REPÚBLICA FEDERATIVA DO BRASIL

UNITED NATIONS DEVELOPMENT PROGRAM (UNDP)

Research on the Interrelationships Between Costs of Highway Construction Maintenance and Utilization

Report II - Midterm Report - Preliminary Results and Analyses - August 1977

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* On loan from Departamento de Estradas de Rodagem de Goiás.

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SPONSORED BY:

Secretaria de Planejamento da Presidência da República - SEPLAN
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WITH THE PARTICIPATION OF:

Departamento Nacional de Estradas de Rodagem - DNER
Departamento de Estradas de Rodagem de Goiás
Departamento de Estradas de Rodagem de Minas Gerais

Report II - Midterm Report - Preliminary Results and Analyses - August 1977

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1. Highway investments - analysis models 2. Vehicles - operational cost 3. Drivers - behavior 4. Pavements - performance I. Title II. Title: report n.2; project midterm report - preliminary results and analyses.

SUMMARY INDEX

PREFACE

This Midterm Report describes the research organization established for the project entitled "Research on the Interrelationships between Costs of Highway Construction, Maintenance and Utilization," the procedures being followed in the development of the information, the difficulties encountered, and some of the early results from the study.

The project is the result of an agreement signed in January 1975 between the Government of Brazil and the United Nations Development Program (UNDP). According to this agreement, the Ministry of Transport of Brazil is the Government Cooperating Agency, through *Empresa Brasileira de Planejamento de Transportes* - GEIPOT, and the International Bank for Reconstruction and Development (IBRD) is the executing agency for UNDP. The project is being conducted by GEIPOT and by the *Departamento Nacional de Estradas de Rodagem* (DNER), through its *Instituto de Pesquisas Rodoviárias* (IPR), and both have received grants from the *Instituto de Planejamento Econômico e Social* (IPEA) and from the *Secretaria de Cooperação Econômica e Técnica Internacional* (SUBIN), respectively.

The IBRD has contracted with the Texas Research and Development Foundation (TRDF) to provide the international staff, and to select and purchase overseas the equipment needed to conduct the project.

GEIPOT is thankful for the support received from highway authorities in the geographic area of the research, represented by the Federal Highway Districts of DNER and by the State Highway Departments of Goiás, Minas Gerais and São Paulo. Appreciation is also expressed for the cooperation extended the project by the Federal Universities of Minas Gerais, Rio de Janeiro and Juiz de Fora, and by the Universities of Texas and Birmingham, as well as by the Western Australia Main Roads Department, which have made it possible for highly qualified members of their staff to fill many key positions in the project's technical team.

Finally, GEIPOT wants to express its appreciation for advice received from the Transport and Road Research Laboratory (TRRL) at the project's inception, and from the Expert Working Group, which has periodically visited Brazil to review progress on the research with the project's technical team.

Eng. JOSÉ MENEZES SENNA
President

ABSTRACT

This status report on the project was developed to summarize project achievements and results at midterm, and to define a work program for the balance of the project. The study procedures and accomplishments of the 150-man research force are detailed for the three principal study groups which are addressing pavement performance, driver behavior and vehicle operating costs in Brazil. Preliminary equations are presented relating roadway characteristics to vehicle speed and fuel consumption. Extensive axle-loading data are summarized while the extent of vehicle overloads in Brazil is highlighted.

A work program and schedule are presented to accomplish project objectives and to produce an operational Brazil Highway Investment Analysis Model by November 1978.

CHAPTER A

INTRODUCTION

1 OBJECTIVES

This Research Project aims at establishing relationships between the costs of highway construction and maintenance, and the operational costs of vehicles that will use those highways during their useful life. These interrelationships will be incorporated in a computer-based mathematical model, which can be used to cheaply and quickly establish the costs of alternative highway construction and maintenance policies, as well as those of highway users.

Such a model would enable Brazilian authorities to optimize highway investments and vehicle operational costs, with a view to improving the allocation of limited resources for investments on infrastructure.

Within the general scope of obtaining these interrelationships, three immediate sub-objectives have been identified for this project:

- To establish the relationships between road user costs, road geometric standards and surface conditions for rural roads;
- To measure the relationship of road deterioration and maintenance costs, as a function of pavement and geometric design standards, as well as of traffic volume and composition under Brazilian climatic conditions;
- To develop new or modify and adapt existing mathematical models for Brazilian use, with parameters developed from experiments and measurements carried out to meet the preceding items.

These objectives are being achieved through the following project activities:

- A road user costs survey, where a diversified vehicle fleet, drawn from organizations operating buses, trucks, and automobiles, is monitored to determine actual user costs for a variety of operating conditions in Brazil;
- A series of experiments to measure speed and/or fuel consumption for both existing traffic and a controlled fleet of instrumented project vehicles over a range of roadway geometric, operational and environmental conditions;

- A study of the behavior of selected road test sections to establish roadway performance and maintenance requirements, as a function of different pavement and geometric design standards and maintenance levels, in the Brazilian environment.

This report presents a summary of project achievements at the midpoint, and also accomodates the early dissemination of project results. Where data were available, preliminary analyses were made and the results presented. However, the reader is reminded that all results presented in this report are preliminary in nature and are only early indicators of the types of relationships being found. Further, the influence of some of the factors being studied on the early analyses has not been fully considered.

a *Existing Model*

The framework for the desired model already exists as a result of a series of studies initiated by the World Bank in 1968. The Bank desired to develop an analytic model for use in evaluating alternative design, construction and maintenance strategies at the project level for low-volume roads. In the first study, the Massachusetts Institute of Technology (MIT) developed an integrated framework relating construction, maintenance and road user costs. Most of the relationships were based on information available from published literature, and could not be confirmed by empirical data.

In a subsequent World Bank cooperative effort in Kenya with the Transportation and Road Research Laboratory (TRRL), field studies produced empirical relationships which were incorporated into a revised version of the MIT model entitled Road Transport Investment Model. Following the publication of this model by TRRL in 1975, the Bank coordinated an agreement with both TRRL and MIT to produce a unified model which combined the strengths of each model, while avoiding the weaknesses of both. Therefore, the current model version, The Highway Design and Maintenance Standards Model (HDM), uses the structural framework of MIT's first model, results from field investigations in Kenya, as well as new technology published in current literature. It includes modules to predict roadway performance, construction and maintenance quantities and the impact on the costs to users operating on roads with varying characteristics. Automatic costing with current unit prices permits an economic evaluation of the implications of alternate design and maintenance strategies on total transportation costs.

The HDM will be tested by the research team in connection with several highway projects in Brazil.

Although the HDM is operational, it is not necessarily applicable to Brazilian conditions. Many of its underlining relationships need to be verified before its results can be accepted for Brazil. Also, it has a number of acknowledged limitations, and many of these are being directly addressed in the current study. For example, road performance relationships are based on high-standard asphalt roads used in the AASHO road test and bituminous-treated, cement-stabilized base roads in Kenya. In the case of unpaved roads, relationships reflect Kenya gravel roads. Therefore, as part of this project, a series of pavement and maintenance studies are being made on typical Brazilian roads. These studies will establish performance relationships for roads in Brazil, subject to different levels of maintenance.

The relationships developed between road user costs and roadway geometrics in Kenya do not cover the wider range existing in Brazil. Further, the HDM embraces only a limited number of vehicles which are not necessarily typical of those used in Brazil. The major thrust of this study is to develop more comprehensive information and relationships on vehicle user costs. In addition to fuel consumption, special efforts are being directed to the development of tire wear, vehicle maintenance and vehicle depreciation.

Finally, the effect of congestion and traffic composition on operating costs is not based on empirical data in the HDM. Special studies and experiments in this study address these influences in greater detail.

b *Scope*

This study has been organized to make use of sound experimental design and survey techniques to minimize the magnitude of the data collection effort, yet ensuring where practical that quantitative statements of accuracy can be made about models developed in the study. Data are collected through controlled experiments, direct meas urements and from information contributed by participants in the user surveys.

The study areas are in central Brazil as originally planned. One exception is the inclusion of user survey routes in the State of Mato Grosso to capture flat routes for the user survey factorial. This is illustrated in Figure 1 where the actual area covered by user survey routes is shown. The pavement and maintenance study locations are shown in Figure 2, and embrace a three-state area. Finally, the sections selected for the various controlled experiments on vehicle speed, fuel and traffic-interaction effects are indicated in Figure 3. These latter sections were located close to Brasilia, where possible, to minimize the logistics costs associated with moving the project's fleet of instrumented test vehicles.

This study which started in July 1975 is at the halfway point. Data collection started in July 1976, although this varied somewhat from sector to sector.

