investigator:	Dr. Fred Moavenzadeh Professor of Civil Engineering Room 1-173 Massachusetts Institute of Technology
Sponsor:	Agency for International Development New State Department Building Washington, D.C. 20523
Project Monitor:	Mr. John Fry Office of Science and Technology Agency for International Development
Duration:	June 30, 1974 to June 29, 1977
Contract Amount:	$397,886.00
Amount Expended to Date:	As of February 1, 1975: $70,540

Quarterly Progress Report

NARRATIVE SUMMARY

Summary of Goals

The goal of the program is to develop improved guidelines for evaluating low volume road investment in developing countries. The work focuses both on project level decisions and on planning, programming, and budgeting decisions for the road network as a whole.

The first year of the program consists of four tasks--(1) modification of an existing project evaluation model to reflect recent research in road deterioration and user costs; (2) demonstration of the usefulness of the model in assessing road construction projects throughout East Africa; (3) building institutional capabilities for subsequent use of the model within the highway department of an East African country; and (4) the development of a framework for making planning, programming, and budgeting decisions for road networks in their entirety.

Summary of Progress

MIT has developed a working agreement with the Ethiopian Highway Authority (EHA) for a joint program in highway planning. The agreement extends over a two-and-one-half-year period and covers work in project evaluation, network planning, and programming and budgeting. The text of this agreement is included in this Report as Appendix C. The objective of the collaborative program is to improve the capabilities of the EHA's Planning and Programming Division. The first phase of the program is now underway, and a member of the EHA staff is currently working

at MIT pursuing studies in the area of project evaluation.

MIT is nearing completion of revisions to a project planning model known as the Highway Cost Model. This model is intended for use in the feasibility stage of project planning in order to evaluate alternative design, construction, and maintenance strategies for low volume roads. The current revisions incorporate results from field studies recently completed in Kenya by the Transportation and Road Research Laboratory in collaboration with the International Bank for Reconstruction and Development. The revisions also reflect recent work in Ethiopia and discussions with Ethiopian highway officials.

MIT has identified road projects which will be used to demonstrate the capabilities and usefulness of the model in three East African countires. These projects cover a range of project types, including new construction to both gravel and paved road standards, upgrading of existing roads, and the development of reconstruction or maintenance strategies for a rapidly deteriorating paved road. Analysis is underway on two of these projects, and results will be available by the end of the first year's work.

MIT has completed the preliminary development of a framework for evaluating investment strategies for the road network as a whole. This framework accounts for dependencies between projects in terms of their impact on utilization patterns over the entire network. It also accounts for budgetary and resource constraints which affect the level or pattern of transport investment.

Summary of the Report

This Progress Report consists of five sections, each dealing with

a separate aspect of the work described in the Project Proposal, "An Evaluation Framework for Transportation Planning in Developing Countries." Part I, "Joint Program in Highway Planning with the Ethiopian Highway Authority," deals with MIT's attempts to identify a host country for the development and implementation of the Highway Cost Model and reports on the establishment of relations with the Ethiopian Highway Authority and the subsequent collaborative relationship developed with that agency.

Part II, "Model Development and Project Evaluation," is concerned with MIT's work in revising and modifying the existing Highway Cost Model to reflect recent research in East Africa.

Part III, of the Report, "Selected Case Studies," deals with our efforts to select and develop case studies which would aid the group research by reflecting previous work done in the context of collaborative working relationships with various East African countries.

Part IV, "Evaluation of Network Improvements," reports the progress made in extending the Highway Cost Model to cover the area of network evaluation.

Part V, "Future Work," presents the group's planned efforts for the rest of the year; it, in turn, is divided into four sections to reflect the four main tasks of Phase I of the first year's work.

Appendix A lists the participants in the program; Appendix B gives the contacts developed with various international and governmental agencies in East Africa. Appendix C is the agreement between MIT and the EHA; Appendix D lists the data requirements of the Highway Cost Model; and Appendix E contains descriptions of the two current case studies.

I. Joint Program in Highway Planning with the Ethiopian Highway Authority (EHA)

MIT and the EHA have agreed in principle on a three-phase program in planning and project evaluation. The stated goal of the program is to improve the project evaluation, planning, programming, and budgetary capabilities of the EHA's Planning and Programming Division. The program is cooperative in nature and will include a joint review of existing EHA procedures, a review of available alternatives for improving these procedures, and the development of a project evaluation manual. Two or three members of the EHA staff will each come to MIT for five months to participate in the program and to pursue topics of specific interest to the EHA. This program is now underway, and an EHA engineer is currently at MIT doing work in the area of project evaluation. MIT will spend approximately three man-months a year in Ethiopia gathering data and reviewing the results of the program with the EHA staff.

The agreement with EHA was reached in the following manner: under the terms of the contract with AID, Dr. Moavenzadeh and his staff traveled to Ethiopia, Kenya, and Tanzania in August 1974 to determine whether working agreements could be established in any of these countries. In each case contacts were made with the local AID mission and with government transport officials to determine first whether there was interest in the effort, and second, whether there were sufficient technical resources to support the program.

