CHAPTER 4
GENERAL EVALUATION

4.1 INTRODUCTION

The singular magnitude of this research project required that many Brazilian and foreign technicians, from various national and international teaching and research institutions, be brought together into a multidisciplinary team. At one point, the technical team had 36 professionals with undergraduate or graduate degrees, 11 of whom were foreigners. During the entire course of the work, the team was involved in a highly valuable professional exchange of experiences.

In the light of the substantial progress made in terms of knowledge of highway costs, the result obtained can, in general, be considered as satisfactory. However, just as in any other research project, many doubts and questions were raised, and their clarification will demand a good deal of additional work. Although they may be modified or updated as a consequence of the studies and research going on both here and abroad, the equations that represent the interrelationships of highway costs may henceforward be utilized by Brazilian technicians in the task of highway planning.

There is a need to improve the three models - a task GEIPOT is now undertaking - so that new versions of the Model of Highway Costs (MICR), the Model of Time and Fuel Consumption (MTC) and the Model for Simulating Traffic (MST) will be forthcoming and overcome some of their current limitations.

4.2 SURVEY OF USER COSTS

This was the aspect of the PICR that involved the greatest number of problems and uncertainties since, at the very beginning of the work it was found that the majority of the highway users did not possess trustworthy records of the different items that compose the total operating cost of vehicles, with the sole exception of fuel consumption.

The group responsible for gathering data on user costs had to develop special techniques, adapted to the size and structure

of the companies and individuals involved. In some cases, when the desired information did not exist, specific methods were created or adapted to the records of the transportation companies. Special attention had to be given to the data gathered from owner drivers. Normally, these users did not possess detailed records on operating costs, thus demanding additional work in order to obtain trustworthy information on the different cost elements, some of which are essential to the composition of the total cost.

Another important aspect was the reference file on the routes chosen for collecting information on operating costs. It was necessary to design, construct and adapt the instruments which, installed in the PICR vehicles, would quantify routes in terms of their horizontal and vertical geometry and surface quality.

The methods and techniques utilized by the group responsible for collecting this data are described in Chapter 3 of Volume 2.

Equations for calculating the costs of the different items which compose the operating cost of vehicles resulted from the analysis of the data collected. As a consequence of both a reanalysis of the data collected in the PICR file and of new research efforts, the results obtained should be perfected in the future. The results are fully documented in Volume 5 of this report and, contrary to certain previously utilized procedures, are consistent with the rates and freights charged by transportation companies.

The cost variables in the equations are expressed in physical terms, with the exception of parts and expenditures on mechanic's labor. Since it is impossible to quantify the latter in physical terms, the values are expressed in cruzeiros. This preference for physical units was designed to prevent the invalidation of the PICR results due to disproportionate increases in the prices of the different cost items. In the case of parts, a specific deflator was created to correct the nominal monetary values, since it was observed that increases in the prices of spare parts closely accompany the percentage increases in the prices of new vehicles.

The results of the PICR represent a distinct improvement on other studies whose hypotheses are less reliable and whose empir-

ical basis is several decades old. In the future, additional research will be necessary to adapt the conclusions of this study to a changing of the national vehicle fleet, to the use of new fuels and to the technological development of vehicles. However, since these modifications will occur in a gradual and progressive manner, the conclusions presented herein will be of great utility in the years to come, while the PICR models can be updated as such changes come about.

4.3 TRAFFIC STUDIES

The work developed in this area consisted of observing and surveying road users' behavior in terms of vehicle speed under different combinations of road geometry and surface quality. This behavior was then simulated in vehicles that were representative of the different classes and which were equipped with instruments designed to measure fuel consumption.

The results of these observations and experiments made it possible to characterize the performance of the different classes of vehicles of the national fleet and to develop two simulation models that will be quite useful in highway planning. They are the Model of Time and Fuel Consumption (MTC) and the Model for Simulating Traffic (MST).