MT-GEIPOT

▲ MAIN SURVEY CENTERS

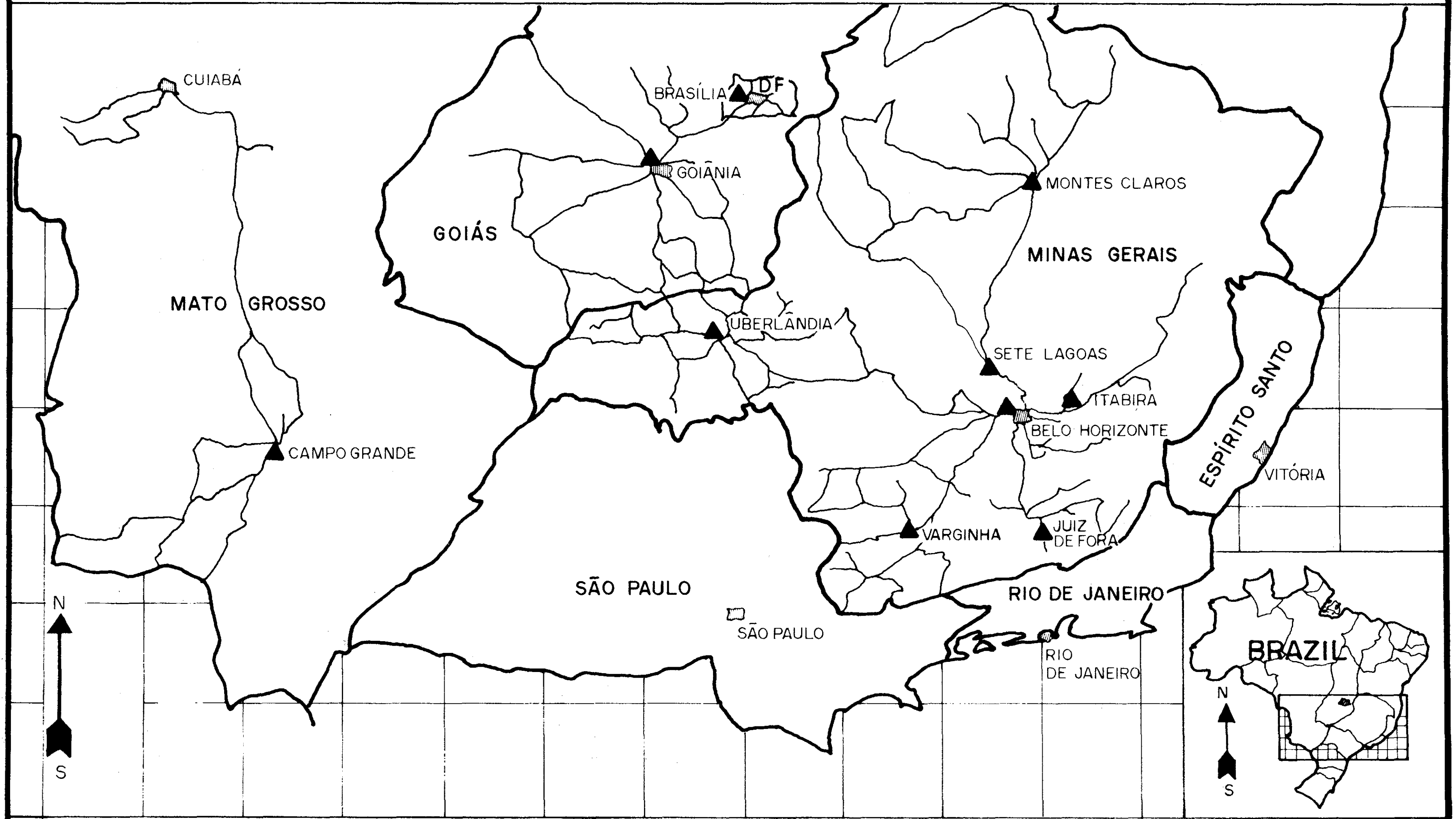


FIG. I

LOCATION OF ROUTES INCLUDED IN THE ROAD USER COSTS SURVEYS

MT - GEIPOT

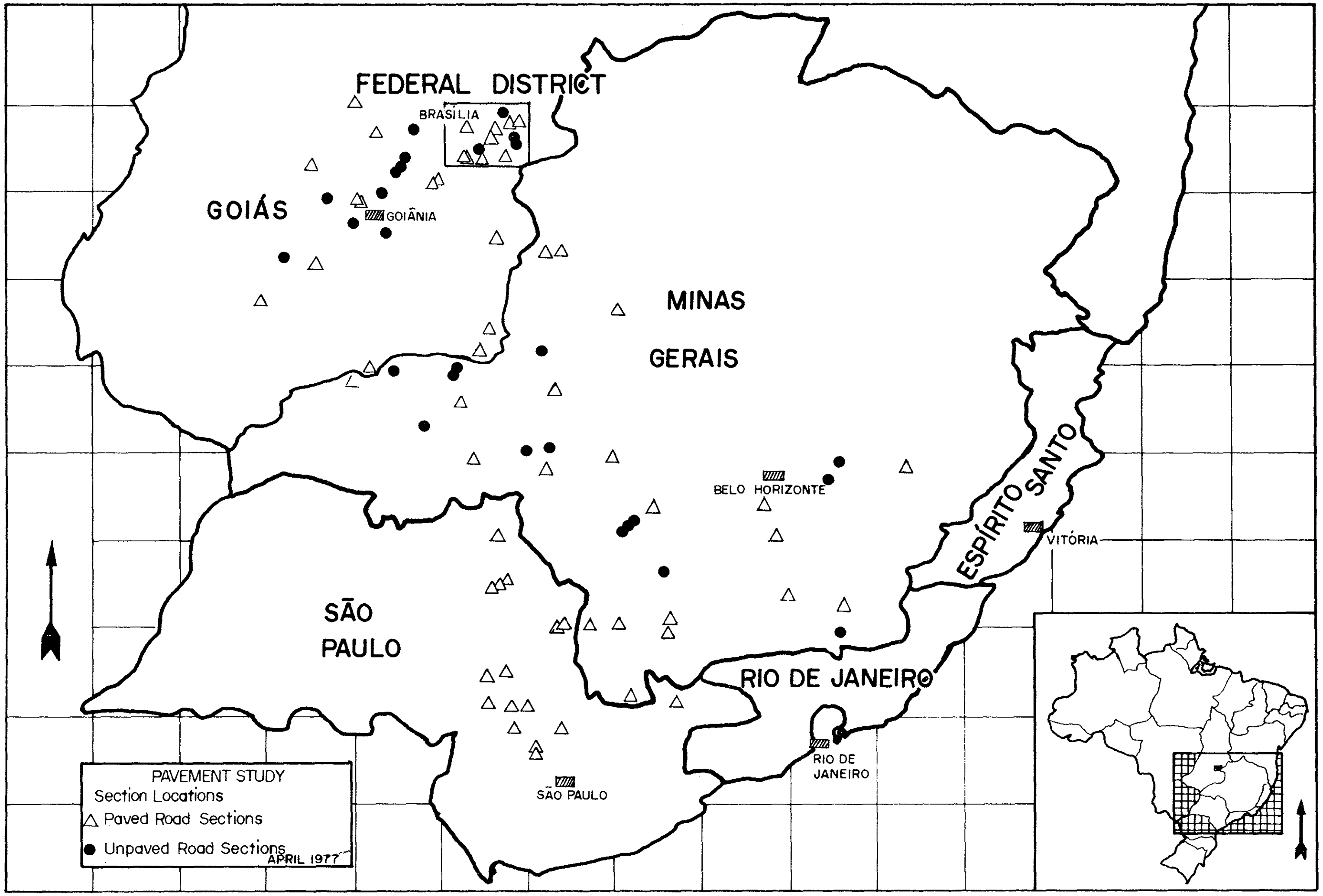


FIG. 2

LOCATION OF SECTIONS FOR THE PAVEMENT AND MAINTENANCE STUDIES

MT-GEIPOT

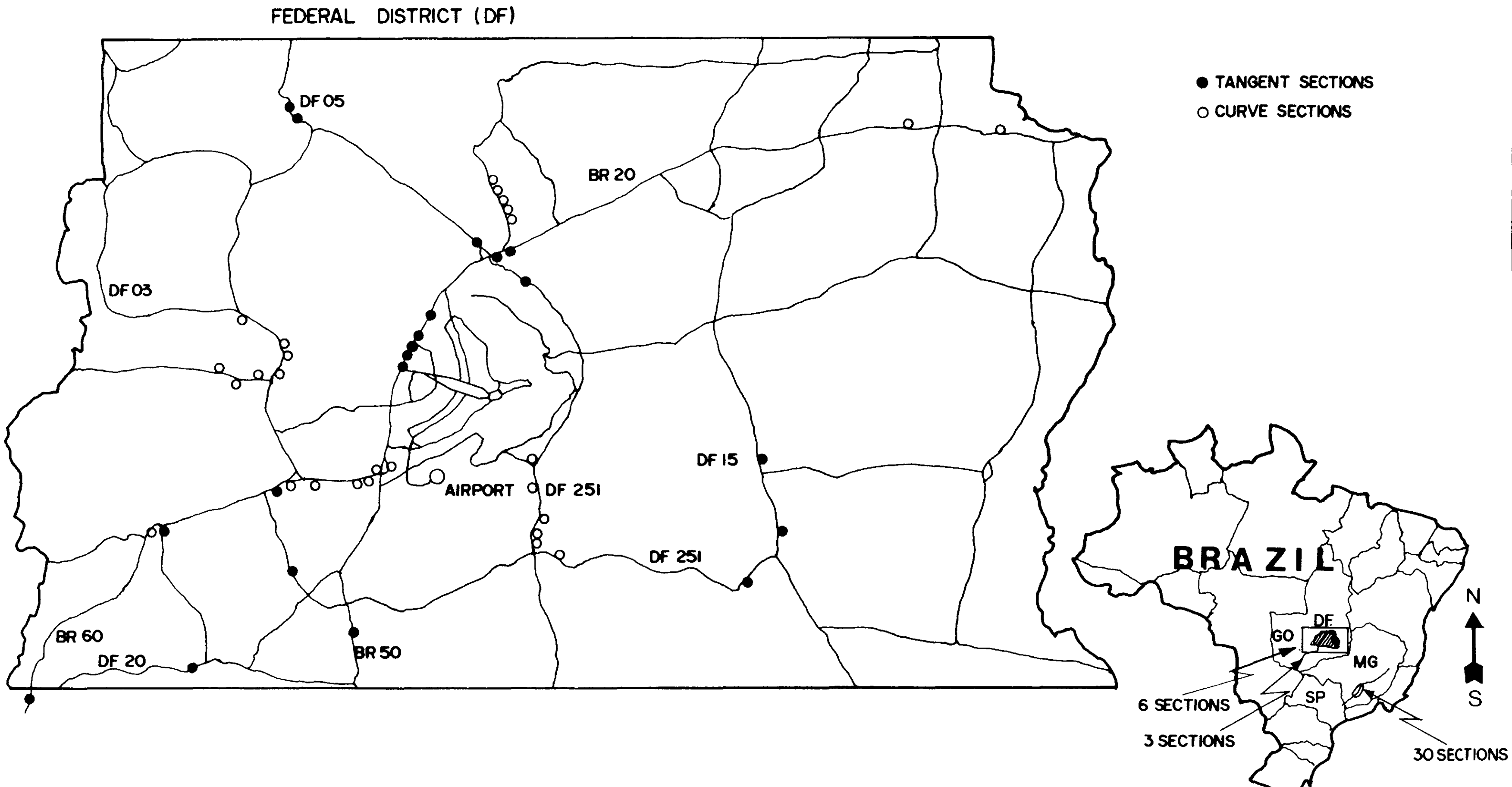


FIG. 3

LOCATION OF TEST SECTIONS FOR THE USER COST AND TRAFFIC EXPERIMENTS

CHAPTER B

GENERAL PROJECT ACHIEVEMENTS

1 ORGANIZATION

As a result of the studies and requirements outlined in the Inception Report (Ref. 1), an organizational structure was established for the project as shown in Figure 4. This structure was designed to deal functionally with the major areas of the research which are outlined in the project objectives. These are the studies to develop user costs relationships, using surveys and a series of experiments, together with a study of roadway performance in Brazil. These basic research areas are supported by a management, statistics, computer and instrumentation group.

As can also be seen in Figure 4, where the project's senior personnel are identified, the leadership of the project has been established so that it is shared by the international staff and the Brazilians. The detail organizational requirements have changed a number of times since the Inception Report, although the total personnel requirements have remained more or less constant.

Figure 5 shows the present organizational requirements. These staffing requirements were about 80% satisfied, at the end of the first year of the study. In the last months that figure has slowly moved upward and is at 90% presently. However, the project is unlikely to ever be fully staffed due to personnel attrition, which has averaged about 5% on a quarterly basis over the last year.

2 MEASUREMENT EQUIPMENT

The majority of the activities of this research project involve measurements of one type or another. Therefore, the acquisition or fabrication of the necessary equipment and instrumentation to permit these measurements was a major project undertaking. An even more substantial challenge has been keeping the equipment operational during the study.

Table B.1. shows the various equipment or instrumentation purchased or fabricated to make these required measurements. Each unit is associated with the type of measurement needed. Where a measurement system has been modified to satisfy project needs, the Instrumentation Group has been identified as the Source. The difference between purchase date and the date available for use reflects delays in

MT-GEIPOT

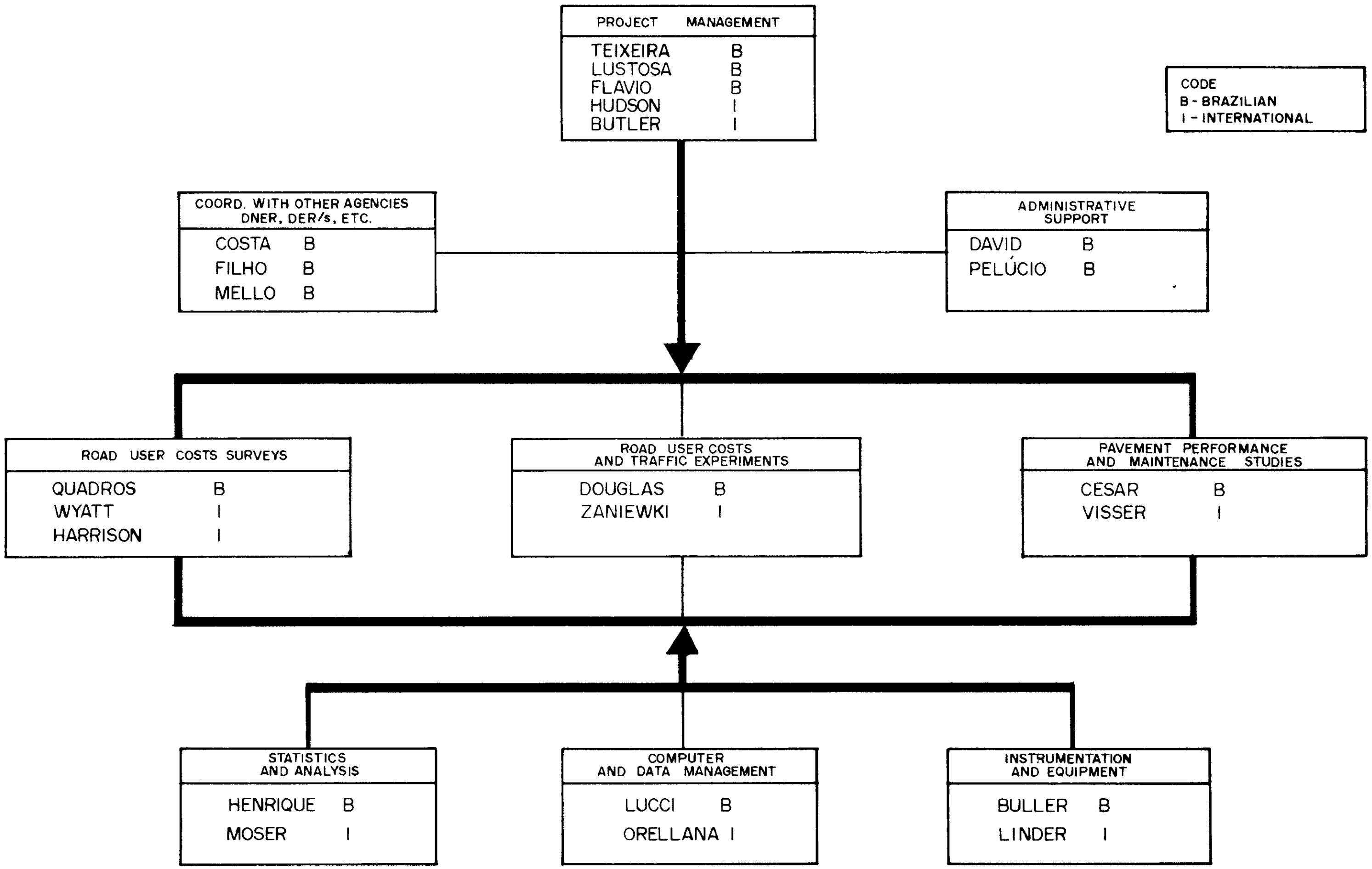
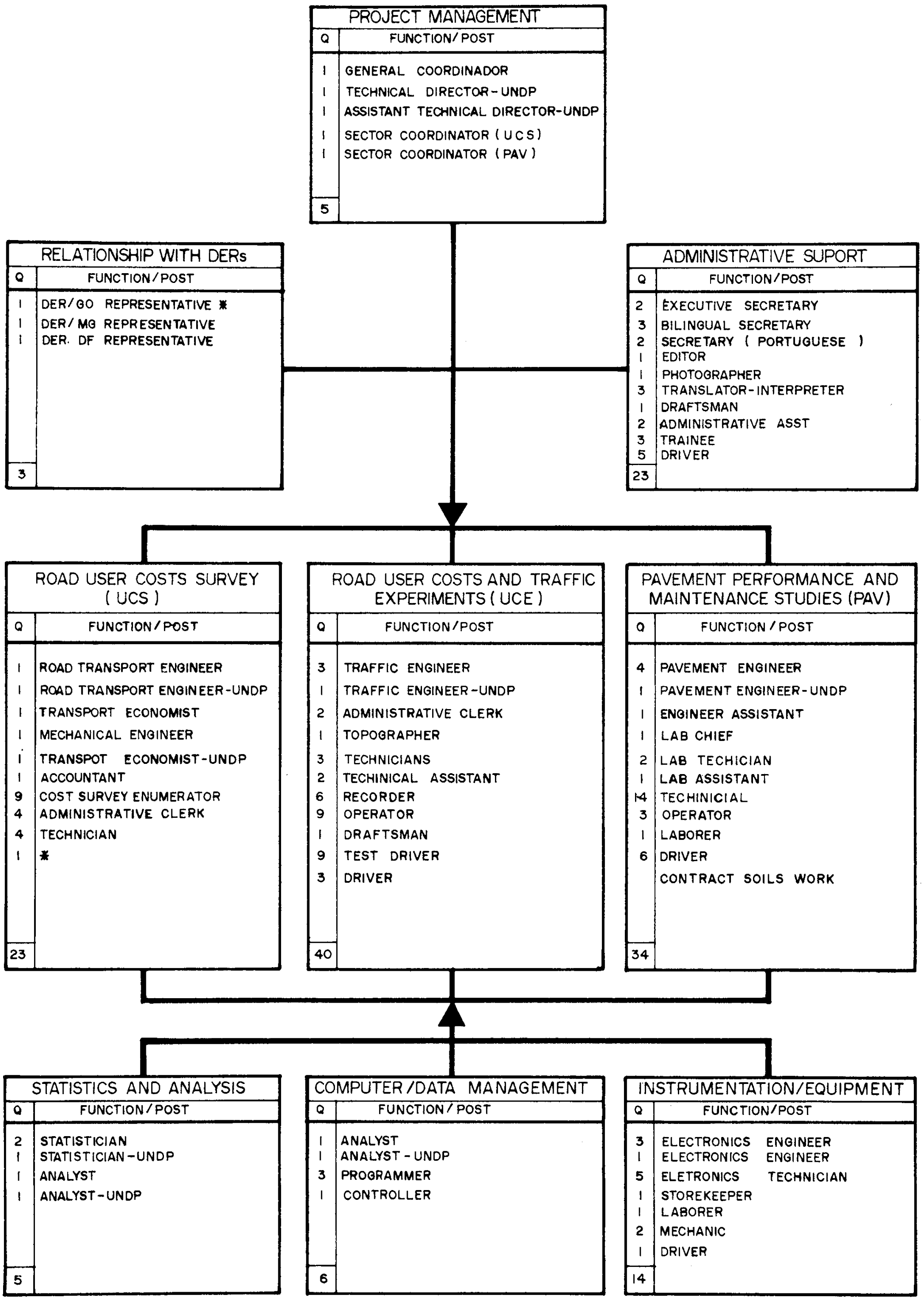


FIG. 4

FUNCTIONAL ORGANIZATION CHART OF PROJECT

MT-GEIPOT



* DER/GO REPRESENTATIVE SPENDS OF HIS TIME ON THE USER COST SURVEY

FIG. 5

DETAIL ORGANIZATION CHART OF PERSONNEL (REVISED JULY 1977)

TABLE B.1 - DISPOSITION OF EQUIPMENT AND INSTRUMENTATION ACQUIRED FOR PROJECT MEASUREMENTS

TYPE OF MEASUREMENT	EQUIPMENT NAME	MANUFACTURER OR SOURCE	DATE OF PURCHASE OR MANUFACTURE	QUANTITY ON HAND	DATE AVAILABLE FOR USE	PERCENTAGE OF TIME IN:		
						USE	STANDBY	REPAIR & SERVICE
Pavement Deflection	Dynaflect	SIE	May 76	1	June 76	63%	16%	21%
	Benkelman Beam	Rainhart Co.	March 76	2	March 76	100%	0%	0%
	Benkelman Beam	DNER	March 76	2	March 76	0%	100%	0%
Vehicle Weight	WIM 1E	Unitech, Inc.	November 75	1	July 77	5%	3%	82%
	Wheel Scales Model MD500	General Dynamics Corp.	August 75	4	October 75	55%	44%	1%
Traffic Counts	Manual Traffic Counter	Denominator Co., Inc.	August 75	4	October 75	0%	100%	0%
	Non-Recording JRT	Streeter-Amet	August 75	30	October 75	1%	99%	0%
	Non-Recording Model 3700	Fisher & Porter Co.	August 75 and November 75	5 5	October 75 and March 75	1%	99%	0%
	Recording Automatic Counter	Leopold & Stevens, Inc.	August 75 and November 75	10	October 75	10%	80%	10%
Time	Single Action Stop Watch	Camero	August 75	30	October 75	0%	100%	0%
	Double Action Stop Watch	Handhart	August 75	10	October 75	0%	100%	0%
	Split-Second Hand Stop Watch		December 75	8	February 76	95%	0%	5%
Wind Velocity	Windial Wind Speed Indicator = 918	Airglide Instrument Co.	January 76	3 3	March 76	95%	4%	1% 0%
Soils Lab. Equipment	Dynamic Modulus Tester	Russ Newcom SEE	October 75	1	February 76	70%	28%	2%