Based on the conclusions of that trip, Dr. Moavenzadeh returned to East Africa in November 1974 with Messers. Fry and Stearns of AID. During this trip the EHA approved the concept of the study, and agreed in principle to undertake the work jointly with MIT; and the details

of this arrangement were worked out in discussions in Addis Ababa during the early part of January 1975 between staff members of the EHA and MIT. The results of these meetings were confirmed in a letter of understanding from Dr. Moavenzadeh to the General Manager of the EHA in late January (Appendix C). We anticipate that additional details of this agreement will be developed in early March when the General Manager will visit MIT.

This proposed program has been divided into the following three phases: phase one will concentrate on project evaluation, phase two on planning for the highway network as a whole, and phase three on programming and budgeting. All three phases will include a review of existing and available procedures and the training of EHA personnel in their use and applicability. The objective of the program will be to demonstrate both the advantages and limitations of the various approaches to project evaluation and selection, and to put them into a coherent framework for use by the EHA.

The project evaluation phase is scheduled to run from the beginning of February 1975 through the end of August 1975. An EHA staff engineer is currently at MIT pursuing course work and individual study in project evaluation methods. As discussed elsewhere, EHA and MIT have jointly identified several projects which illustrate the range of project types for which the EHA has responsibility and for which feasibility studies have recently been completed. These studies will provide the basis for a critical review of EHA procedures and the demonstration of alternative approaches.

MIT currently plans to present these efforts to the EHA management in July or August of 1975. In conjunction with this work MIT is ex-

ploring the possibility of holding a conference in Addis Ababa in late July. The conference, which would last two or three days, would cover project planning and evaluation methods and related topics, including labor substitution, design standards for low volume roads, and estimating feasibility costs. Those attending would include interested individuals from highway organizations in East Africa, the international consulting community, the World Bank, the Transportation and Road Research Laboratory, AID, and MIT.

The second phase of the work program--in the area of network planning--will start in September of 1975. The past experience and future development of the Ethiopian highway network will provide a basis for this research. As in the previous phase, a member of the EHA staff will come to MIT to study for a period of approximately five months. MIT will return to Ethiopia in June 1976 to present this work to EHA and to review the overall results of the program.

The optional third phase of the program--programming and budgeting--is contingent upon AID's continued funding of MIT's work.

The current financial problem facing the program is the question of the funding of foreign exchange costs for EHA participation expenses in the United States. Dr. Moavenzadeh understood from his discussions with the EHA General Manager in November that money could be made available from educational funds within the Fifth Ethiopian Highway Program, which is financed by the IBRD. Negotiations for the Fifth Highway Program are still in progress, however, and these funds are not currently available. MIT has been given interim authority to pay for the first participant out of its own contract funds, but no additional funds have been made available to the project, nor has any provision been made to

cover the costs of future participants.

II. Model Development and Project Evaluation

MIT is now completing revisions to a project planning model known as the Highway Cost Model. The model is designed for use by project evaluators in analyzing the economic tradeoffs between alternative design, construction, and maintenance strategies for low volume roads. Revisions reflect recent empirical research in East Africa on road deterioration and user costs, a review of studies undertaken in Ethiopia, and discussions with Ethiopian highway officials.

When these revisions have been completed MIT intends to demonstrate the capabilities of the model by using it to evaluate several road projects in East Africa. MIT has also agreed to make the model available to the Ethiopian Highway Authority and to provide training in its use and maintenance.

Recent research in project planning models has its origins in the Highway Design Standards Study initiated by the World Bank in 1969. The objective of the program was to investigate design standards and investment strategies for low volume roads in developing countries. The first phase of the program was completed at MIT in 1971. This work identified important relationships between design and maintenance standards, and construction maintenance and user costs, but concluded that there was insufficient empirical data to permit the study team to make definitive policy recommendations.

Subsequently, the World Bank, in collaboration with other agencies,

has undertaken field studies to obtain data on cost and deterioration relationships. The Transportation and Road Research Laboratory has recently completed a program of empirical research in Kenya in the area of road user costs and pavement deterioration. Their work included a statistical survey of road users to determine their operating costs; measurements of vehicle speed and fuel consumption under varying conditions; and measurements of road deterioration for different types of roads and different maintenance policies. Much of their work is applicable to other East African countries, including Ethiopia. The Bank is about to begin similar studies in Brazil and India, the results of which should have at least tangential value for project evaluation efforts in East Africa.

In its present form, the model can be used to estimate construction, maintenance, and road user costs for low volume gravel or paved roads. These costs may be computed for each year in the evaluation period for any construction or maintenance policies being considered and for different assumed traffic and growth estimates.

The range of policy alternatives considered may include the do-nothing alternative, improved maintenance of the existing road, reconstruction or upgrading of the existing road, or construction along a new alignment. Policies may be further differentiated in terms of design standard, construction or maintenance methods, or in the timing of investment. Staged construction alternatives may be considered. In each case, a policy is defined by indicating the construction or maintenance activities which are to take place in each year through the evaluation period.

Depending upon the type of work, construction quantities are es-

timated for site clearing, earthwork, minor and major drainage structures and paving. Earthwork quantities are estimated using alternative procedures, based on the availability of data.

The procedures used to price out quantities may be tailored to the needs of the planning organization using the model. Where good construction records are available, the most satisfactory approach is usually one based on labor and equipment productivities; where such data are not available, adjusted contract unit cost data may be employed.

Construction cost reports are also easily modified to suit diverse organizational requirements. Summary cost breakdowns are available for financial, economic, local currency, and foreign exchange components of cost.