The results obtained are of good quality, since they are derived from experiments carried out with the major factors under control. In the future, some complementary experiments, together with improved analysis techniques, will generate more solid equations and data.

The methods and techniques applied to obtain the data are described in Chapter 4 of Volume 2 of this report. Volume 6 deals with the analysis of the data and describes and documents the conclusions.

4.4 STUDY OF HIGHWAY DETERIORATION

During the research period, data was collected and measure-

ments were made on highway sections that fitted the factorial matrix cells, which were designed in such a way as to represent the varied universe of Brazilian paved and unpaved roads, with different levels of traffic.

The characterization of the structures obeyed the test techniques practiced in Brazil under DNER norms. For the first time in this country, the test for determining the resilient modulus (MR) of the materials utilized in road construction was applied in a systematic manner.

Also for the first time in Brazil, systematic measurements of road roughness were made. The *Mays-Ride-Meter*, known simply as the *Maysmeter*, was utilized in these measurements. To ensure the trustworthiness of these measurements, the *GMR-Profilometer*, also called *Surface Dynamics Profilometer*, an instrument of high technical sophistication, was employed in the calibration of the Maysmeters.

The methods and techniques utilized in collecting data, and undertaking measurements and experiments are described in Chapter 5 of Volume 2, while the results obtained from data analysis are documented and presented in Volume 7 of this report.

In general, the equations and models developed to calculate the beginning and progression of paved-road deterioration are of good quality and, in some aspects, represent a substantial increase in our understanding of the performance of the structures of Brazilian paved roads.

Insofar as unpaved roads are concerned, the results obtained still seem to be inadequate for general use, and should thus be employed with caution and reservations. Additional studies have already been recommended so as to obtain more realistic and trustworthy models for use in highway planning.

4.5 MODELS

Among the initial objectives of the PICR, the adaptation and development of a model of highway costs for Brazilian needs was

explicitly included. In the terms of reference of the project, the *Highway Design Model* (*HDM*) and the *Road Transport Investment Model* (*RITM*) are explicitly cited as those most studied for this adaptation.

The 1979 version of the HDM was selected and the equations and correlations obtained by the PICR were introduced into this model. This adaptation was termed *Model of Interrelationship of Highway Costs* (*MICR*) and is described in Volume 8 of this report.

At the present time, the MICR is being tested by the DNER and by GEIPOT in studies of the feasibility of investments in highway maintenance and rehabilitation. The knowledge acquired through the use of the HDM will make it possible, over the short term, to produce a new, more flexible and improved version of this Model, for wider use in the future.

Initially, the traffic studies and experiments made it possible to develop the Model of Time and Fuel Consumption (MTC), which had the sole function of determining the parameters for use as inputs for the Highway Cost Model. However, since the MTC proved to have greater potential for application, a new and improved version of this Model will be developed for use in highway planning. The description of the current version of the Model and the outlook for future improvements are found in Volume 9 of this report.

The Model for Simulating Traffic (MST) was developed as a subproduct of the traffic studies, and is described in Volume 10 of this report. In the new version of the MST, the MTC will be included as a subroutine. In this way, the MST will acquire the capacity to calculate travel time and fuel consumption in non-free traffic flow.

The combined use of these models (MST and MTC) will make it possible for the highway planner to evaluate the performance of the fleet on a given highway section, in terms of both travel time and fuel consumption. It will also make it possible to determine when and where a given highway ceases to possess free-flow traffic conditions, a situation that causes a decline in service level and performance of the fleet by reducing circulation speed and increasing fuel consumption. These data will indicate where and when highway authorities should intervene to ensure a better flow of traffic on

the highway, through the rectification of design, construction of a third (climbing) lane, duplication, etc.

In their present versions, the models contain certain deficiencies and must be perfected insofar as conception and computer language are concerned. These shortcomings will be corrected in the new versions, a task GEIPOT is now carrying out, with the aim of providing increasingly useful models for Brazilian highway planning.