TABLE B.1 --DISPOSITION OF EQUIPMENT AND INSTRUMENTATION ACQUIRED FOR PROJECT MEASUREMENTS (CONT.D)

TYPE OF MEASUREMENT	EQUIPMENT NAME	MANUFACTURER OR SOURCE	DATE OF PURCHASE OR MANUFACTURE	QUANTITY ON HAND	DATE AVAILABLE FOR USE	PERCENTAGE OF TIME IN:		
						USE	STANDBY	REPAIR & SERVICE
Rainfall	Eletric Rain Gauge	Texas Electronics Inc.	March 76	2	April 76	0%	100%	0%
	Plastic Rain Gauge	Taylor Sybron Corp.	March 76	6	April 76	95%	5%	0%
Fuel Consumption	Automotive Fuel Measurement System	Fluidyne Instruments	August 75	1	November 75	2%	98%	0%
	Fuel-o-meter	Columbia System Co.	April 76	6	May 76	2%	98%	0%
	Cylinder Fuel Meter	Instrumentation Group	January 76 April 77	9	March 76	56%	21%	23%
Distance	D.M.I. P 1071	Nu-metrics	September 75 through present	18	November 75 through present	55%	35%	10%
	Rolatape Model 394	Rolatape Corp.	October 75	5	November 75	99%		1%
	Surveyors Tape 30 & 15m	K & E	August 75	3		100%		0%
Road Grade	Electronic Grade Meter	Instrumentation Group	October 76	2	October 76	100%	0%	0%
	Ball & Tube Grade Meter	Instrumentation Group	November 76	1	November 76	5%	95%	0%
Roughness	Profilometer	K. J. Law Engrs.	September 75	1	May 76	40%	18%	42%
	Modified Mays-Ride-Meter	Instrumentation Group	March 76 through October 76	4	May 76 through October 76	67%	12%	21%
Road Horizontal Curvature	Gyro Compass	Aviation Instrument Mfg. Corp.	January 76	2	October 76	50%	49%	1%
Vehicle Speed	TR-6 Radar System	Kustom Signals, Inc.	January 76	4	May 76	94%	2%	4%
Vehicle Acceleration	Camera Box	Instrumentation Group	September 76 through August 77	3	September 76 through August 77	55%	30%	15%
	Fotimeter	Instrumentation Group	March 77	2	October 77	0%	100%	0%

shipping or the need to completely check out the unit before it could be used operationally. Some of the equipment shows little or no use during the study and these items warrant a brief explanation.

The DNER Benkelman Beam has not been used because its 4:1 ratio is not as precise as the 2:1 Rainhart unit.

The manual traffic counters have not been needed. Both of the non-recording counters have only recently been designated for use and will be installed at various locations throughout the State of Goiás in the coming months.

Of the three stopwatch types, only the split-second type watches have been useful in the traffic experiments conducted thus far.

The rain gauges were received too late for the rainy season last year, and are currently being installed to monitor the coming season.

Both the Columbia and Fluidyne systems will be used in calibration experiments that have not yet been implemented.

3 *WORKSHOPS*

From the project's inception it was realized that instrumentation support was basic to the objectives of the research, as the studies and experiments planned demanded the installation, adaptation and fabrication of sophisticated equipment, and the maintenance of a diversified vehicle fleet.

The workshops were set up in the garage building of GEIPOT, which was given over to the project. The premises are located about 7 km from the project headquarters, in GEIPOT's main office building. The garage building area was partitioned with wire cages to house the different workshops, and electricity supplies were installed. Other cages were used to accomodate supply stores, the soils laboratory - a support element for the pavement studies - and a staff room. The existing offices are being utilized as indicated in Figure 6, with the technical office being partitioned to house the analogue-to-digital converter and to provide suitable space to work on the associated data.

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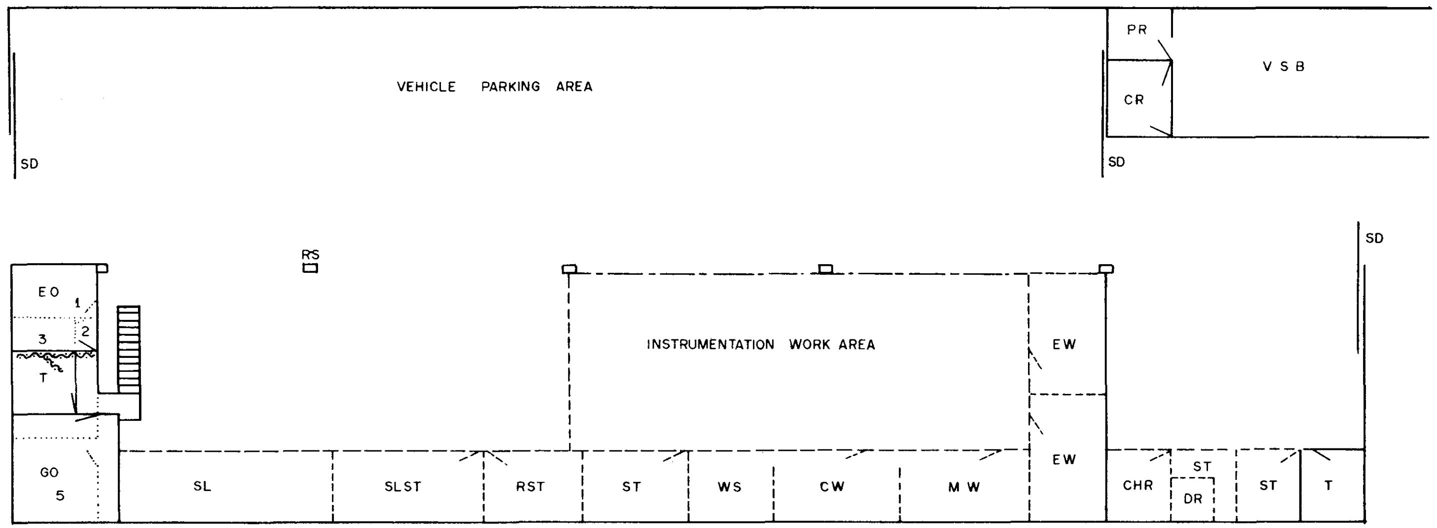

LEGEND

CR COMPRESSOR ROOM
CHR CHANGE ROOM
EO ENGINEERS' OFFICE
EW ELECTRONICS WORKSHOP
DR DARK ROOM
GO GENERAL OFFICE
CW CARPENTRY WORKSHOP
MW MECHANICAL WORKSHOP
PR PUMP ROOM
RS ROOF SUPPORT PILLAR
RST RADAR STORE
SD SLIDING DOOR
SL SOILS LABORATORY
SLST SOILS LABORATORY STORE
ST STORE
T TOILETS
VSB VEHICLE SERVICE BAY
WS WELDING SHOP

1 TRANSPORT OFFICE
2 TOILET
3 ANALOGUE-TO-DIGITAL CONVERTER ROOM
4 TECHNICAL OFFICE
5 SOILS LABORATORY

} GROUND FLOOR

——— CONCRETE BLOCK WALL (ORIGINAL)
– – – – PROJECT ADDITION
········ ORIGINAL GROUND FLOOR CONCRETE BLOCK WALL
~~~~ PARTITION (PROJECT ADDITION)
—·— DEMARKATION LINE PAINTED ON THE FLOOR

FIG. 6

GARAGE AND WORK SHOPS FLOOR PLAN
~~~~

The vehicle service bay was equipped with a hydraulic lift and pressurized greasing operation, and the two electrocnics workshops were lined with sound-proofing material to reduce noise levels. The objective of the adaptations was to provide the best possible facilities for all the electrical, electronic and mechanical work required, within reasonable financial limits.

The workshops' functions are:

- To install, test, calibrate and maintain available instruments;
- To design, construct, make work, install, calibrate and maintain other instruments, as required;
- To carry out all minor vehicle repairs and maintenance;
- To train staff in the operation of all the instruments used and workshop practices and maintenance methods;
- To ensure maximum possible availability of all equipment for use in the field.

Major achievements in the area of instrumentation support include the installation of the Mays-Ride-Meter, the adaptation of fuel meters to test vehicles, the manufacture of camera boxes, the development of a digital display unit for the Maysmeter, and the correction of faults in the Profilometer, WIM system, Dynaflect, DMI and radar speed monitors. A complete and detailed report covering all the project's instrumentation is currently being written. This report will detail instrumentation design and fabrication, together with measurement system development, calibration, maintenance and repair. It will also outline equipment and instrumentation crew requirements, training and operating procedures, schedules, production and problems.

a Soils Laboratory

A soils laboratory was established to control the work performed by the consultants in the field. This initial objective has been augmented by having the research laboratory carry out all the laboratory tests. This was required because of the unexpectedly high cost and the low precision achieved when the work was done by consultants in the field.

Space for the laboratory was found in the GEIPOT garage, with adequate water and electricity supplies, occupying a total area of 63.3 square meters. A floor plan of the laboratory area is shown in Figure 6.

The laboratory is equipped to carry out most standard laboratory tests, such us:

- Sample preparation;
- Grading analysis;
- Atterberg limits;
- Moisture contents;
- Laboratory density;
- Laboratory CBR;
- Resilient modulus of soil and asphaltic material samples.

4 *COMPUTER FACILITIES*

At the start of the project it was recognized that the magnitude of the data to be handled would require access to suitably equipped computer facilities. Specifications were drawn up outlining the basic characteristics required. Identified initially as fulfilling these specifications were two installations in Brasilia, the facilities of the Senate and those of the University of Brasilia. Neither proved suitable and the search was continued.

The Expert Working Group (EWG) in their meeting of December 1-5, 1975, strongly recommended to GEIPOT that the project have an electronic data-processing capability within their offices. This involved the establishment of a fully remote batch terminal. This criterion was added to the specification and a concerted effort was made to establish these inhouse capabilities.

In the interim, it became mandatory to have some facilities available, even if less than desired. So,

- A contract was established in February 1976 with *Companhia Auxiliar de Empresas Elétricas Brasileiras* (CAEEB). Their facilities were small (252k memory), and they did not have any statistical software to support our analysis requirements. However, they were fairly reliable, close to GEIPOT, and they could be used in the establishment of programs and files to handle the substantial data management requirements of the project. This installation con tinues to serve in this role at present;

- In April 1976, arrangements were made with *Empresa Brasileira de Pesquisa Agropecuária* (EMBRAPA) to use their facilities and software statistical package (SAS).

After an exhaustive review of options, GEIPOT made the decision to install a remote job entry terminal which could be tied to the DNER IBM 370 computer facilities located in Rio de Janeiro . The steps needed to implement this decision included:

- Locating available terminal equipment;
- Obtaining authorization from the Ministry of Transport;
- Establishing a contract with DNER;
- Arranging contracts with the telephone companies in Rio and Brasilia;
- Selection and purchase of complementary equipment and installations;
- Contracting with Burroughs for the actual installation of the terminal in GEIPOT.

The remote terminal was installed in February 1977, but only in June 1977 was the remote job entry system usefully operational.

Project files and programs were established at the DNER facility during July and August 1977; so the inhouse computer facilities, sought since early in the project, have only recently become available to the project, that is, two years after the start of the project. This facility will be used for all data processing requirements. However, as backups, both the CAEEB and EMBRAPA installations are being retained.

CHAPTER C

ROAD USER COSTS SURVEYS

1 OBJECTIVES

The overall objectives of the User Costs Surveys remain those stated in the Inception Report (Ref. 1). The surveys are to establish relationships between various components of vehicle roughness and vertical and horizontal alignment, for essentially low-volume rural roads. The major components of vehicle operating costs being collected by the surveys are:

- Fuel;
- Oil;
- Tires;
- Maintenance parts;
- Labor;
- Depreciation.

The Surveys have retained the basic format developed in the Inception Report, but several refinements have been incorporated as a result of field experience, pilot studies and advice from the Expert Working Group.

The data items which will be examined to establish and corroborate the relationships between vehicle operating costs and road design variables are given in Table C.1. The table lists each data item, gives its survey number and identifies the general analytical category to which it has been assigned. Each data item collected by the User Surveys Group is identified by a unique combination of prefix and number. The prefix specifies the survey or survey area responsible for its collection, and the number locates the data item within that survey data. The prefixes are defined as MS (Main Survey), MSC (Main Survey Continuous), RS (Route Survey) and SS (Supplementary Surveys).

A majority of the surveys directly address the problem of identifying the relationship between the consumption of user cost items and road geometry and surface characteristics. It is of considerable importance for the analyst to have a good range of observations, and so a number of factorial designs have been considered to ensure that extremes would be covered by the surveys.

The route surveys have only recently generated sufficient data to give adequate descriptions of routes traveled by user vehicles. The original factorial, as shown in Table C.2. was therefore qualita-

TABLE C.1 - USER COST SURVEYS DATA ITEMS

Data Item	Survey Number	Category
Fuel	MSC 1	Dependent Variables
Oil and Grease	MSC 2	
Tire Life	MSC 3	
Tire Tread Measurements	SS 1	
Maintenance Parts	MSC 4	
Maintenance Labor	MSC 5	
Maintenance Standard Labor Hours	SS 2	
Accident Costs	MSC 6	
Crew Time	MSC 7	
Depreciation	MS 1	
Age	MS 2	Independent Variables: Vehicle
Payloads, Freight and Passengers	MSC 8	
	SS 3	
Distance Travelled	MSC 9	
Time Spent on Route	MSC 7	
Number of Stops, Loading and Unloading	MSC 10	
	MSC 7	
Vehicle Speed	MSC 9	
Vehicle Specifications	MS 3	
Pavement Type	RS 1	Independent Variables: Route
	MS 4	
Roughness	RS 2	
Vertical Geometry	RS 3	
Horizontal Geometry	RS 4	
Pavement Width	RS 5	
Land Use	RS 6	
Traffic Vol/Composition	SS 4	Additional Factors/ Variables
Tacograph Studies	SS 5	
Taxes and Duties	SS 6	
Inflation Indices	SS 7	
Labor Rates	SS 8	
Bus Tariffs	SS 9	
Haulage Rates	SS 10	
Fleet Size	MS 5	
Nature of Business	MS 6	

TABLE C.2 - QUALITATIVE FACTORIAL DESIGN FOR MAIN SURVEY

	Paved	Mixed	Unpaved
Flat			
Rolling			
Hilly			

tive in nature. The preliminary analysis has enabled us to produce a quantitative factorial, shown in Table C.3, which will be tested over the next three months by positioning all surveyed routes into appropriate cells and evaluating the dispersion.

2 *ORGANIZATION*

The organization of the User Surveys Group is designed to perform two major activities:

- Collection of vehicle cost data;
- Measurement of route characteristics.

These are completely different in terms of methodology, techniques, equipment, management and personnel. However, in terms of the Group's primary objectives, these activities must be closely coordinated from the stage of initial data collection until the final analysis.

The organization chart shown in Figure 7 presents the structure and current staffing of the group. As indicated, vehicle-cost data collection activities are split into two main geographic areas:

- The Federal District, Southern Goiás, *Triângulo Mineiro* and Mato Grosso, with researchers based in Goiânia and Brasília; and

- Minas Gerais, with researchers based in the DER-MG headquarters in Belo Horizonte.

