5.4   VOLUME 4 - STATISTICAL GUIDE

5.4.1   Structure of Volume 4

         CHAPTER 1 - Introduction

         CHAPTER 2 - PICR Statistics and Sources

         CHAPTER 3 - How to Locate the Statistics

         CHAPTER 4 - Statistical Index

5.4.2 Summary of Volume 4

The *Statistical Guide* provides information on the availability and sources of the statistics contained in the PICR files. It contains an index to allow the reader to locate those parts of the Guide dealing with each alphabetized statistic and its respective file.

The statistics were classified into subgroups by cross referencing the method used to obtain them (collection, survey, and experiment) with their objective (pavement, traffic, and road users). The Guide indicates the purpose of the statistics of each subgroup, along with their sources and the procedures used in gathering them.

In the chapter *How to Locate the Statistics,* a brief comment is made on each of the statistics and the file where they are kept. The location code is also given.

The *Statistical Index* presents all the statistics alphabetized according to their designations, indicates the item in the chapter *PICR Statistics and Their Origin* where each one can be found, gives the code that leads to a specific comment about the statistic, and indicates the card(s) or file(s) showing where they can be located.

5.5 VOLUME 5 - STUDY OF ROAD USER COSTS

5.5.1 Structure of Volume 5

CHAPTER 1 - Objectives, Scope and Organization

CHAPTER 2 - Analysis Procedures

CHAPTER 3 - Analysis Results

CHAPTER 4 - Total Vehicle Operating Costs

CHAPTER 5 - Conclusions and Recommendations

5.5.2   *Summary of Volume 5*

Volume 5 records the activities of the PICR User Cost Surveys Group which conducted a large vehicle operating cost survey in Central, Western and Southern Brazil during the period 1975 to 1981. The Group was responsible for the collection and analysis of vehicle maintenance parts and labor costs, tire costs, depreciation and interest charges, and drivers' salaries. In addition, fuel consumption and speed data were collected (the latter when easily available) to serve as consistency checks on the equations derived from experimental data. The Group was also responsible for collecting data on surface roughness, as well as vertical and horizontal geometry characteristics of the routes of those operators registered in the survey.

The primary data collection phase ran from 1975 to 1979 and 26 staff members were employed, comprising 14 field workers, 8 clerical assistants and 4 supervisors. More than two years was spent in developing and testing appropriate methodologies, documentation and data processing systems for the collection, checking, storage and analysis of both operating cost and highway characteristics data. Contact was made with over 300 companies and more than 2500 vehicles were registered for survey membership. Operating cost data were then collected on a regular basis from company records. Many difficulties had to be overcome during this period. A number of companies only had records of a few cost components and, where possible, assistance was given to provide the necessary documentation and training to collect missing items. Some companies dropped out of the survey and data collection in others was discontinued because the route characteristics of their vehicles were found to be redundant for the needs of the PICR. Finally, data on over 1600 vehicles derived from 132 companies were available in 1979 for preliminary analysis.

Highway characteristics were collected using two specially instrumented vehicles. Roughness was measured with a Maysmeter and calibration maintained through a GM Profilometer and Quarter-Car-Simulator which generated a series of profiles for a calibration course of highway sections established near Brasilia. Vertical geometry was measured using a linear accelerometer connected to a panel scale capable of recording grade changes of $\pm$ 1% to $\pm$ 12%. Horizontal measurements were taken from a standard aircraft directional gyro compass, mounted in the survey vehicles. Over 85,000 km of roughness and geometry data

were collected after measuring more than 36,000 km of operators' routes. After editing, these data had then to be combined with the vehicle operating cost data so that a single file comprising both dependent and independent variables could be made available for analysis.

The second PICR Phase covered the period 1980 to 1981. The staff was reduced to 5, who were principally engaged in conducting more detailed analyses. The statistical methods employed were divided into distinct groups of techniques and advanced econometric procedures were used. An important technique which provided a number of the equations reported herein was the generalized least squares estimation of the error component model. The latter considers the company specific error term and the vehicle specific error term which jointly form the components of the unknown random error term considered by ordinary least squares techniques. This is perhaps the first reported application of error components analysis in the field of transportation studies. All the different techniques are detailed in the analysis procedures section of this volume. The analyst was able to run a selection of these techniques simultaneously on any data set. This made comparison of the results and the choices of recommended equations an easier task.

Vehicle operating cost information presented for analysis cover the full range of vehicles operating on Brazilian highways. These are grouped into cars, utility vehicles, buses, medium trucks and heavy articulated vehicles for analysis purposes. The results of the analyses of fuel consumption, oil and grease consumption, maintenance parts and labor, tire consumption, depreciation and interest charges and vehicle speed are presented. All five vehicles classes are used in the analyses, except for speed, which is restricted to cars and buses, and tire costs, which are analysed by tire size. The equations recommended in this volume concentrate on estimating roughness, vehicle age, and other characteristics (where appropriate), and geometry effects only when these appear unambiguous. A substantial amount of time was spent estimating the effect of geometry on the various operating cost items and details on the progress made are given in the main text and selected appendices. It is clear that more time is needed to resolve this issue. Further small analyses, together with the findings of the operating cost study in India, presently being analysed, may result in the emergence of a more coherent pattern of the geometry effect on user costs.

The PICR User Survey data are the most comprehensive collected to date and are important both to Brazil, where out-of-date cost tables are widely used, and to the international research community, where they complement the Kenya, Carribean and India studies. The PICR survey data covers a spectrum of vehicle types and appears to be the only study with a full range of truck classes. The data have now passed through several phases of analysis and the results presented in this volume, together with the relevant technical memoranda, can be regarded as an interim final form. They are now ready for extensive evaluation in a variety of economic exercises. When they have passed these tests they can be viewed as being in final form for the period ending December 31, 1981.