The model differs from most conventional approaches to project evaluation in that it accounts for the gradual deterioration of the riding surface over time, and for the impact of varying levels of maintenance. Road deterioration is treated as a function of traffic, environment, surface type and thickness, and maintenance policy. It is measured in terms of increased roughness, rutting and washboarding, and is most importantly reflected in increased user costs. Maintenance expenditures have the effect of improving the riding quality of the road and of slowing the rate of deterioration. They thus lead to some reduction in user costs, and enable the highway authority to defer the date when expensive reconstruction measures will become necessary.

User costs in any year are a function of design standard of the road, surface condition, and the operating characteristics of the vehicles on the road. Vehicles considered are those typical of the country's fleet; they may include passenger cars, buses, and several classes

of trucks, ranging from light goods vehicles to tractor trailer combinations.

The costs considered include the so-called running costs (fuel, oil, tires, and maintenance parts and labor) and other costs which are more nearly a function of travel time (depreciation, driver and helper wages, insurance, registration and license, and the value of time for cargo and passengers). Costs are computed for travel in both directions.

Limitations

A major limitation of the existing model is that it does not consider benefits other than savings in road user costs and reductions in maintenance expenditures. Although many projects are justified on the basis of these benefits alone, it is apparent from discussions with Ethiopian highway officials that a substantial proportion of future expenditures will be for rural penetration and feeder class roads where justification must rest on broad developmental and social benefits.

MIT is taking two courses of action to meet this need. First, work is currently underway on an agricultural development model which can be used to estimate both the benefits and traffic volumes arising from growth along a penetration or feeder class road. Second, MIT will prepare a project evaluation manual for the Ethiopian Highway Authority outlining procedures for considering the economic, social, and environmental consequences of road construction.

Another limitation of the model is in its treatment of earth roads. The Highway Cost Model incorporates relationships based on engineering judgements for handling this class of road, but at present there is practically no research confirming these relationships. While such roads

are seldom the subject of feasibility studies, there are cases where construction of an earth road or improved maintenance of an existing track might have been a satisfactory short-term solution.

Advantages

At present, the model can be used to estimate construction, maintenance and road user costs for low volume, two-lane, all-weather roads. When compared to conventional methods of analysis, the model should be able to provide more accurate estimates of cost for a wider range of alternatives. The following are a few examples of the model's usefulness in these areas.

In the area of construction costs, there should be significant improvements in accuracy, particularly in estimating earthwork quantities. Moreover, the approach taken requires no more data than is generally available at the point when feasibility studies are prepared.

The assumption made in most feasibility studies is that axle load regulations will be enforced and that the condition of the riding surface will be maintained at or near the initial quality over the design-life of the project. These assumptions are demonstrably inaccurate, particularly in developing countries where weight control and maintenance organizations are frequently non-existent or ineffective. Because the Highway Cost Model incorporates the cycle of road deterioration into its analysis, it is possible to make more realistic assumptions regarding actual axle loads and maintenance, and to trace consequences for road users and for the life of the road.

Since maintenance requirements are estimated in detail, it will be possible to program maintenance expenditures over the life of the

project with better accuracy than can be obtained employing the usual methods. While these costs are usually small in relation to construction and user costs, and thus have only a marginal impact on the cost-benefit ratio, they are important from the standpoint of programming and budgeting maintenance expenditures.

The model also incorporates the most recent findings in the area of user costs, and should thus be an improvement over conventional approaches for estimating these costs.

III. Selected Case Studies

MIT has identified road construction projects in three East African countries for purposes of demonstrating the usefulness of the Highway Cost Model as an evaluation tool. These case studies were selected after consultations with the EHA and REDSO/EA and reflect a spectrum of project types, design standards and traffic conditions (Table 1).

The availability of data was an important criterion in selecting projects as case studies. This requirement was met in all cases through reference to project feasibility reports, and to more general transport sector reports, where available. The type of information sought in each case was as follows:

1. Description of the alignment and topography;
2. Design standards considered;
3. Construction unit costs;
4. Traffic;
5. Vehicle characteristics;
6. Vehicle operating costs;
7. Maintenance standards and practices;
8. Maintenance unit costs;

9. Road conditions data;
10. Policies and alternatives considered, and reasons for rejection;
11. Shadow prices, discount rates, and other economic data.*

A second criterion in selecting projects was to demonstrate the generality of the Highway Cost Model by applying it in several countries to several different types of work. Besides accounting for obvious differences in design standards, traffic volumes, geology, and climate, this approach will allow MIT to demonstrate the model in situations where development goals and cost relationships are different, and where reccommended policies may vary.

The countries in which projects are being studied include Ethiopia, Malawi, and Tanzania. Project types range from new construction to a feeder road standard, to upgrading to paved standards.

Because of the differences which exist from country to country, it is necessary to calibrate the structure and the data base of the model to accurately reflect these variations. The case studies are a valuable aid in this process. Model results can be compared with the results of the original feasibility study, and discrepancies can be identified and traced to their origin. This may result in

1. adjustment of the model's data base to reflect a country's specific conditions;
2. identification of an area of disagreement with the original report; or
3. identification of an error in the basic formulation of the

*A more detailed description of data requirements is contained in Appendix D of this report.

model, which can then be corrected.