There are several main centers of data-collection activity within both areas, where visits are made at least once per month. These are shown on the map indicating the geographical scope of the Surveys (Figure 1, chapter A).

The route survey team is in the process of measuring approximately 50,000 km of operator routes located within the survey area. The survey vehicles are instrumented, serviced and based at the GEIPOT garage and workshop. At the moment, there is no field capability to repair or calibrate survey vehicles, and any serious problems, therefore, force them to return to Brasília. It may be necessary to make some small organizational changes to support the survey programs in Mato Grosso.

TABLE C.3 - QUANTITATIVE FACTORIAL DESIGN FOR MAIN SURVEY

ROUGHNESS	HORIZONTAL	VERTICAL: FLAT <4.5	ROLLING 4.5 - 7	HILLY 7+
SMOOTH 0 - 50	0- .3			
	.3+			
MIXED 50 - 90	0- .3			
	.3+			
ROUGH 90+	0- .3			
	.3+			

Units

Vertical and Horizontal = Algorithmic values
Roughness = QI counts per km.

MT-GEIPOT

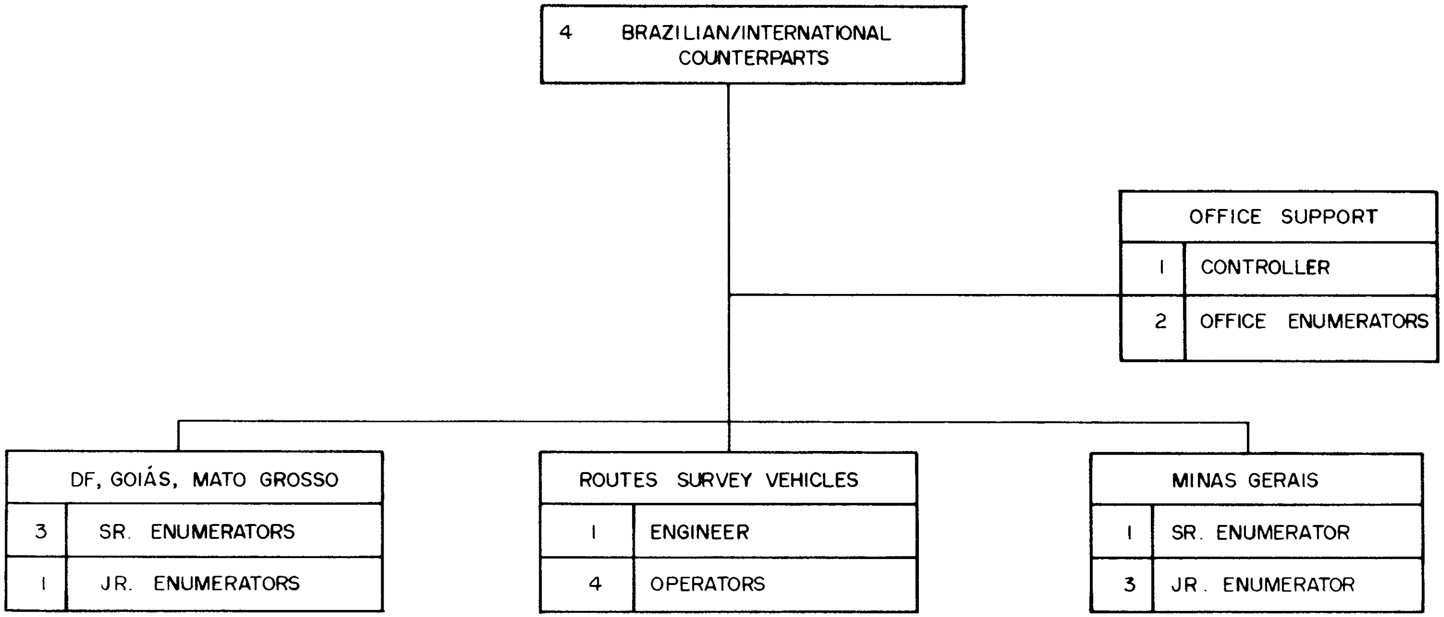

FIG. 7

USER COSTS SURVEY ORGANIZATION CHART

3 COSTS SURVEYS

No formal methodology was available for planning and managing surveys of the size and complexity planned for Brazil. There were a number of important unknown factors to address before the surveys could begin to generate good analytical data. These were:

- The response rate of vehicle operators and willingness to supply operating data;
- Availability and quality of operating data, particularly on vehicle parts consumption;
- The frequency with which vehicles remained on known routes;
- The position of these routes in the fatorial of road characteristics.

Vehicle operators were interviewed to gain information on the response rates, data quality and type of routes likely to be identified by the Surveys. Pilot studies were conducted to test vehicle selection, with respect to route type, data collection, documentation, computer coding and analysis procedures, assess data collection costs and train field enumerators. Only recently, all these objectives have been attained, together with the realization that good Surveys management depends on fast, summary output from the computer files.

a Methodology

Since the study began, a variety of data-collection documents have been tried and continued efforts made to standardize the format of the information, to expedite its transfer to computer files for analysis. This standardization has not proved possible because the record-keeping practices of companies vary tremendously. It has been necessary in almost every situation to custom design the methodology to be used for each user survey participant. This process has required the continued presence of senior survey personnel at the user's offices during the establishment of procedures and to train the field enumerator.

There are two basic approaches that have been implemented. One is to make maximum use of the companies' own records, where the field enumerator is required to tabulate data in a manner suitable for later standardization. The second approach involves self-administered questionnaires designed to generate data where records are non-existent or inadequate.

(1) *Companies' Own Records*

This method is reliable and efficient, once experience has been gained in the use and interpretation of the companies' material. The methodology has evolved through the study of photocopied company records or of information tabulated from them. The first approach involves extensive use of local photocopy shops to duplicate original company records. These are then brought to our offices and the data are transferred directly to keypunch documents by the field enumerator himself. This process requires skill and frequent assistance from senior researchers because some element of transformation is always involved. The data are normally compiled on a monthly basis by the vehicle operators, but sometimes also on a weekly basis. All photocopied records are labeled with the company's identification number and carefully preserved as original documents in the appropriate company file.

The second approach is used when photocopying is not possible. Special field forms are designed or adapted for use by the field enumerators in tabulating information from company records. This first requires a detailed examination of the various records the operator is using. A document is drawn up which very closely follows the format of the operator's own documents. It is designed to facilitate, to the maximum extent possible, the task of copying the information, on the theory that the simpler the task, the less the possibility of errors. This special field document is then returned to our offices where it is transferred to a keypunch document in the same manner as original records, and stored in the same way. This second method involves spending more time at the company's premises.

(2) *Self-administered Questionnaires*

This method has never been considered very satisfactory because:

- It presupposes inadequate records;

- The response rate is very low, with only a faithful minority continuing to fill them out;
- It is practically impossible to make cross-checks on the data, so they must be considered unreliable.

Self-administered questionnaires, mainly those distributed, to *autonomos* (owner operators), continue to be used, since this is the best method we have found to extract data from this important class. Whenever possible, the *autonomo* is persuaded to retain invoices and receipts for parts purchases, so that the information given may be checked.

b *Survey Scope and Size*

The present geographic scope of the surveys, and the main centers of data collection are shown in Figure 1. This represents an area of approximately one million square kilometers (386,000 square miles), or more than 10% of the total area of Brazil. The principal study area includes Minas Gerais, the Federal District and Goiás. Satellite studies were to be extended to other parts of Brazil, as necessary. In order to obtain a sufficient range of road geometric conditions, it was found necessary to collect data in Mato Grosso, a predominantly flat region. This area has been developed into more than a satellite study area, owing to the importance of flat routes in the survey factorial.

c *Data Collection*

In recent months, our data-collection efforts and the quality of fieldwork in general have improved considerably. This is due in large measure to further concentration on training of newly hired field enumerators, but also to the greater familiarity the users now have with the objectives and methods of the research.

Access to company records is freer now than in the early stages of full-scale field work and our people have a better idea of where to look for useful data. The users, for their part, have more confidence in our ability to interpret their material correctly.

Since the beginning of our survey effort, we have identified 66 companies and 237 *autonomos* to participate in the study. For each of these panel members we have established a file showing the member's name, address, fleet size and commercial activities, among other items needed for future evaluations of the member.

Every vehicle considered suitable for inclusion in the study, also must be appropriately identified in considerable detail and placed on file. In establishing this file it has been necessary to make repeated calls on the members. At present we have a detailed description of 1261 vehicles on this file.

A number of our members have dropped out because they have disposed of their vehicles or we have not been able to maintain their interest. Also, where it has not been possible to establish reliable data, the member has been dropped. Currently, members are being screened to see where they fall in our factorial requirements. They are being dropped when the cost involved in collecting data from them is both high and they fall in cells already covered.

As a result of dropouts or of our elimination of some participants, we now have 41 companies and 59 *autonomos*, from whom we are currently collecting data. This reflects a response rate of 62% and 25% for the companies and *autonomos*, respectively. The vehicles still included encompass 285 buses, 166 trucks and 103 cars from companies, and 67 medium and light trucks from the *autonomos*, which represent about half our current vehicle file.

A substantial amount of detailed user costs data has been collected from the survey participants. This information encompasses all of the items classified as MSC in Table C.1. Since March of 1977, a concentrated effort was made to incorporate those data into computer files, where they could be structured for analysis. In the process, it has been established that the existing data-processing system is not efficient in handling a large part of these vehicle-cost data. First, the data needed to be carefully checked for consistency and accuracy. We find that initial computer editing rejects approximately 10% of the punched cards as being in error, and manual checking is revealing many more errors. For these reasons, more pre-checking of data was indicated, and this is now being done. Early in 1977, our office staff was understrength, although this situation has now improved with the hiring of two more clerks who have now been trained. Table C.4 shows that a considerable quantity of data has accumulated in the past few months, which has not been handled satisfactorily by the existing data-processing system. It also shows that important data items, par-

TABLE C.4 - USER COST SURVEYS - PROGRESS TO AUGUST 1977

Data Items	Collected	Processed	Checked and Analyzed
	Vehicle - Months of Data		
Fuel	7760	1840	1221
Motor Oil	7650	1750	1199
Oil changes	7650	1750	1147
Other oils	7320	1580	995
Grease	7480	1620	1029
Tire changes	6810	1340	933
Parts Costs	6550	1090	-
Labor Hours	3010	250	-
Loads	1900	1120	945

ticularly parts costs and labor hours, must be given special attention immediately. Information that is classified as collected means that it falls between being a copy of the user's documents and being coded and ready for keypunching. Processed material is keypunched and on file, but not yet rechecked and cleared for analysis. To date, only 13% of all data collected have been checked and those were the data used in the preliminary analysis. A second preliminary analysis is planned for the earliest possible date.

Nearly half of the information that must be processed is in a monthly rather than a daily form. A monthly data system has been designed which will enable the group to process these data. This system is in the final stages of programming, and it is hoped that the backlog of data will be cleared by the end of September. Shortly after that time, we will be able to access the data files to obtain details of the exact disposition of vehicle data items across the factorial cells.

In determining vehicles to be added to the survey in the future, it is now of much greater importance to consider the value of any given vehicle remaining in the survey, and the marginal value of potential new entries. To do this, we need to know, as exactly as possible, the position of the vehicles in the factorial cell design. Where cells are filled, the value of additional vehicles to the cell is negligible, as may be the value of existing vehicles in the cell if it is already overcrowded.

In contrast, the value of having vehicles in certain other cells, for example, heavy trucks on hilly, unpaved routes, will be very great, possibly more than ten times the present average data-collection cost per vehicle.

At this time, all the information we need to aid in decisions on survey membership is not yet available from the computer files, but the problem is being worked on and has been given top priority, as an essential element in guidance of future field work.

4 ROUTE SURVEYS

The Inception Report did not address in detail the issue of appropriate surveying procedures for user routes identified by the user costs surveys. It took over six months to develop:

- An efficient management structure for the survey team;
- The best instruments to measure highway characteristics for survey analysis;
- A numerical format for the measurement and analysis of routes;
- A training program for survey vehicle drivers and operators;
- Effective documentation for the recording and processing of route data.

The most important development was the transfer of all procedures, except vehicle servicing and instrument performance, to the User Surveys Group, making it responsible for the collection of both dependent and independent data items.

a *Survey Vehicle Performance*

Two fully instrumented survey vehicles with trained crews began work in December 1976, and a breakdown of performance this year is given in Table C.5. It is interesting to note that over 20% of the available time for both vehicles is spent in calibrating the Maysmeters and verifying their calibration. This highlights the importance placed on the reliability of roughness measurements in our survey program. Results to date indicate a productivity figure of appromimately 180 km of combined geometry and roughness data per working day. It is not felt that this figure will be improved, because travelling, as opposed to actually measuring, will increase as routes in Mato Grosso and southern Minas Gerais are identified.

It is estimated that since the start of the program the vehicles have measured over half of all routes giving good user-cost data, which suggests that all routes should be surveyed by May 1978.

b *Data Processing*

Routes identified for analysis are given a unique number and described using nodes which are three-digit numbers representing a specific geographic location. The route number and node sequence are then recorded on File 27, and an example of its output is given in Exhibit 1. No cost data are accepted unless the route codes assigned to those

TABLE C.5 - SURVEY VEHICLES ACTIVITIES JANUARY-JUNE 1977

	Vehicle 653	Vehicle 282	Both
Vehicle Repair	3	5	4
Defective DMI	2	5	3
Defective Maysmeter	15	2	9
Training Staff	0	2	1
Vehicle Maintenance	3	8	6
Adding Instruments	0	2	1
Verifying Calibration	6	12	9
Calibration Maysmeter	11	12	12
Administrative Problems	4	5	4
Total	44	53	49
Working	56	47	51

Note: Units in percentage of available time

ROTA	QUANTIDADE NOS	NOS
4176	17	305 303 316 477 326 335 329 332 333 332 329 335 326 477 316 303 305
4177	11	305 302 301 341 386 387 386 341 301 302 305
4178	15	305 302 301 327 306 307 308 334 308 307 306 327 301 302 305
4179	15	305 303 316 477 326 335 329 332 329 335 326 477 316 303 305
4180	11	305 304 319 352 320 321 320 352 319 304 305
4181	11	305 303 316 477 326 335 326 477 316 303 305
4182	13	305 302 301 341 386 387 336 387 386 341 301 302 305
4185	15	305 303 316 477 326 335 329 330 329 335 326 477 316 303 305
4186	31	305 302 301 327 328 323 324 479 561 480 481 482 398 397 396 395 396 397 398 482 481 480 561 479 324 323 328 327 301 302 305
4187	43	305 302 301 341 386 417 416 412 411 410 409 421 422 423 424 425 426 431 432 433 435 436 435 433 432 431 426 425 424 423 422 421 409 410 411 412 416 417 386 341 301 302 305
4188	15	305 304 337 344 345 346 347 484 347 346 345 344 337 304 305
4189	29	305 304 337 344 345 346 347 484 485 486 487 488 490 491 492 491 490 488 487 486 485 484 347 346 345 344 337 304 305
4191	05	323 496 497 496 323
4194	15	388 409 421 440 442 443 511 445 511 443 442 440 421 409 388
4195	13	388 409 421 440 442 506 507 506 442 440 421 409 388
4196	15	388 389 390 391 392 393 394 508 394 393 392 391 390 389 388
4197	17	388 389 390 391 392 393 394 395 396 395 394 393 392 391 390 389 388
4198	11	388 389 390 563 564 446 564 563 390 389 388
4200	13	388 409 410 411 412 414 415 414 412 411 410 409 388
4201	15	388 409 410 411 412 416 417 418 417 416 412 411 410 409 388
4202	15	388 409 410 411 412 416 418 325 418 416 412 411 410 409 388
4203	23	388 409 421 422 423 424 425 426 431 432 433 434 433 432 431 426 425 424 423 422 421 409 388
4204	15	388 409 421 422 423 424 425 426 425 424 423 422 421 409 388

EXHIBIT 1 - Example of the Route Link File

data are described on this file. Two hundred routes located in DF, Goiás and Minas Gerais are presently held on the file, and routes in Mato Grosso and southern Minas Gerais will be added in the next three months.