Comparisons are made between total operating costs predicted from the various equations recommended in this volume and prevailing transport service rates and tariffs. The results are encouraging and give confidence to the view that the recommended equations will provide better predictions of vehicle operating costs than anything currently used in Brazil. It is recommended that a user cost manual be prepared to allow the results of the PICR survey to be widely disseminated.

5.6 VOLUME 6 - STUDY OF VEHICLE BEHAVIOR AND PERFORMANCE

5.6.1 Structure of Volume 6

CHAPTER 1 - Introduction

CHAPTER 2 - Influence of Speed Limit on Data Collected

CHAPTER 3 - Influence of Road Riding Quality

CHAPTER 4 - Results of Free-Flow Speed Surveys

CHAPTER 5 - Results of Speed-Mode Survey as Vehicles Approach Obstacles or Small-Radius Curves

CHAPTER 6 - Results of the Experiment on Vehicle Acceleration Measurements on Positive and Negative Grades

CHAPTER 7 - Influence of Adding Alcohol to Gasoline

CHAPTER 8 - Results of the Experiments on Fuel Consumption Measurement at Steady-State Speed

CHAPTER 9 - Influence of Momentum Acquired by Vehicles on Negative Grades

CHAPTER 10 - Results of the Experiment on Fuel Consumption Measurement in Deceleration Mode

CHAPTER 11 - Results of the Experiment on Fuel Consumption Measurement in Acceleration Mode

5.6.2   Summary of Volume 6

The type of vehicle, its operating speed, and highway charac-
teristics, such as grades, curves and surface roughness, are key vari-
ables in determining fuel consumption and travel times. The Research
on the Interrelationships Between Costs of Highway Construction, Main-
tenance and Utilization (PICR) thus sought to specify the relationships
among these variables by conducting controlled experiments and by ob-
serving vehicle behavior on highways with given characteristics. This
knowledge enabled the PICR team to utilize the Model of Time and Fuel
Consumption (MTC) to calculate travel time and fuel consumption for
any normal highway design or existing roadway whose characteristics are
known. If congestion is present, the MTC can be used in the Model for
Simulating Traffic (MST) to achieve similar goals. Volume 6 describes
those experiments and observations and their results (the MTC and MST
are described in Volumes 9 and 10 of this report, respectively).

The road test sections were selected in such a way as to en-
sure the inclusion of principal characteristics of different types of
roads comprising the Brazilian highway network. These characteristics
included type of road surface (paved or unpaved), grades (from 0 to
$\pm$ 8%) and curves (radii from 20 m to 3,000 m).

5.7 VOLUME 7 - STUDY OF PAVEMENT MAINTENANCE AND DETERIORATION

5.7.1 Structure of Volume 7

CHAPTER 1 - Introduction

CHAPTER 2 - Paved Road Roughness Analysis

CHAPTER 3 - Paved Road Cracking and Rut Depth Analysis

CHAPTER 4 - Unpaved Road Roughness Analysis

CHAPTER 5 - Unpaved Road Gravel Loss Analysis

CHAPTER 6 - Unpaved Road Rut Depth Analysis

CHAPTER 7 - Conclusions and Recommendations

5.7.2   Summary of Volume 7

The primary objective of the Pavement and Maintenance Studies was to develop models to describe pavement performance and behavior for Brazilian paved and unpaved roads. The models are needed to relate road user costs and road maintenance costs to roadway conditions in order to predict total highway transport costs.

The experimental design sampling matrix addresses the major factors thought to influence pavement performance and behavior. Existing road sections were selected and used to satisfy the requirements of the sampling matrix. Detailed information on traffic, vehicle weights and material characteristics was collected for each section. The same data were collected on unpaved roads as well as information related to blading and regravelling. On paved roads, the dependent variables measured were roughness, rut depth, cracking and patching. The dependent variables studied on unpaved roads included roughness, rut depth, and gravel loss.

The results presented in this report are based on data files completed in 1981. The data collection effort will continue and future analyses of the expanded data base are expected to change some of the equations. Because of the preliminary nature of the relationships presented, no consideration was given to modifying the equations so that they could be directly implemented. Therefore, engineering judgement and experience should be used in any application of the equations. Finally, the application of the models is defined by factor ranges and the study environment. Extreme care should be taken in extrapolating the models beyond these limits.

5.8 VOLUME 8 - HIGHWAY COSTS MODEL (MICR)

5.8.1 Structure of Volume 8

CHAPTER 1 - Introduction

CHAPTER 2 - Objectives and Major Characteristics of the MICR

CHAPTER 3 - Considerations Regarding the Model

5.8.2 Summary of Volume 8

Volume 8 describes the major characteristics of the Highway Costs Model (MICR), which constitutes one of the products of the Research on the Interrelationships Between Costs of Highway Construction, Maintenance and Utilization (PICR), carried out in Brazil.

Chapter 1 presents the background of the MICR, in order to inform the reader about the history of its development. There is also a brief presentation of the beginning, objectives and development of PICR studies.

Chapter 2 describes the objectives and major characteristics of the Model. Finally, Chapter 3 contains a number of considerations regarding the Model, describing its limitations, analyzing its fundamental variables, suggesting improvements and commenting on the validity of its application by Brazilian highway authorities.

The MICR User's Manual is bound separately in a limited edition. Information on the program is also available (in the Portuguese version).