Once this process has been completed, the project evaluator need only provide the model with basic route information and policy alternatives for <u>any</u> project. Thereafter minor changes to the data base will permit the analysis of a multitude of tradeoffs. If, for example, a nation has limited foreign exchange reserves, a project evaluator can search for the policy which results in the least expenditure of this resource. This alternative can be compared to the policy which has the highest cost-benefit ratio, or another policy which contributes to different national development goals, or which has different budgetary impacts. At a more detailed level, the model can be used to analyze, among other things, the impact of alternative maintenance policies, or of the absence of weight controls.

At present, MIT has two projects underway. These are the Asela-Dodola Road in Ethiopia and the Dar-es-Salaam-Morogoro section of the Tam-Zam Highway. Summary descriptions of these projects are contained in Appendix E. The issues raised by the Asela-Dodola project include design standard, the timing of construction, the possible staging of construction, and the possible use of labor-intensive methods. The most interesting issues on the Tam-Zam project arise from the rapid deterioration of that road under severe overloading and a minimum of maintenance, and from uncertainties over future growth in demand.

Results from both of these efforts will be included in the first year progress report.

IV. Evaluation of Network Improvements

Investment in the national road network is one way in which the government of an emerging nation can promote economic and social growth. This investment may take many forms, ranging from the construction of new primary and secondary roads to reduce transport costs; to the construction of penetration and feeder roads to open up new territory and to increase the utilization of the existing roads. Similarly, each potential investment may meet the development objectives of the country in a different way, and may be subject to different budgeting, resources and political constraints.

Rationalization of the many possible investment alternatives into a coherent program is a complex task and one where errors are frequent and costly. The reasons for these failures are not hard to find. Improvements to one part of the road network may effect utilization patterns throughout the country, but the impacts are often hard to trace. Similarly, the multitude of investment alternatives generally available may make it an extremely time-consuming job to identify the few overall programs which best meet national objectives.

The goal of MIT's work in this area is to develop evaluation methods which will reduce possibilities for error and which will assist transport planners in preparing national road investment programs. The methods may be used at the point when planners have been able to identify--at least in general terms--a number of investment possibilities at the project level. These projects will ordinarally reflect national development goals and may be designed to meet such specific objectives as the linking of population centers or the expansion of agricultural production.

The next step in the planning process is to develop a prefeasibility level evaluation of each project. This evaluation should result in a preliminary estimate of the worth of the project, and in a narrowing of the range of possibilities which should be considered in programming investments.

Analysis at this level is based on the use of the Highway Cost Model. The model is used to evaluate alternative design standards and investment and maintenance policies for individual projects, based on preliminary estimates of demand. Each strategy considered will result in different costs and benefits and will have different budgetary impacts. At this stage of the analysis, however, only those alternatives which are obviously unsuitable will be eliminated.

The next step is to combine individual projects into programs. It is here that traditional planning methods may break down; the number of possible programs is usually very large, and the quantity of data may be such that few indicators of the impact of each individual project can be carried through and reflected in program totals. The approach being developed by MIT provides for the automatic generation of many programs by computer. The programs are screened to see that they meet budgetary and resource constraints, and that they reflect priorities which have been established by the planner. Those that meet these tests are simulated over the planning period; changes are made in the road network according to the program schedule, the effects on network utilization are determined, and costs and benefits are computed for each year. The results of this simulation are presented to the planner in the form of summaries which describe the impact, costs, and benefits of each program.

The basic approach taken in computing program costs and benefits is to first evaluate the existing road system over the planning period, assuming that no discretionary investment will take place in the transport sector. All other programs are evaluated in terms of incremental costs and benefits.

An important assumption made in the analysis, and one which greatly reduces computational requirements, is that traffic congestion is not a major factor. A second assumption is that there are not so many routing alternatives avaliable to truckers that scheduling becomes an important consideration in traffic assignment. It seems that both of these conditions are valid in the context of the Ethiopian highway system, and that they will generally be met in other developing countries,

The status of the network model is as follows: programming of a preliminary version is well advanced. This work will be completed during the coming period. The current plan is to then test the program using a portion of the Ethiopian highway network consisting of about 25 links and 5 investment possibilities. The results of these tests will be used to determine the strengths and weaknesses of the model, and in an iterative fashion, to point in the direction of needed improvements.

V. Future Work

We plan the following activities for the coming period. MIT and the EHA will complete arrangements for a joint program in highway planning. The EHA engineer currently at MIT will finish his work in project evaluation methods and return to Ethiopia in early July. The MIT project team will arrive in Ethiopia in the latter part of that month to brief

EHA officials on the work to date, to install the Highway Cost Model for use by the Ethiopian Highway Authority, and to demonstrate its capabilities. This exercise will be performed on a project of current interest, and if it can be arranged, in conjunction with a conventional analysis by the EHA planning staff.

MIT will complete its revisions to the Highway Cost Model and prepare a user manual and appropriate documentation. The penetration road submodel will also be completed.

MIT will demonstrate the capabilities of the Highway Cost Model on the Tan-Zam and Asela-Dodola projects. The results of this work will be reflected in the final report in June. Preliminary work will be completed on one project from Malawi and one additional project in Ethiopia. These results, however, will probably not be available until the end of the summer.