The geometry file* contains about 12000 km of data, and examples of the output from the vertical and horizontal link geometry program accessing this file are given in Tables C.6 and C.7. The roughness file has 14020 km of combined paved and unpaved route data, and exceeds the size of the geometry file because of replicate route sections. The file has been designed to accept replicates so that a time series analysis can be conducted on unpaved routes to capture the range of roughness and ensure more accurate independent data for analysis. This replicate program is scheduled to start in 1978, after all routes have been surveyed once for geometry and roughness data.

c *Roughness and Geometry Algorithms*

Survey vehicles produce a flow of data on geometry and roughness characteristics which must be transformed into a single route statistic for each independent variable. Each statistic must produce a suitable range for analysis and at the same time preserve the key characteristics of the variable being measured. Small but very rough sections, for example, within a moderately rough route need to be captured by the statistic so that the full impact of roughness on user costs is retained for analysis.

Geometry and roughness algorithms were developed as initial attempts to quantify these important route variables. Output from the geometry algorithms, by link, are given in Exhibit 2 and links are combined into appropriate routes for analysis. A priori, a link with a steep positive grade in one direction and therefore a steep negative grade in the other, should impose different costs on a vehicle, depending on its direction of travel. The geometry statistics for each link produced by the algorithm reflects the direction of travel of any vehicle by following its route description on the route file. We believe this represents an improvement over the rise-plus-fall statistic.

Roughness output shown in Exhibit 3 is part of the program to calculate this independent statistic. It can be seen that sections or bands of roughness within a link are calculated, where roughness is not uni-

*The current status of route files is given in Table C.8

TABLE C.6 - OUTPUT FROM LINK GEOMETRY FILE: VERTICAL DATA

LINK 260292

NUMERO DO GREIDE	COMPRIMENTO METROS	VALOR DO GREIDE
1	270	4.0 %
2	720	-5.0 %
3	530	6.0 %
4	290	-1.0 %
5	790	-2.0 %
6	470	-4.0 %
7	740	6.0 %
8	590	1.0 %
9	510	-2.0 %
10	520	-6.0 %
11	770	5.0 %
12	1190	-2.0 %
13	570	-5.0 %
14	930	6.0 %
15	1050	1.0 %
16	740	3.0 %
17	610	-3.0 %
18	1110	0.0 %
19	1350	-5.0 %
20	470	5.0 %
21	540	-1.0 %
22	610	3.0 %
23	630	-5.0 %
24	420	2.0 %
25	480	-4.0 %
26	420	4.0 %
27	890	-2.0 %
28	500	2.0 %
29	510	1.0 %

TABLE C.7 - OUTPUT FROM LINK GEOMETRY FILE: HORIZONTAL DATA

LINK 260292

NUMERO DA SECAO	TIPO DA SECAO	RAIO (METROS)	ANGULO SUBTENDIDO	DIRECAO	COMPRIMENTO (METROS)	PAVIMENTO
1	T				1570	P
2	C	720	23	E	290	P
3	T				790	P
4	C	700	38	D	470	P
5	T				430	P
6	C	630	28	E	310	P
7	T				3680	P
8	C	850	12	D	180	P
9	T				5760	P
10	C	1140	9	E	180	P
11	T				1250	P
12	C	600	20	E	210	P
13	T				160	P
14	C	550	38	E	370	P
15	T				600	P
16	C	550	33	D	320	P
17	T				1210	P
18	C	1030	5	E	90	P
19	T				790	P
20	C	1140	10	D	200	P
21	T				510	P

LINK	% PAV	CLASS 1 NUMERATOR		COMPLIMENTS
		HORIZONTAL	VERTICAL	(KMS)
409388	1.00	12.56	105.54	18.28
388409	1.00	12.33	105.86	18.28
409421	1.00	7.66	92.37	17.77
421409	1.00	7.31	100.64	17.77
410409	1.00	1.52	21.84	3.94
409410	1.00	1.56	15.86	3.94
410420	1.00	2.76	38.62	6.53
420410	1.00	2.65	37.26	6.53
411410	1.00	13.80	149.32	30.37
410411	1.00	13.54	134.73	30.37
412411	1.00	13.84	224.45	36.11
411412	1.00	13.79	196.39	36.11
412414	1.00	6.57	143.64	17.78
414412	1.00	7.45	138.40	17.78
414415	1.00	12.25	146.30	20.91
415414	1.00	11.74	177.79	20.91
416412	1.00	4.32	52.40	10.93
412416	1.00	4.26	59.45	10.93
417416	1.00	10.78	189.23	27.36
416417	1.00	10.77	195.18	27.36
417418	1.00	12.89	111.29	20.54
418417	1.00	11.95	172.10	20.54
417419	1.00	1.06	22.93	1.72
419417	1.00	1.57	7.55	1.72
421422	1.00	3.23	34.30	6.89
422421	1.00	3.19	40.94	6.89
421440	1.00	10.62	134.08	21.84
440421	1.00	11.19	95.54	21.84
422423	1.00	6.78	52.34	11.85
423422	1.00	6.07	91.99	11.85
423424	1.00	5.55	39.00	9.13
424423	1.00	4.64	91.07	9.13
424425	1.00	6.93	103.94	17.24
425424	1.00	6.35	116.38	17.24
425426	1.00	11.31	156.12	23.34
426425	1.00	10.94	157.23	23.34
426431	1.00	14.87	198.12	23.93
431426	1.00	14.96	151.76	23.93
431430	1.00	7.58	61.23	11.67
430431	1.00	7.39	72.76	11.67
431432	1.00	5.70	52.44	8.18
432431	1.00	5.00	97.96	8.18
432433	1.00	6.19	62.60	9.83
433432	1.00	5.85	68.30	9.83
433434	1.00	3.41	24.15	7.95
434433	1.00	3.19	46.16	7.95
433435	1.00	4.21	29.21	4.76
435433	1.00	4.34	37.79	4.76
435436	1.00	7.42	51.29	12.38
436435	1.00	6.28	101.58	12.38
440441	1.00	1.36	24.57	2.37
44144	1.00	1.1[illegible]	25.55	2.37

EXHIBIT 2 - Horizontal and Vertical Link Statistics Generated, in Both Directions, by the Geometry Algorithm Program for Paved and Unpaved User Routes

LINK	EST.	PROCEDENCIA	DESTINO	PAV	VEIC	DATA DE TESTE	NO. DA SECAO	IRR MEDIA CONV	DESVIO PADRAO	DISTANCIA (KMS)
							4	225	31.5	4.18
510400	MG-184	CARMO RIO CLARO	ENT CCNC APAR	P	C653	18/04/77	1	261	119.5	0.64
							2	145	47.4	0.64
							3	166	35.5	13.20
							4	234	27.0	0.64
402388	BR-167	ENT TRES PONTAS	ENT VARGINHA	P	C653	17/04/77	1	269	159.8	0.64
							2	154	17.2	3.22
							3	271	11.1	1.28
							4	188	29.1	1.61
							5	209	72.8	0.65
							6	220	26.9	0.64
							7	133	22.6	2.58
							8	216	22.6	1.28
							9	157	33.7	4.19
							10	227	60.0	0.64
							11	136	31.1	7.73
351350	BR-262	STA BARBARA	B COCAIS	P	C282	25/04/77	1	103	15.3	10.94
354356	BR-356	ENT MARIANA	ENT ALCAN	P	C282	23/04/77	1	144	17.2	14.16
562316	BR-356	OURO PRETO	ENT C/ BR-040	P	C282	23/04/77	1	61	14.9	61.15
349364	BR-262	CHETE BH	B HORIZONTE	N	C282	25/04/77	1	292	107.5	30.69
021022	MG-223	MG223ENT.M.CARM	MG-223ENTCASC.R	P	C282	17/02/77	1	74	15.3	49.24
017023	MG.190	E.BR352 MG190	MG190 M CARMELO	N	C282	17/02/77	1	483	85.0	22.20
480561	MG-446	ENT PASSOS	ENT ALFINOPOLIS	P	C282	05/04/77	1	97	23.4	25.17
520310	BR-262	ENT BR-354	ENT P/BARUI	P	C282	20/03/77	1	60	17.9	11.90
310309	BR-262	ENT BARUI	ENT LUZ	P	C282	29/03/77	1	91	23.0	42.48
359356	BR-365	BR365TREVOPATOS	BR-365PATROCINI	P	C282	15/02/77	1	74	20.1	64.69
273272		PETROLINA	NEROPOLIS	P	C282	30/01/77	1	118	34.6	10.94
							2	104	25.7	27.03
035057	BR-153	ENT GOIATUBA	ENT BURIT ALEGR	P	C282	01/02/77	1	64	33.0	6.75
035057	BR-153	ENT GOIATUBA	ENT BURITI ALEG	P	0436	17/11/76	1	80	19.5	6.75
036037		ENT ITUMBIARA	ITUMBIARA	P	0436	17/11/76	1	59	13.9	1.60
234226	GO-174	MONTIVIDIU	AMORINOPOLIS	N	0436	09/12/76	1	428	116.7	0.64
							2	262	126.9	2.57
							3	247	91.8	115.67
043244	BR-060	ENT STA HELENA	BR060ENT GO 407	P	0436	02/12/76	1	69	13.0	21.66
042545	BR-060	BR060ENTJANDAIA	BR060ENTPARAUNA	P	0436	02/12/76	1	59	12.5	51.49
045046	BR-060	BR060ENTPARAUNA	ENT STA HELENA	P	0436	02/12/76	1	57	22.6	25.49
299040	BR-060	GOIANIA	ENT. PALMEIRAS	P	0436	01/12/76	1	57	13.1	56.90
542541	BR-050	ITUVERAVA CENT	ITUVERAVA ENT	P	C282	11/03/77	1	136	22.4	1.93
							2	51	6.2	0.64
534533		UBERABA-CENTRO	ENTRADA-UBERABA	P	C282	10/03/77	1	121	15.7	1.93
364365	BR-365	TREVO-CAMPINOP	ENT-ITUIUT	P	0436	03/02/77	1	125	21.9	0.64
							2	75	9.0	0.64
170182		BRASILIA	UNAI	N	0436	03/11/76	1	383	109.5	65.01
157142		DOIS IRMAOS	BARRO ALTO	N	0436	05/11/76	1	225	97.2	37.65
181182		CABECEIRAS	UNAI	N	0436	10/11/76	1	555	115.1	76.92

EXHIBIT 3 - Link Roughness, in Maysmeter Counts per .2 Mile, Converted to a Measurement Speed of 80 kph and Grouped, where Roughness is not Uniform, into Sections of Roughness within each Link

TABLE C.8 - STATUS OF ROUTE FILES: AUGUST 1977

	File Number	Status
Route Link File	F27	200 routes coded
Roughness File	F73	9070 km paved 5950 km unpaved
Geometry File	F25	12000 km

form, as part of the algorithm. The roughness values are converted from the measurement speed, where necessary, to 80 km/h, and the program gives mean and standard deviation values for each section of roughness at that speed. These data are then converted to QI counts per km by referencing the car, the date of measurement and the relevant calibration equation.

The roughness and geometry programs now enable the team to evaluate the importance of a route in terms of its position in the analytical factorial, where the route links have been surveyed. This will provide an important management, as well as analytical, procedure of the project.

5 *PRELIMINARY RESULTS*

A preliminary analysis of the user-costs data was made to test our complete study program and to see if it was suitably designed to produce the desired quantitative relationships between user cost and highway design characteristics. The data-processing system to handle the survey data has not yet been totaly programmed and therefore many of the data files are incomplete. Nevertheless, it was possible to perform an analysis for a portion of the companies and their routes. The probability of obtaining meaningful relationships from this analysis was small, but it was recognized that the main benefits would center on testing the effectiveness of the collection and processing systems. These results were considered vital in ensuring the efficient management of the surveys in the second half of the project. Accordingly, 19 companies that were expected to produce good cost data and whose routes had been surveyed were selected for this analysis. Operating-cost and vehicle-characteristics data were manually prepared from summary reports of various vehicle files. Single statistics for vertical and horizontal geometry by user route were produced by manually summarizing data that had been produced at a link level. A QI (quarter car simulator base system roughness measurement) was developed for each route using the file modification and manipulation capabilities of SAS. The cost and route characteristic values, by vehicle type, were then keypunched and SAS used to analyze the data.

a *Analysis of Data*

The operating-cost data compiled from 19 companies comprised of 165 vehicles: 87 2-axle trucks, 39 3-axle trucks and 39 buses.

The routes of these companies exhibited high correlations between the major independent variables. Table C.9 shows the spread of the vehicles across the various factorial cells. The distribution of vehicles within the factorial cells reflects the high correlations that existed between the horizontal and vertical components. Buses, in particular, are almost entirely confined to the rolling geometry level. Of all the vehicles, 56% are located in the rolling, straight and smooth factorial cell. These high correlations made it impossible to separate the effects of the various route components.

b *The Data-Processing Systems*

The data-processing system that was designed to edit and place survey vehicle measurements from the user survey routes on computer files, consolidate this information to produce a single statistic of geometry and roughness, and associate this information with operating-costs data by vehicle, works very well and no changes are recommended for this processing system.

The data-processing system designed to handle the flow of vehicle operating-cost data did not work as planned and is considered unsuitable to the needs of the field enumerators. The existing system is designed to develop information on a daily basis. The problem is that daily records do not reveal discrepancies in the data which are obvious when that same information is summarized monthly. Also, the daily records have created a workload burden that has overwhelmed our office clerical staff with the consequence that the records have not been diligently screened, and many errors are detected by program edits. The data rejected by the edits must be corrected before they are stored on a computer file. This file is then processed for consistency and the generation of summary outputs where data are again screened. These latter summaries are revealing discrepancies that must be resolved at the field level.

Frequently, three to four months pass before all data on user vehicles are collected and processed. Field enumerators find it

TABLE C.9 - MIDTERM ANALYSIS - VEHICLES IN FACTORIAL

ROUGHNESS	HORIZONTAL	VERTICAL: ROLLING 4.5-7	VERTICAL: HILLY 7 +
SMOOTH 0 - 50	0 - 0.3	42 2-axle trucks 23 3-axle trucks 28 Buses	
SMOOTH 0 - 50	0.3 +		8 2- axle trucks 13 3- axle trucks
MEDIUM 50 - 90	0 - 0.3		
MEDIUM 50 - 90	0.3 +		
ROUGH 90 +	0 - 0.3	8 Buses (Note: No Roughness Statistic available for 6 Buses)	
ROUGH 90 +	0.3 +		37 2- axle trucks 3 3- axle trucks 3 Buses (Note: No Roughness Statistic available for 1 Bus)

difficult to correct errors that are identified as having occurred four months in the past. The system is currently being modified so that the field enumerators collect monthly rather than daily information. The forms to implement these changes had already been developed to handle the monthly summary data available historically from many of the users. Therefore, the changes currently being made in the system are expected to be smoothly implemented.

c *Route Statistics Algorithms*

The roughness algorithm produced values ranging from 23.9 to 177.7 (QI counts per km) which corresponded with subjective assessments of what constituted the best and worst route. The tentative boundaries for this independent variable range from 0 to 49 (smooth), 50 to 90 (medium rough), and 90 + (rough), with these intervals expressed as QI/km. A route which incorporated a long section of the smoothest route, but then went on to a very rough final section had a QI value of 49.8 counts per km with a standard deviation of 50.1, which is what one would have expected. The roughness algorithm seems to be very satisfactory and QI values by route type are given in Table C.10.

The range of vertical geometry for complete routes (two-way) was from 4.3 to 12.1. The latter (12.1) route had a one-way value of 19, which is likely to be as extreme as will be found in Brazil. The tentative boundaries for vertical geometry are: less than 4.5, flat; 4.5 to 7, rolling; 7 and above, hilly. Flat routes, however, have not yet been placed in the analytical factorial for lack of data, which will only be obtained from surveys to be conducted in Mato Grosso. The definite analytical factorial will be the same as shown in Table C.9, with flat route results included. It is considered that the vertical geometry algorithm gives adequate discrimination for statistical analysis, although changes may be made after further analysis.

The horizontal algorithm produced values from 0.10 to 0.84, and was considered to have achieved an adequate range of values. The tentative boundaries for this item range from 0 to 0.3 (relatively tangent) and more than 0.3 (relatively curvilinear). Traffic data were produced for each route and ranged from 181 to 8279 ADT, and although they were not finally utilized in the analysis, the team has shown a capability of producing route traffic data.

TABLE C.10 - ROUTE FACTORIAL AND ROUGHNESS (QI) VALUES

M = Mean

S = Standard Deviation

	ROLLING						HILLY		
PAVED	1.	M	23.9	7.	M	34.6	1.	M	37.9
		S	8.4		S	5.3		S	8.6
	2.	M	25.8	8.	M	35.9	2.	M	43.7
		S	14.6		S	12.5		S	21.8
	3.	M	22.9	9.	M	31.3	3.	M	37.2
		S	24.2		S	9.4		S	2.0
	4.	M	43.8	10.	M	40.1	4.	M	36.3
		S	11.9		S	15.3		S	2.8
	5.	M	33.3						
		S	7.8						
	6.	M	43.2	11.	M	27.5			
		S	4.9		S	1.5			
MIXED	1.	M	49.8				1.	M	177.7
		S	50.1					S	52.4
	2.	M	36.8				2.	M	138.2
		S	4.9					S	76.0
	3.	M	42.3				3.	M	100.0
		S	28.9					S	69.0
UNPAVED	1.	M	132.6	4.	M	146.5			
		S	32.2		S	40.9			
	2.	M	94.9	5.	M	138.3			
		S	38.6		S	30.4			
	3.	M	105.3	6.	M	151.9			
		S	27.4		S	49.1			

The subjective assessments of geometry and roughness used by the team in placing routes into factorial cells correlated well with the statistics produced by the algorithms used in the preliminary analysis.

However, the limited number of routes analyzed did not produce the spread across the factorial required for a good statistical analysis. Routes which were hilly were also generally rough and curvy. This problem is highlighted by the most extreme vertical route (12.1), which also had the highest roughness (177.7) and horizontal (8.84) values.

d *Summary of Preliminary Analysis*

This preliminary examination of a portion of the surveys data did not produce any meaningful relationships. It did, however, stimulate thought on how the independent data should be utilized to direct the field team efforts towards critical factorial cells. One such procedure would involve calculating all algorithmic values for all routes presently surveyed and guiding the field teams toward key routes for analysis.

The trade-off between what can be most efficiently collected, with given resources, against what is desirable from the analysis viewpoint, remains the key to the success of the project. The statistical exercise has resulted in the development of a meaningful analytical factorial, which can be filled by the Surveys Group and appears effective for the project statisticians. In this respect alone, the statistical analysis was a constructive exercise since it quantified the previous qualitative factorial for vertical, horizontal and roughness values.

It is proposed to evaluate the resultant factorial by conducting a further analysis including vehicle parts costs data, in November or December 1977, when all the necessary computer programs and files are completed. In the meantime, the computer program for route-characteristic data will be run on all existing route data, so that routes of special interest to the analyst can be given a priority in the field cost-collection activities. It remains our intention to "attempt to initially obtain equal cell sizes in the factorial and to have the biggest sample size our resources will permit, consistent with data quality" (Ref. 2).

6 SUMMARY

A work program for the remainder of the project is given in Figure 8 and this shows that a closely coordinated series of activities are required to produce the user-cost input relationships for the Model, by July 1978. Preliminary analysis has revealed the need to change certain procedures so that data can be processed and analyzed on a routine basis. No organizational changes are considered necessary at this point in time. If it becomes obvious that specific factorial cells are underpopulated, some relocation of field staff will be made to search for the relevant cost data.

7 PROCEDURES

All route data on file are being analyzed so that routes can be positioned in the quantitative factorial. All vehicles on the vehicle-data file will be assigned to their routes in this factorial, and an examination will be undertaken of data quality per cell, particularly parts-cost data. This procedure will allow the team to focus on those areas of the analytical factorial not yielding good data.

Field staff will not be permitted to recruit new survey members unless they can show that good data are available. Good data mean accurate values for fuel, oil, tires, parts and labor, collected from routes with a wide variety of geometry and roughness characteristics. If this results in a smaller survey, field staff can spend more time checking data quality.

The preliminary analysis showed that some fully surveyed routes were not being used by vehicles on the vehicle-data file. In the future, only those routes yielding good cost data will be surveyed. It is also thought that the route network will begin to stabilize towards the end of 1977, as fewer new routes are identified. This will allow the survey vehicles to begin a program of replicate roughness measurements.

A monthly system of user-cost data collection is now being implemented. It will enable a more thorough check on data quality to be made by the researchers and also significantly reduce the volume of cards, and hence the load, for data processing. The computer programs for this system must carry the highest priority within the User Surveys Group.

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WORK PLAN AND SCHEDULE

ACTIVITY	1977								1978						
	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N
Collect user cost data	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Survey user routes	X	X	X	X	X	X	X	X	X	X	X	X			
Replicate roughness and geometry measurements on selected routes					X	X	X	X	X	X	X	X	X		
Collect user tachograph data	X	X	X	X	X	X	X	X							
Program monthly user cost collection and processing system	X	X													
Program cost data reports for users			X	X	X	X									
Process user cost data	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Process route survey data	X	X	X	X	X	X	X	X	X	X	X	X	X		
Position existing routes into cells of quantitative factorial	X	X													
Develop constant price system	X	X													
Analyze depreciation data			X	X	X	X	X	X	X	X	X	X	X		
Develop standard labor hours data and relationships			X	X	X	X	X								
Develop traffic data by route		X	X	X	X	X	X	X	X						
Analize data to establish user cost and route relationships	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Define all user cost inputs for model	X	X	X	X	X	X	X	X	X						
Provide input relationships for model					X	X	X	X	X	X	X	X	X	X	X

FIG. 8

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WORK PLAN AND SCHEDULE

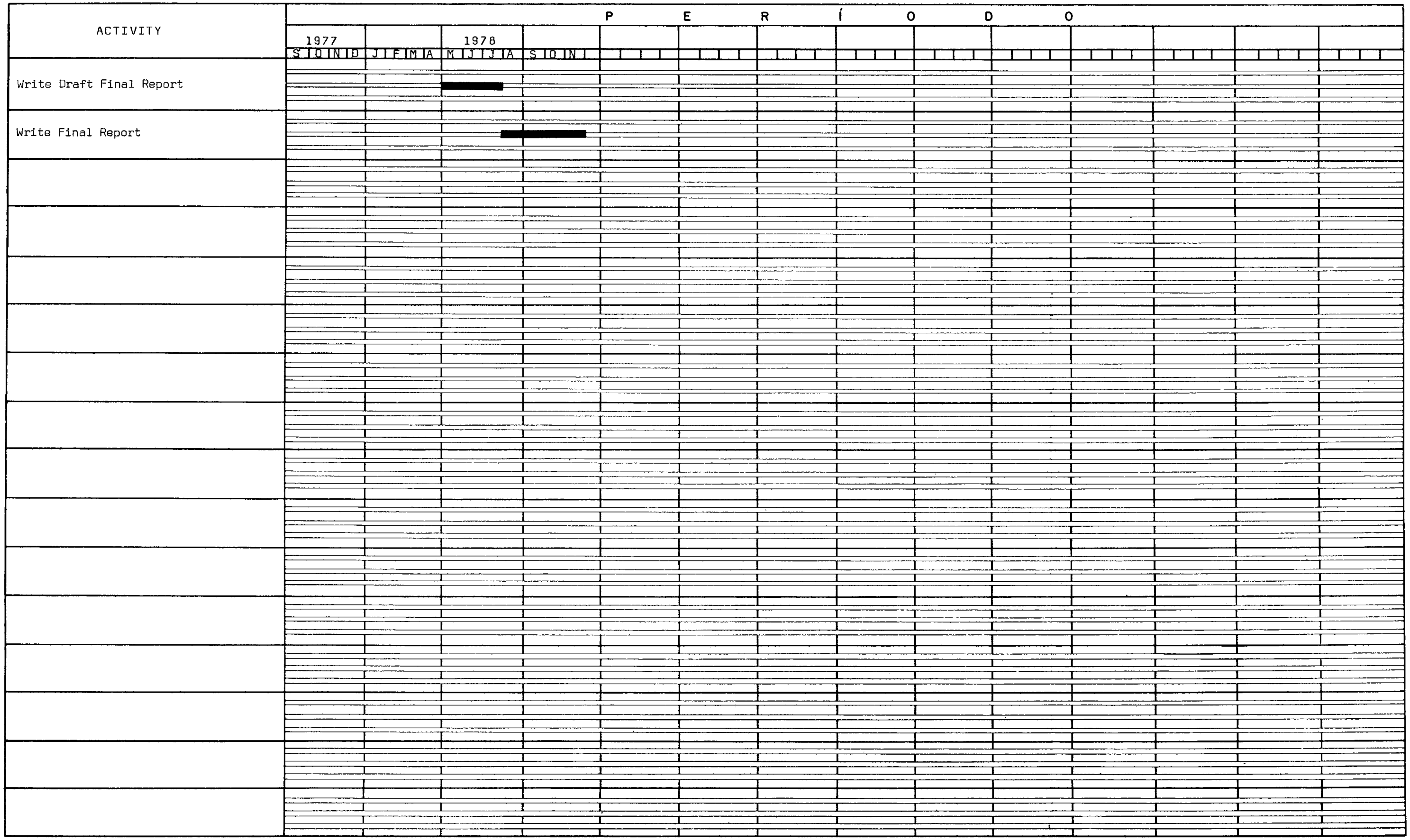

FIG. 8 (CONT.)

8 COMPUTER SUPPORT

The main implication arising from the preliminary analysis is that unless data preparation, processing and analysis can be quickly brought up to date, and thereafter kept current, it will be impossible to provide the necessary data for the final analysis to develop relationships for the model by July 1978.

An estimated average of 28,000 keypunched cards must be handled per month until April or May 1978, when survey-car activities begin to diminish. It is essential that computer support for our group be geared to handle the keypunching, verifying, processing, editing, correcting, and updating of the group's three major computer files and five smaller ones, on a routine monthly basis.

9 DATA COLLECTION

A long lead time is required from first contact with a vehicle operator to the time when a sufficient quantity of accurate data is on a clean file. This lead time is often three to six months, and both hard work and good fortune are necessary to find good contacts. Therefore, search activities for new users must cease in March 1978. Further, only users with good-quality data extending for a minimum period of 12 months will be accepted as survey respondents. This means that it may not be possible to fill some factorial cells for final analysis starting in June 1978.

10 THE COMPUTER MODEL

In the present study, data are being collected to derive relationships for use within the model.

When the model itself is finally ready for use, the model user will find that more data collection in the operational-cost area is necessary. The model user must provide the following inputs in order to use the model:

- Unit costs of petrol, diesel fuel, oils, maintenance labor, new vehicles, tires, driver's and passenger's time;
- Information on standing or fixed costs both for private

cars and commercial vehicles;

- Information on taxes of all items used in vehicle operation and other transfer charges, such as annual licence fees, since the model may be used in either the "financial" or "economic" mode;
- Foreign exchange components of costs, particularly those for fuel, oils and tires.

CHAPTER D

ROAD USER COSTS AND TRAFFIC EXPERIMENTS

1 ORGANIZATION AND OBJECTIVES

Time and fuel savings are two important benefits which can result from road improvements. The Road User Costs and Traffic Experiments Group was established to investigate in detail the relationships between these two components of user costs and roadway characteristics. The main objective of the Group is to produce a model for predicting speeds and fuel consumption for Brazilian driving conditions, as a function of the road's geometry and surface quality.

To meet the objective, a model is being developed for estimating the speeds and fuel consumption of each vehicle class, as it traverses each section of roadway in a sequential manner. This approach requires relationships for predicting the speed and fuel consumption of each vehicle class, as a function of the individual geometric features of a roadway. To accommodate the variability of driver behavior and vehicle performance, empirical rather than theoretical relationships are being developed. Thus, a large experimental program was designed for collecting the data needed to develop regression equations for predicting the speed and fuel consumption of each vehicle class, as it traverses any roadway. The experiments were designed to include extremes of roughness and geometry, so that the relationships developed have the widest possible inference space.

A microscopic simulation model of the traffic-flow process is being developed to investigate how traffic volume and composition affect speed and fuel consumption of vehicles on homogeneous sections. In this model, vehicle-to-vehicle interactions are being realistically modeled to show the impact of various levels of traffic volume and composition on the speeds and fuel consumption of individual vehicles, as they traverse sections with specified characteristics. A staff of 39 was assembled to perform the experiments and develop the necessary models. As Figure 9 shows, this team consists of four engineers, a field supervisor, two clerks, a four-man survey crew, 15 observers, nine test drivers, an instrumentation technician, and three drivers. This team is divided into two field crews and a support staff. One engineer, six observers, and two drivers make up the radar crew which collects data on traffic speeds. The field supervisor, nine observers, and nine test drivers make up the fuel-consumption experiments crew. Nine vehicles representing seven classes, are used in the fuel-consumption tests.