MIT will complete development work on the network model, and test it on a case study to demonstrate its weaknesses and strengths.

TABLE 1

Projects

HCM CASE STUDIES

In Progress and Pending

COUNTRY	PROJECT TITLE	LENGTH (Km)	SUBJECT	FEASIBILITY STUDY PREPARED BY	REMARKS
I. Ethiopia	(A) Asela-Dodola	122	Upgrading and new construction--bituminous surfaced feeder road	SAUTI	All Ethiopian projects chosen by and undertaken at the request of the Chief, Planning & Programming Division
	(B) Zway-Butajira	48	New construction of a gravel feeder road	Planning & Programming Division of Ethiopian Highway Authority (EHA)	
	(C) Kulubi-Mieso	185	Bituminous surfacing of existing gravel road (upgrading)	Planning & Programming Division (EHA)	
II. Malawi	(A) Chikwawa-Bangula	95	Realignment and construction of paved route	Daniel, Mann, Johnson & Mendenhall (DMJM)	USAID funded, project delayed pending additional data
	(B) Lilongwe-Mchinji-Zambia Border	118	Realignment and relocation, upgrading of existing road	Scott, Wilson, Kilpatrick/EIU, with UNDP funds and IBRD as the executing agency	Final Design by DMJM, AID funded
III. Tanzania	(A) Tanzania-Zambia Road (Section 1: Dar Es Salam-Morogoro 186 km)	1920	Realignment and upgrading to asphaltic concrete surface	Stanford Research Institute	Final Design by De Leuw Cather Inc. This section totally funded by USAID

APPENDIX A

List of Participants

List of Participants

Dr. Fred Moavenzadeh -- Principal Investigator

Dr. Paul O. Roberts -- Co-investigator

Dr. Robert Logcher -- Co-investigator

Robert Wyatt -- Project Manager

Brian Bradmeyer -- Research Engineer

Fredric Berger -- Research Assistant/Graduate Student

Dimitrios Tsamboulas -- Research Assistant/Graduate Student

Sam Dzirasa -- Research Assistant/Graduate Student

Anil Bhandari* -- Graduate Student, Tanzanian National

Aberra Wolde-Sadik -- Fellow, Center for Advanced Engineering Study, Ethiopian National

Zemen Lebne-Dengel* -- Graduate Student, Ethiopian National

Johndell Brown* -- Undergraduate

Gary Fostel -- Undergraduate/Programmer

Daniel Franklin -- Undergraduate/Programmer

Margaret Scott Gaines -- Administrative Assistant

Barbara Middleton -- Project Secretary

* Not paid out of Project Funding.

APPENDIX B

List of Contacts

Ethiopia

Ethiopian Highway Authority (EHA)

Hailu Shawel -- General Manager

Yusuf Ahmed -- Planning and Programming Division, Manager

Jack Gunther -- Supply and Equipment Manager

Ato Kasahoun -- Planning and Programming Division Staff

Ato Mengiste -- Planning and Programming Division Staff

Ato Woldu -- Project Superintendent

Ato Shifferaw -- District Manager

Aberra Wolde-Sadik -- Planning and Programming Division Staff

Adella Lulseged -- Head, Contract Construction Division

Haile Selassie Mengistu -- Head, Design Division

Nick Ortega -- Head, Survey and Photogrametry

Ato Asfaw -- Head, Photogrametry Section

United States Agency for International Development (USAID)

Dr. John Withers -- Director of Mission

Burton Gould -- Deputy Mission Director

Roderick MacDonald -- Engineering Advisor

United States Embassy

Mr. Wyman -- Deputy Chief of Mission

Others

Mr. Rebbi -- Systems Representative, IBM World Trade Corporation

G.B. Sooden -- Manager, Burroughs Machines Limited

David Bangert -- Resident Engineer, and Ato Testa -- Contract Superintendent, De Leuw Cather International Incorporated

Ethiopia (continued)

Robert Burns -- Harvard Institute for International Development

A.Z. Garoufalias -- Administrative Manager, Zorzi Giuseppe Construction Company

Kenya

Ministry of Works

F. E. Nderito -- Assistant to Chief of Roads

N. P. Radier -- Chief Engineer of Roads

G. Wabuke -- Chief Development Engineer, Roads Division

Basil Coukis -- Chief Advisor of Roads

Regional Economic Development Services Office (REDSO)

Edward Hogan -- Director

Robert Fedel -- Deputy Director/Chief Engineer

Albert Karian -- General Engineering Advisor, East African Region

David Gephart -- General Engineering Officer/Division Chief

John Westly -- Economics Advisor/Division Chief

United States Agency for International Development (USAID)

Charles Nelson -- Director of Mission

Lois Richards -- Program Officer

International Bank for Reconstruction and Development ((BRD)

Stanley Hayden -- Head, Transport Branch

Jacques Yenny -- Economist, Transport Branch

Others

Mr. Bodsworth -- International Computers Limited

Mr. Rostrut -- IBM World Trade Corporation

Professor A. J. Francis -- University of Nairobi

H. J. Mylchrest -- Senior Consultant, Inbucon

Tanzania

Ministry of Communications and Works

Ken Jardine -- Technical Assistant/Planning Department

Regional Economic Development Services Office (REDSO)

Pushkar Brahmbhatt -- Civil Engineer

United States Agency for International Development (USAID)

Werner Johnson -- Director of Mission

Others

M. Merritt -- International Computers Limited

United Kingdom

Transportation and Road Research Laboratory (TRRL)

Dr. Eric Tingle -- Head, Overseas Unit

P. Boffinger

Henry Hide

John Rawlt

Dick Robinson

APPENDIX C

Agreement Between

The Massachusetts Institute of Technology

and

The Ethiopian Highway Authority

Room 1-171

January 27, 1975

General Manager
Ethiopian Highway Authority
Addis Ababa, Ethiopia

Dear Sir:

This letter will confirm the details for a joint program in highway planning which were discussed between you and members of my staff during 8-14 January, 1975. It describes the goals and scope of the study, and addresses scheduling, staffing and funding issues.