Checking and organizing the data is an important task of the

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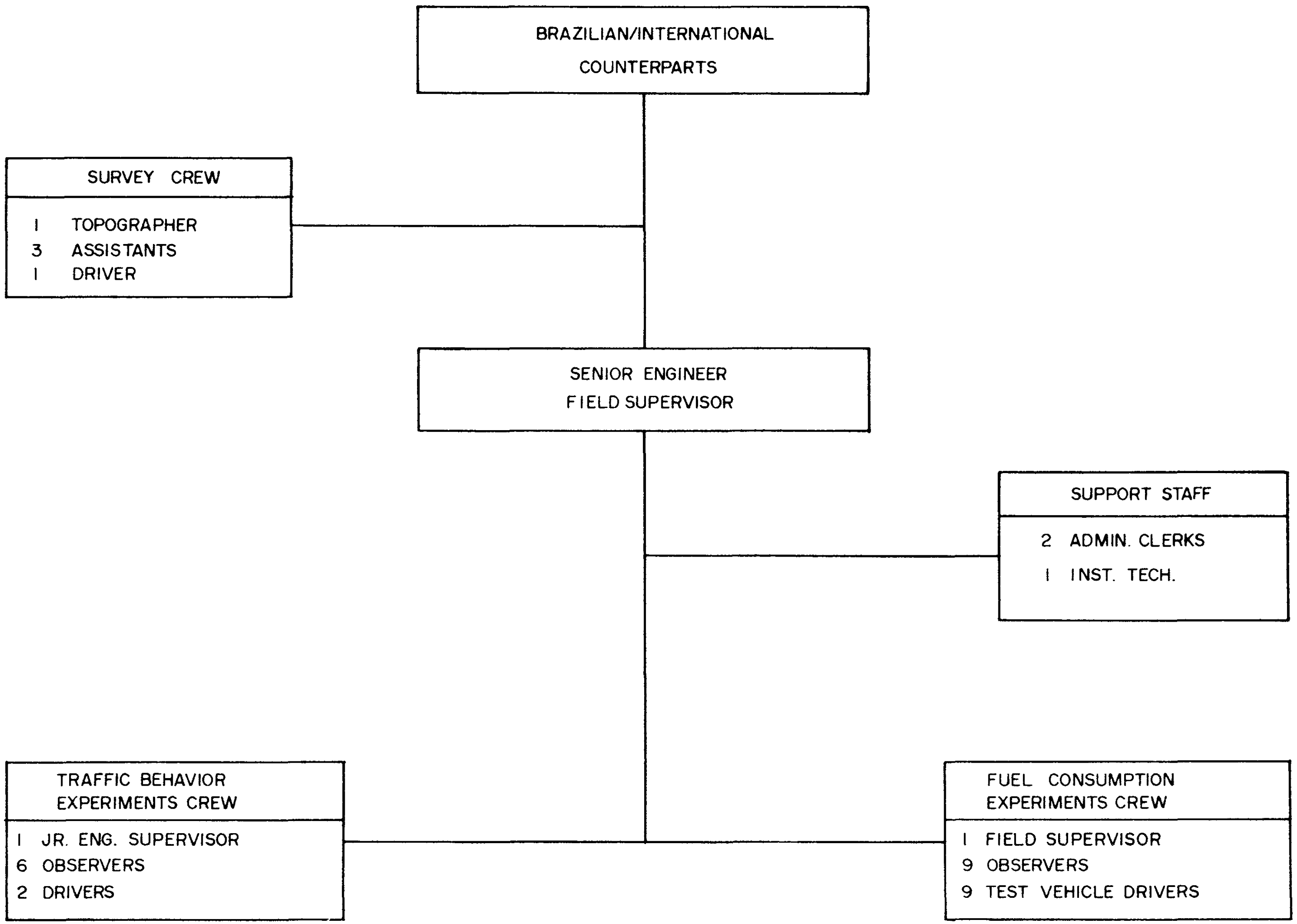

FIG. 9

ROAD USER COSTS AND TRAFFIC EXPERIMENTS PERSONNEL CHART support staff. To facilitate this task, all data are collected on forms which allow direct keypunching. After the data is collected, it is returned to the office for filing and manual editing as shwon in Figure 10. After key punching the data are edited for logic and limit errors and placed on permanent file.

The experimental program is being conducted primarily in the Federal District to minimize the cost of transporting the crews. However, when sections could not be found in the Federal District they were located in the States of Goiás and Minas Gerais, as shown in Figure 3, chapter A.

2 *MODELS*

The Road User Costs and Traffic Experiments Group is developing two models. A Time and Fuel Algorithm (TAFA) computes the physical quantities of time and fuel consumed by each vehicle class as it traverses any section of roadway. This algorithm will be an integral part of the Brazil Highway Investment Analysis Model. The second is a detailed traffic-flow simulation model called SOFOT. This model will be used primarily as a research tool within the project to study the impact of traffic volume and composition on speed and fuel consumption.

a *Time and Fuel Algorithm* (TAFA)

The purpose of the Time and Fuel Algorithm is to predict the quantities of time and fuel used by each vehicle class as it traverses a road section. In TAFA, the individual geometric features of the roadway are analyzed consecutively. This approach is different from the one used in existing highway investment analysis models where the characteristics of the roadway being analyzed are represented by indices which describe the average characteristics of the roadway, such as the use of average rise and fall in the TRRL model. TAFA is an improvement over the index approach, in that the possibility of having two roadways with different characteristics but similar indices, is completely avoided.

The inputs to TAFA consist of parameters describing the traffic and roadway characteristics. The traffic parameters include hourly volumes by vehicle classification. The roadway characteristics are surface type, roughness, and details of vertical and horizontal alignment.

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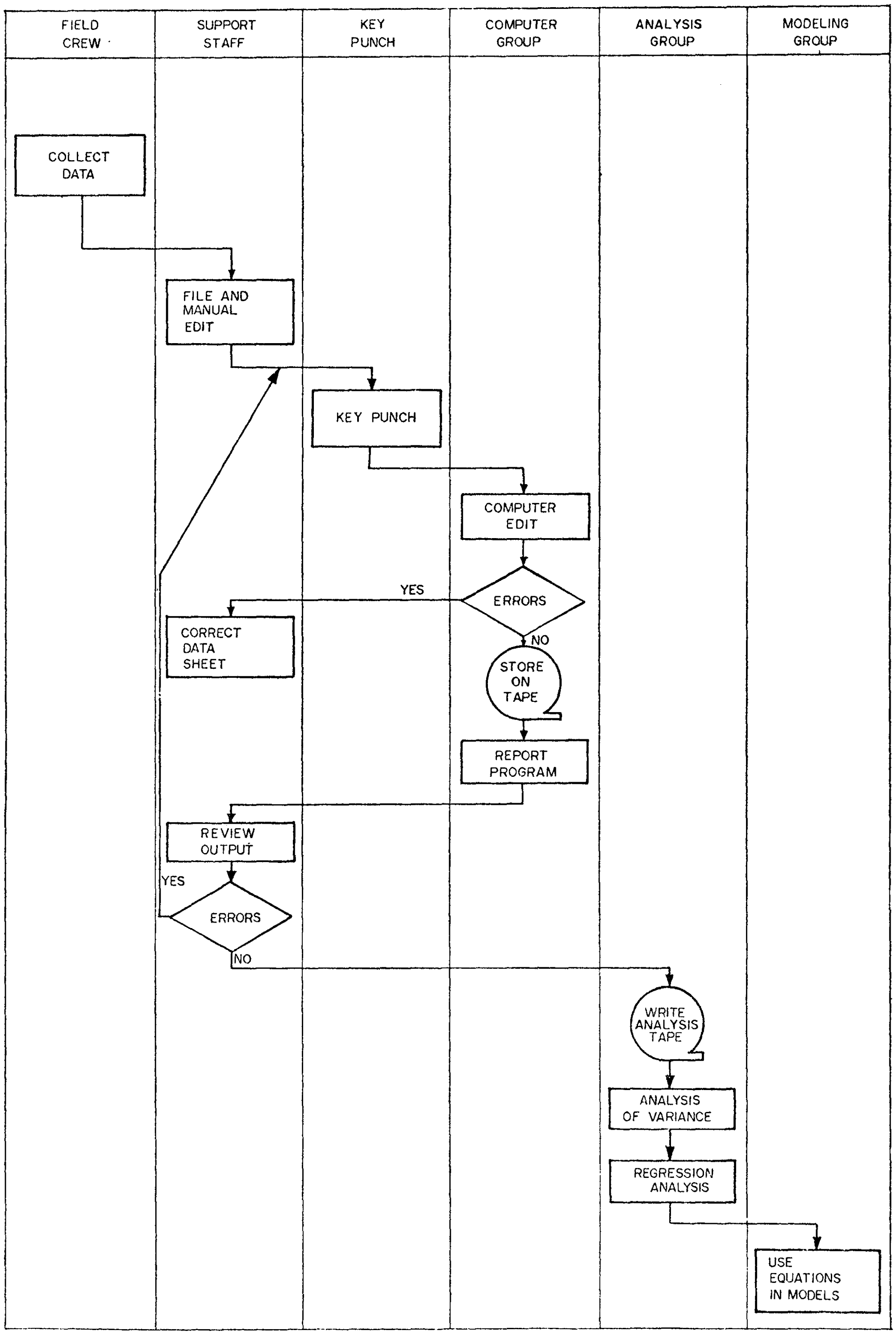

FIG. 10

DATA PROCESSING FLOW CHART

TAFA can be summarized in four steps which are repeated for each vehicle class. These steps are:

- Development of an initial speed profile, based on the vertical profile of the roadway and the performance characteristics of the vehicle class;
- Development of a free-speed profile by modifying the initial speed profile to account for the effect of horizontal alignment on speed;
- Modification of the free-speed profile for traffic volume and composition, thus producing an operating-speed profile;
- Calculation of time and fuel by each vehicle class, as a function of operating speeds.

The initial-speea profile for a vehicle class is computed by sequentially calculating the expected speeds of the vehicle class, as it traverses each constant grade section. The spot speeds of each vehicle class are calculated at points of transition between grades and/or modes of operation. The spot speeds calculated at this point in the model are independent of the effect of horizontal alignment and traffic.

After the initial-speed profile matrix has been established, the model then considers the effect of the horizontal alignment on the vehicle speeds. This is done by sequentially considering the properties of each individual curve. For each curve, the average speed of the vehicle class is calculated. This speed is then compared to the initial-speed profile at this point on the roadway. If the avegage speed for the curve is greater than or equal to the initial speed, then the curve has no effect on the speed profile and the next curve is selected from the horizontal alignment table. When a curve is found with a lower expected speed than the speed in the initial-speed profile, then the effect of the curve must be calculated and the speed profile modified.

The results of this process define the free-speed profile for the vehicle class. This profile is actually the average speeds of a typical vehicle in the vehicle class, if other traffic is not affecting the speed of the vehicles. Since the true or operating speed of vehicles will be affected by the volume and composition of traffic, parameters will be developed for estimating the operating speed of each vehicle class as a function of the free speed, the roadway geometry, and the traffic volume and composition. By applying these parameters to the free-speed profile for each section of roadway, an operating-speed profile can be developed. From the operating-speed profile, the time and fuel consumption of the vehicle class will be obtained for each combination of traffic volume and composition. The total time and fuel consumption for each vehicle class will then be obtained by summing the time and fuel consumption for each period of specified traffic volume and composition.

Flow charts have been developed for accomplishing the first step of the Time and Fuel Algorithm, i.e., the calculation of the initial-speed profile. Flow charts for accomplishing the second step, modifying the initial-speed profile to produce the free-speed profile, are presently being developed. Programming of the model has not been started.

b *Simulation of Traffic Flow (SOFOT)*

The traffic-flow simulation model will provide the project with a research tool capable of generating data relating traffic volume and composition to time and fuel consumption for specific roadway characteristics. Initially, consideration was given to collecting the data experimentaly, but it was realized that traffic composition and directional split could not be controlled in conjunction with the other independent variables. Hence, these factors were to be used as covariates. This then indicated that unless the experiment was massive, variations in traffic composition and directional split would probably be small, and hence the relationships developed from such an experiment would have a limited inference space. Furthermore, fuel-consumption data could not be collected from this type of experiment. After examining other approaches for obtaining these data, development of a simulation model was selected as the most feasible alternative. It was reasoned that the simulation model, once calibrated, could be operated outside the inference space of the field observations, by using different traffic volumes, compositions, and directional splits, to produce the data necessary for developing models which could be used in TAFA for developing the operating-speed profile.

For the convenience of the user, the input to the model has been divided into two files. One file contains data about the free speed of vehicles as they traverse the roadway. The data in this file does not have to be altered when studying the effects of traffic volume and composition for a particular roadway. The second file consists primarily of traffic data, such as volume, percentage of vehicles in each class, and directional split, and parameters controlling the length of the run and the points of output.

Vehicle arrivals at the start of the section are randomly generated. Schuhl's distribution (Ref. 3) is used to determine the headway between vehicles at the start of the section. Vehicle Classifications are randomly assigned, but weighted according to the percentage of vehicles in each class. As each vehicle is generated, it is given a performance rating to reflect the variability of individual driving behavior. A normal distribution, truncated ± 2 standard deviations, is used to weight the distribution of performance ratings.

Once the arrival distribution of the vehicles has been determined, the program uses a periodic-scan technique to move the vehicles along the section. Processing of the vehicles along the roadway involves the simulation of vehicle-roadway and vehicle-vehicle interactions. The vehicle-roadway interactions are simulated by knowing the free-speed matrix for each vehicle class, plus the individual vehicle performance rating, which defines the maximum speed that a vehicle can have along the roadway. Vehicle-vehicle interactions are handled by looking for possible conficts at each time period. If a conflict can occur, then the vehicle is regulated to one of 11 modes of operation, and appropriate modifications are made to the speed of the vehicle.

SOFOT has been programmed and successful trial runs have been made using default values for the free-speed matrix. The model successfully simulated the queueing and subsequent passing of vehicles. The program must now be calibrated for Brazilian driving conditions, and a routine must be developed for generating the free-speed profile for each vehicle class. Completion of these steps will be subject to the progress being made on the experimental program.

3 *EXPERIMENTAL PROGRAM*

The preceding discussion of the models shows that a large experimental program is required for developing relationships to predict speed and fuel consumption for practically every phase of traffic behavior. As shown by Table D.1 several experiments have been designed for this purpose. The alpha-numerical designation of the experiments given in this table will be used when referring to an experiment.

Two levels of experiments have been defined. Main experi-

TABLE D.1 - ROAD USER COSTS AND TRAFFIC EXPERIMENTS

CATEGORY	NUMBER	TITLE	PURPOSE
TRAFFIG BEHAVIOR MAIN EXPERIMENTS	TB-1	Free Speed on Positive Grades	Determine the distribution of free speeds on positive grades for each vehicle class
	TB-2	Free Speed on Negative Grades	Determine the distribution of free speeds on negative grades for each vehicle class
	TB-3	Acceleration on Grades	Use test vehicles to determine acceleration rates on positive and negative grades
	TB-4	Free Speed on Curves	Determine the distribution of free speeds on horizontal curves for each vehicle class
	TB-5	Trip Purpose	Determine if free speeds are a function of trip purpose or length
	TB-6	Free Speed Calibration	Independent data collection for verifying and calibrating models from experiments TB-1 through TB-5
	TB-7	Radar Effect	Determine if speed data is being affected by test procedures
	TB-8	Speed/Capacity	Collect data for developing speed versus volume relationships for simulating operating speeds on rural roads
	TB-9	Operating Speed Calibration	Independent data collection for verifying and calibrating models from experiment TB-8
TRAFFIC BEHAVIOR SATELLITE STUDIES	TBS-1	Wet/Dry	Define differences in driver behavior due to climatic conditions
	TBS-2	Surface Types	Define differences in driver behavior due to different gravel surface types
	TBS-3	Deceleration	Collect data on deceleration rates used when approaching a horizontal curve
	TBS-4	Dust Effect	Collect data on the effect of dust on vehicle speeds and headways

TABLE D.1 - ROAD USER COSTS AND TRAFFIC EXPERIMENTS (CONT'D)

CATEGORY	NUMBER	TITLE	PURPOSE
FUEL CONSUMPTION MAIN EXPERIMENTS	FC-1	Steady-State Fuel Consumption	Collect data for vehicles operating at steady-state speed over tangent test sections on a variety of grades
	FC-2	Momentum	Determine the effect of momentum on fuel consumption. Important at the base of positive grades preceded by negative grades
	FC-3	Curvature	Test the effect of horizontal curvature on fuel consumption
	FC-4	Fuel Consumption Calibration	Collect independent data over long sections to verify and calibrate models developed from FC-1 to FC-3
FUEL CONSUMPTION SATELLITE STUDIES	FCS-1	Tuned vs.Untuned	Test the variability of fuel consumption due to engine condition
	FCS-2	Curvature	Similar to FC-3 but more complete coverage of curvature
	FCS-3	Sag Curves	Determine fuel consumption when sag curves are traversed
	FCS-4	Acceleration	Determine the effect of acceleration on fuel consumption when approaching a sag curve
	FCS-5	Big Cars	Determine the fuel consumption of an Opala and Dodge car at steady-state speed

ments are necessary for accomplishing the objective of the research. Satellite studies would benefit the project by increasing the inference space of the experiments, or by reducing the assumptions needed in developing the models. Satellite studies can generally be delayed until the end of the project, and will be performed only if time and money permit, unless there are valid reasons for performing these studies earlier.