The goal of the program will be to improve the project evaluation and selection methods of the Ethiopian Highway Authority (EHA). The effort will be a cooperative one, and it is understood that the successful outcome of the program will be the joint responsibility of the EHA and the Massachusetts Institute of Technology (MIT).

The first phase of the program will be to improve methods of project evaluation used by the EHA. Consideration will be given to major policy issues of project evaluation, including the standard and timing of construction, and possibilities for staging construction.

The second phase of the program will be to improve methods of program planning for the highway network as a whole. Emphasis will be placed on identifying methods for choosing among projects, given development goals and priorities, and resource and budget constraints.

An optional third phase of the program will focus on programming and budgeting issues. The objective here will be to integrate planning decisions with program and budget considerations.

The three phases of the work will emphasize analytic methods, and the training of EHA personnel in their use and applicability. An important part of the work will be to demonstrate both the advantages and limitations of the various approaches to project evaluation and selection, and to put them in a coherent framework for use by the EHA.

The first phase of the work program--to improve methods of project evaluation--will include the following: demonstration

of an analystic model which has been developed at MIT for use in project evaluation (the Highway Cost Model); education of a member of the EHA staff at MIT in project evaluation methods and in the use of the model; and development of a project evaluation manual.

During their recent trip, members of my staff and the EHA jointly identified several projects for which feasibility studies have recently been completed, and which illustrate the range of project types for which the EHA has responsibility. These projects will be turned into case studies to demonstrate the use of the model and to provide a basis for a critical review of EHA evaluation procedures. This work will be performed in the United States during the period January to June 1975.

During this same period, a member of the EHA staff will come to the United States and serve as a Fellow at MIT's Center for Advanced Engineering Studies. In addition to course work in the area of project evaluation, he will work closely with my project staff on the case studies and on the development of a project evaluation manual. He will be sufficiently familiarized with the operation of the model so that he can coordinate use of the model by the EHA, and supervise modifications to the model and its data base as additional data becomes available from current and future studies.

Members of the MIT project staff will come to Ethiopia to present the results of these efforts to the EHA in July or August of 1975. During this period, they will also attempt to install the Highway Cost Model on the EHA's new Burroughs computer. It is therefore advisable that the date of the trip be kept flexible so that we can ensure that the computer has been delivered and is running. At the latest, however, my staff must return to Boston in early September, 1975 to prepare for the academic year.

It must be understood that the Burroughs machine is somewhat small in relation to the MIT program, but that it may nevertheless be possible to install the Highway Cost Model because of certain features of the Burroughs equipment. Efforts will be made in the U.S. prior to arrival to facilitate conversion; however, should the conversion be either too time-consuming or impossible, the EHA will have to make other arrangements to use the program.

If installation of the program is successful, a parallel feasibility study will be undertaken in Ethiopia. The Planning & Projects Branch of the Planning and Programming Division will

prepare a conventional feasibility study, while the EHA staff member, with the assistance of my project staff, will prepare a feasibility report on the same project using the Highwgy Cost Model.

The second phase of the work program--to improve methods of project selection--will proceed as follows: In either August of 1975 or February of 1976, a second member of the EHA staff will come to MIT as a Fellow of the Center for Advanced Engineering Studies to undertake work in methods of project selection. While he will be familiarized with the results of the first part of the work program, primary emphasis will be placed on course work in planning, programming, and budgeting. As with his predecessor in the program, he will work closely with members of the MIT faculty in developing new methods of program planning for the road network as a whole. During this phase of the work, MIT will rely heavily on the EHA to identify development objectives, and the nature of the resource and budget constraints which should be considered in the work.

Upon completing approximately five months of study at MIT, the EHA staff member will return to Ethiopia to reassume his duties in the Planning and Programming Division.

During June of 1976, I and my staff will come to Ethiopia to assist you in preparing an evaluation of our cooperative effort. If it is agreed that this program has been successful and mutually beneficial, and if the necessary approvals can be obtained, the period of this agreement will be extended.

This optional third phase of the program will focus on programming and budgeting methods. Depending upon the success of our previous efforts and the availability of funding, this phase of the work may include provision for a third member of the EHA staff to come to MIT to take courses, to work with our faculty, and to undertake studies of specific interest to the EHA.

MIT, as part of its contract with USAID, will cover all of the following costs: salaries of MIT staff, travel of MIT staff to and from Ethiopia, and living expenses of the MIT staff while in Ethiopia. In addition, MIT will provide office space and secretarial assistance to members of the EHA staff sent to MIT during the period of this arrangement.

EHA will be responsible for the following costs: salaries of EHA staff assigned to the program either in Ethiopia or in the United States. In addition, the EHA will provide office

space and secretarial assistance to MIT project staff during their periods of work in Ethiopia.

As of this date, the question of responsibility for tuition and living expenses of EHA personnel who come to MIT has not been settled. MIT has been authorized by AID to use current contract funds to pay for the first participant, but no additional funds have been allocated to the project, nor has any provision been made to cover the costs of future participants. However, this should not delay our program, and I am confident that a source of funds can be found. A summary breakdown of the costs involved is attached.

Both the EHA and MIT will provide any letters required by the other to assist in the fulfillment of visa requirements.

As principal investigator under the USAID Funding Agreement, I will serve as the program coordinator for MIT; the Chief of the Planning and Programming Division will serve as coordinator for the EHA. In addition, both MIT and EHA will designate at least two individuals to participate in the exchanges described above. Each will insure that the exchange participants are properly qualified in either engineering or economics so that they may undertake the tasks alloted to them.

I trust that the above meets with your approval and I look forward to allong period of fruitful cooperation.

Very sincerely,

Fred Moavenzadeh
Professor of Civil Engineering

cc. Dr. Withers
John Fry
Professor R.S. Eagleson

APPENDIX D

Data Requirements for the Highway Cost Model

Appendix D: Data Requirements for the Highway Cost Model

1. Alignment and Topography:

   - maps showing the location of proposed alignments and potential sources for construction materials
   - if available, longitudinal profiles for each alignment showing existing ground
   - if profiles are unavailable, contour maps are an acceptable alternative

2. Design Standards:

   - proposed cross-section showing width and cross-slope of pavement, shoulders and ditches, and slopes in cut-and-fill sections, or standard cross-sections for the country
   - pavement cross-sections, or if unavailable, design standards for the country, including procedures for the utilization of local materials
   - project plan and profile showing final grade, or if unavailable, standards for curvature, gradient, and design speed

3. Construction Productivity and Costs:

   - if available, detailed construction cost and productivity data, including hourly rates for labor and equipment, material unit costs, and crew sizes and productivities broken down by operation

4. Traffic:

- volume, composition and growth characteristics of traffic, with distinctions between normal, diverted and generated traffic
- if available, characterizations as to the uncertainty in these projections

5. Vehicle Characteristics:

- characteristics of representative vehicle types, including gross vehicle weight, horsepower, number of axles and wheels, fuel type and consumption characteristics, width, height, design speed, and average annual and lifetime mileage in kilometers

6. Vehicle Operating Costs:

- financial and economic components of vehicle operating costs including purchase price of vehicle and tires, annual costs for finance, insurance, and license and registration

7. Maintenance Standards and Practices:

- maintenance standards and practices, including the frequency and quality of the maintenance effort and types of operations performed
- if this information is unavailable, information from adjacent countries may be utilized with appropriate adjustments for differences in climate, traffic volumes and design standards
- aggregated, per kilometer estimates of maintenance costs are generally not acceptable

8. Maintenance Unit Costs:

- best available data on maintenance unit costs, particularly for major rehabilitation items such as pavement overlay

9. Road Conditions:

- best available information on pavement condition for existing roads, and on any special maintenance problems peculiar to the country concerned

10. Policy Information:

- political, financial or other constraints on the range of alignments or design alternatives to be considered, and possible alternatives for staging construction over time

11. Economic Data:

- social rate of discount, foreign exchange rate
- shadow prices for skilled and unskilled labor, material, equipment, and foreign exchange

APPENDIX E

Current Case Studies

Appendix E: Selected Case Studies

1. Asela-Dodola Case Study (Ethiopia)

The Asela-Dodola Road is in the Arussi province of Ethiopia, southeast of Addis Ababa. At the time of the feasibility study (1969), the road was a 120 km (75 mile) earth track and could be used only by four-wheel-drive vehicles during the dry season. During the wet seasons the route was virtually impassable. The location of the road is shown on the attached map.

The possibility of upgrading the road was the subject of a feasibility analysis carried out by SAUTI, an Italian consulting firm, for the Ethiopian Highway Authority. Improvement would provide a shorter, more direct, and supposedly cheaper highway connection between Addis Ababa and the rich agricultural areas to the southeast of the capital, where agricultural production is expected to increase substantially in the future.

After projecting the traffic growth and evaluating the economic and financial costs for each alternative alignment both for labor- and capital-intensive methods, SAUTI concluded that the optimum strategy was a bituminous surfaced primary road for the Asela-Meraro portion of the road, and a bituminous surfaced secondary road from Meraro to Dodola. The optimum year of opening was calculated to be 1981 for a labor-intensive strategy, or 1977 for a capital-intensive alternative. Furthermore, no advantage was found for staging construction.

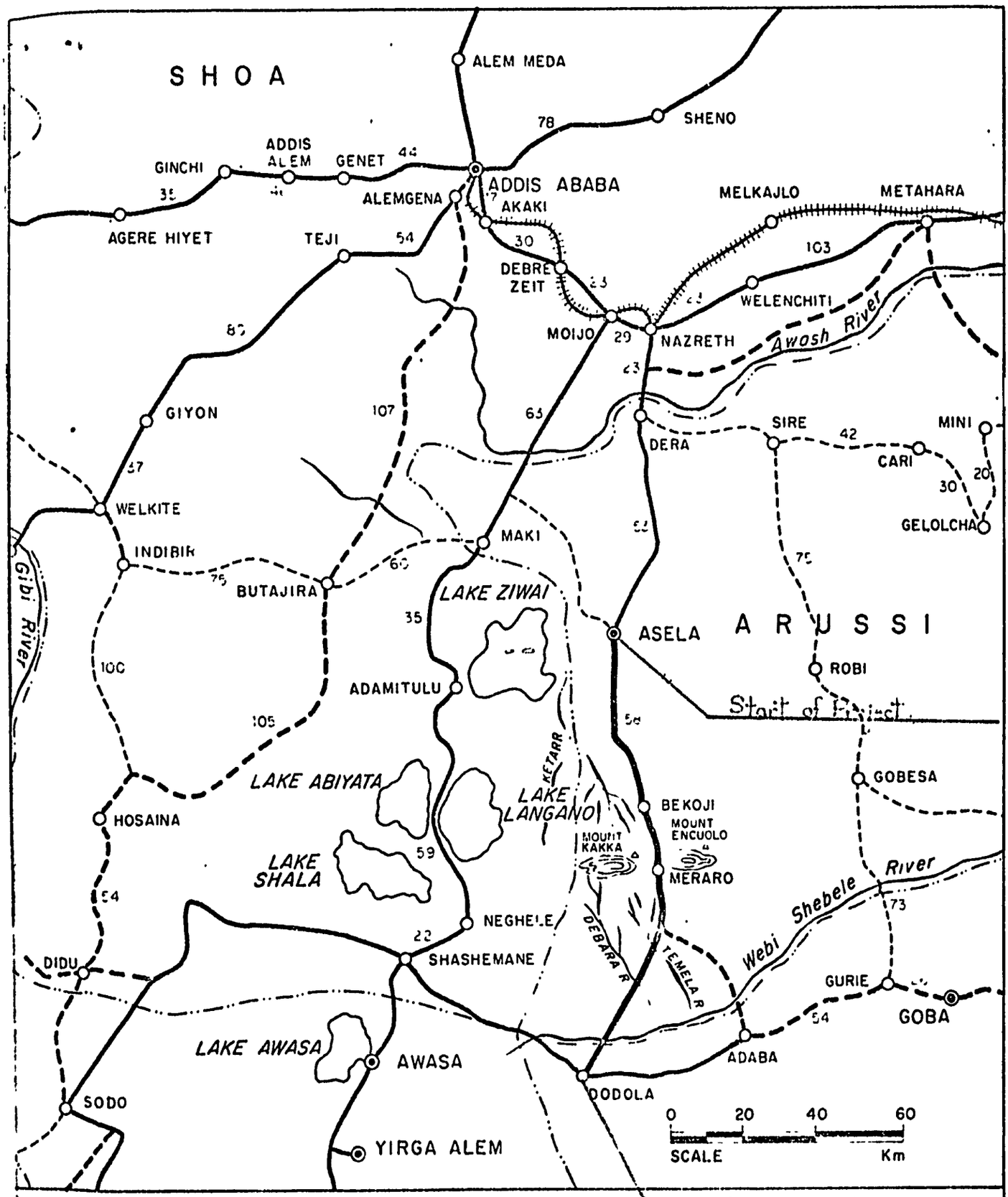

Fig 1

EXISTING NETWORK

2. Morogoro - Dar-es-Salaam Case Study (Tanzania)

The Tanzania-Zambia Highway (Tan-Zam) is approximately 1920 km (1200 miles) from the copper belt in Zambia to Dar-es-Salaam, the capital and chief port of Tanzania. Large sections of the road were to be upgraded or realigned in order to provide an all-weather highway that would handle both present and projected traffic between the two countries. The highway become even more important after the United Nations imposed an embargo on traffic with Rhodesia, an act which lead Zambia to seek alternate routes for its sea-going import-export traffic.

A feasibility study was conducted in 1966 by the Stanford Research Institute (SRI) for the entire Tanzania-Zambia Highway. The section selected for the present case study (186 km, or 115 miles) is the most heavily traveled part between Morogoro and Dar-es-Salaam in Tanzania; it is circled on the attached map. This section is the most important link in the transportation network connecting Dar-es-Salaam not only with the rest of Tanzania, but also with the surrounding countries. Excluding Zambian copper, most of the freight transported over this section consists mainly of agricultural products, manufactured goods, and construction materials.

The terrain surrounding the road varies from flat to rolling country; rainfall is heavy near the coast, decreasing towards Morogoro. The existing road was a two-lane bituminized highway built in the mid-fifties with some very curved and undulating sections, and with a paved way 6.1 m. (20 feet) wide on a 8.5 m. (28 feet) wide formation. The pavement had deteriorated to an almost-poor condition due to heavy traffic and lack of adequate maintenance.

The SRI feasibility report proposed to replace this section of the existing highway with an asphalt-concrete road with a 7.3 m. (24 foot) wide paved way on a 12.2 m. (40 foot) wide formation, with major horizontal and vertical realignments. Subsequent studies conducted by De Leuw Cather, Incorporated, led to a more detailed engineering design for this section of the highway which has since been completed and in use for some time.