The geometric features of test sections are surveyed prior to testing and the location of each station is marked. Rut depth of the sections is measured using the device designed at the AASHO Road Test (Ref. 4). Roughness is measured with Mays-Ride-Meters which are calibrated against a surface dynamics Profilometer. On gravel sections, roughness is measured before and after testing. The looseness and corrugations of gravel sections are measured periodically using the procedures developed at the Kenya Road Study by TRRL (Ref. 5). Wind, rainfall, and temperature are measured periodically throughout the days when tests are being performed.

a *Traffic-Behavior Experiments*

The traffic-behavior experiments will provide the data required for modeling vehicle speeds as a function of roadway characteristics. Nine main experiments have been designed, six for measuring the free speed of vehicles, two for measuring operating speed, and one for measuring acceleration using the project test vehicles.

Radar speed meters are used for measuring the spot speeds of vehicles at specific points on the test sections. Vehicles are classified according to Figure 11 as they are observed. In addition, each class except for cars, is categorized as empty, half full, full, or undefined.

(1) *Free Speeds on Positive Grades (TB-1)*

The purpose of this experiment is to define the speed pattern of vehicles on positive grades. The sampling frame, Table D.2, shows that a minimum of 12 test sections are required, but due to the variability of traffic speeds, repeat sections will be sought for at least half of the cells. Thus a total of 18 sections will be used.

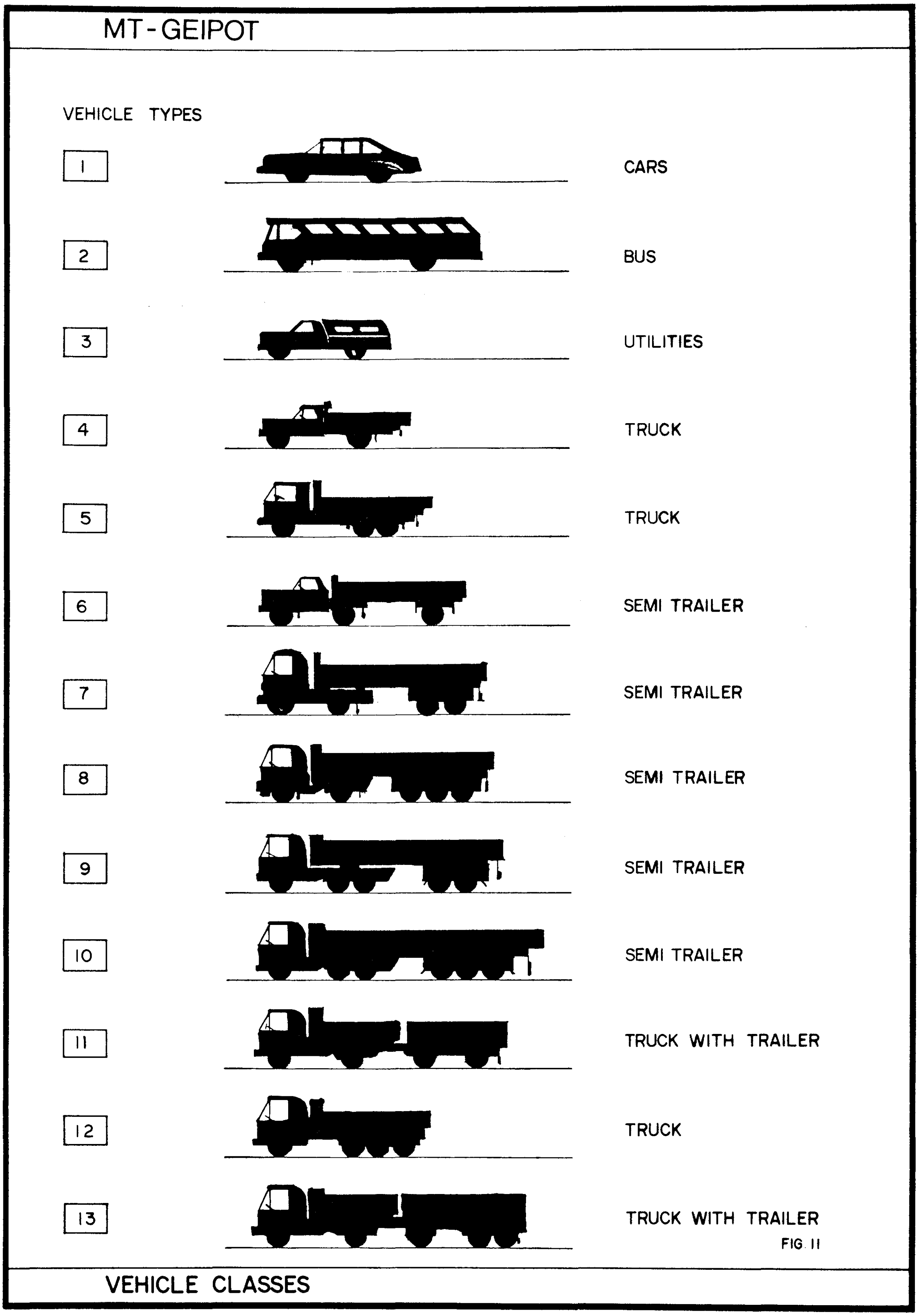
MT-GEIPOT
VEHICLE TYPES
1 CARS
2 BUS
3 UTILITIES
4 TRUCK
5 TRUCK
6 SEMI TRAILER
7 SEMI TRAILER
8 SEMI TRAILER
9 SEMI TRAILER
10 SEMI TRAILER
11 TRUCK WITH TRAILER
12 TRUCK
13 TRUCK WITH TRAILER
VEHICLE CLASSES
FIG. 11

TABLE D.2 - SAMPLING FRAME FOR TRAFFIC ON POSITIVE GRADES, EXPERIMENT TB-1

HORIZ. ALIGN.	VERT. PROFILE	SURFACE TYPE: PAVED		UNPAVED	
	ROUGHNESS	1	2	3	4
TANGENT	0-2				
	3-4				
	5-9				

The data are collected using three radar units and nine mirror boxes set up as shown by Figure 12. Thus a total of nine spot speeds are measured at intervals of 167 meters. This methodology is used because the speed pattern of the vehicles is more accurately defined than if space-mean speeds were measured.

Data have been collected on nine test sections covering six cells in the factorial. However, after the experiment had been in progress for about six months, the Brazilian government instituted a program of strict speed-limit enforcement. Therefore, a study has to be performed to indicate how this new policy affected the speeds measured prior to the start of the enforcement program.

(2) *Free Speeds on Negative Grades* (TB-2)

The purpose of experiment TB-2 is to determine the speed pattern of vehicles on negative grades. The sampling frame and test section requirements are the same as for experiment TB-1. Whenever possible, the same test sections are used for both experiments. The radar units are set up at intervals of 500 meters and measure speeds at five points.

Data have been collected on 11 test sections covering six cells or one half of the factorial. These data have also been affected by the change in the government policy on speed-limit enforcement. To determine if the speed-limit enforcement policy affected the speeds being observed, data were collected on four sections before and after the change in enforcement policy. The analysis of these data presented later indicates that the speeds measured after the speed-limit enforcement program were significantly lower than before the law. This effect was much more pronounced on the steeper grades where speeds are generally higher.

(3) *Acceleration on Grades* (TB-3)

The purpose of this experiment is to determine the acceleration rates vehicles can use on grades. Two methods of performing this experiment were considered:

- Stop a sample of vehicle in all classes at the start of the test section and measure spot speeds of vehicle as they

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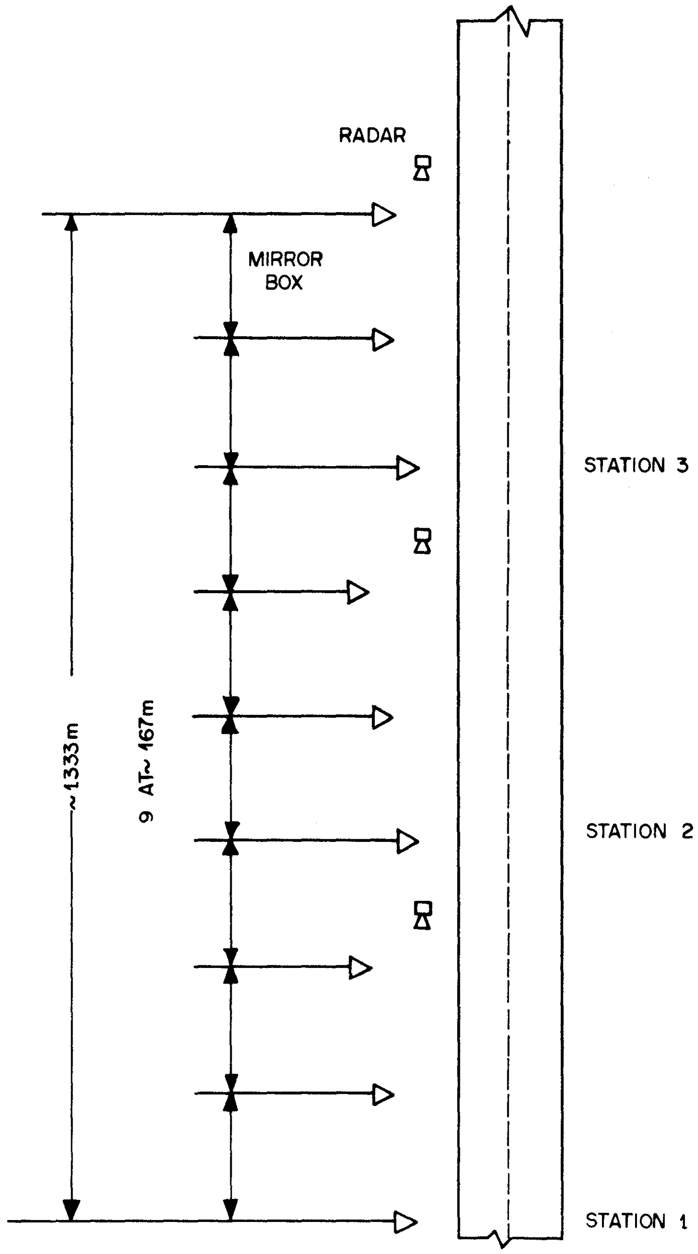

FIG. 12

LAYOUT OF EQUIPMENT FOR EXPERIMENT TB-1 AND TB-2 accelerate;

- Measure the acceleration of the project vehicles.

Due to logistic problems associated with the first method and the possibility of having a bias sample, use of the project test vehicles was selected.

The sampling frame of this experiment is the same as for experiments TB-1 and TB-2. However, because a fleet of controlled test vehicles is being used, it is not necessary to have repeat sections, so only 12 test sections will be used for this experiment.

Three camera boxes consisting of a movie camera, a distance measuring instrument (DMI), a crystal stopwatch, and an information screen have been constructed for performing this experiment. The crystal stopwatch has been modified so that every second, the DMI and stopwatch freeze and the camera is tripped. After the camera shutter has closed, the DMI and stopwatch catch up to display the actual time and distance until it is time for the next shot. After the film has been shot and developed, it is returned to the office where the data are transcribed to data forms.

The methodology for performing the experiment is to start the test vehicles at the beginning of the section, from a dead start, and then have the vehicles accelerate to maximum speed while the camera box is operating. Currently, to maintain repeatability, the drivers are instructed to use maximum acceleration. It is believed that this is fairly realistic for the trucks and bus, since they have low-acceleration rates. It may not be realistic for the lighter vehicles to use maximum acceleration. Therefore, further tests will be performed using less than maximum acceleration with the Volkswagen and Kombis.

Acceleration rates of all vehicles have been measured on the rough paved test sections which represent one fourth of the factorial. These data are currently being transcribed in the office and are not yet available for analysis.

(4) *Free Speeds on Curves (TB-4)*

The purpose of this experiment is to determine the speeds drivers use on curves. In this experiment, speeds are measured on individual curves which are classified according to their radius, surface type, and roughness. Speeds on individual curves are being studied as this allows the extremes of curvature to be investigated since and it is possible to locate sharp curves on smooth paved roads in semi-urban areas. Superelevation of the curves will be used as a covariate in the analysis. The sampling frame for experiment TB-4 is shown in Table D.3.

Radar speed meters placed tangentially to the center of the curve are used to measure the spot-speed of the vehicles. The radar crew is hidden from the view of the drivers for this experiment.

The speeds of vehicles on curves have been measured for all of the smooth paved test sections, a few of the required rough paved test sections, and some rough and smooth gravel sections. In all, the experiment is about 50% completed.

(5) *Trip Purpose (TB-5)*

It has been hypothesized that speeds will vary as a function of trip length or purpose, and that in general these parameters are related to geographical location. The purpose of this experiment is to determine if there is a significant relationship between speeds and geographic location. If there is such a relationship, then adjustments will have to be made to the prediction of expected speeds on level tangent sections which will in turn affect the whole speed profile predicted for a roadway.

The sampling frame is shown on Table D.4. Spot speeds will be measured at the midpoint of level tangent sections which are at least 1500-m long. Only smooth paved test sections will be studied.

(6) *Free-Speed Calibration (TB-6)*

The above experiments will provide the relationships required to develop the free-speed part of TAFA. The purpose of experiment TB-6 is to provide independent data for checking and calibrating this part of the algorithm. No work has actually been performed on this experiment, but two methods for collecting the data have been proposed.

First, free-speed observations will be made on two fairly short sections (4 to 5 km) of road in rolling terrain. Observers stationed

TABLE D.3 - SAMPLING FRAME FOR EXPERIMENT TB-4

HORIZ. ALIGN.	VERT. PROFILE	SURFACE TYPE: PAVED		UNPAVED	
	ROUGHNESS	1	2	1	2
<100 m	0-2				
	5-9				
100 - 200 m	0-2				
	5-9				
200 - 400 m	0-2				
	5-9				
>600 m	0-2				
	5-9				

TABLE D.4 - SAMPLING FRAME FOR TRIP PURPOSE, EXPERIMENT TB-5

GEOG. AREA	1			2			3			4		
LOCATIONS / VEH. CLASS	1	2	3	4	5	6	7	8	9	10	11	12
1												
2												
● ● ●												
12												

along the sections will record intermediate times and ensure that the vehicles observed are actually travelling at free speed. The average space-mean speed of each vehicle class throughout the section can then be computed and compared to estimates made by TAFA. Homogeneous sub-sections, where the estimates are not in agreement with the observed data, will have to be retested so that the predictive equations can be more accurately developed.

The second method of calibration is to obtain speed profiles from user vehicles operating on fixed routes approximately 50 km in length. The field crews will not be involved in the collection of these data. The speed profiles will then be compared to output generated by TAFA. Some speed profiles of buses on fixed routes have already been collected by the Survey Group.

(7) *Radar Effect* (TB-7)

In experiments TB-1 and TB-2, the radar equipment and mirror boxes are set up on the side of the road in plain view of the drivers. Since the police in Brazil use radar for speed-limit enforcement, the experimental setup may be affecting the behavior of the drivers. Therefore, the purpose of experiment TB-7 is to collect data with the radar crews completely hidden to determine if the equipment set up is affecting driver behavior.

Hidden radar data have been collected on four sections. It is necessary to collect data on at least three more sections in order to develop parameters for correcting the data already collected in experiments TB-1 and TB-2. In the future, the radar will be hidden whenever possible to avoid the need for correction factors.

(8) *Speed/Capacity* (TB-8)

The purpose of experiment TB-8 is to provide data for the development of the traffic-flow simulation model. The following information will be collected during this experiment:

- Headway;
- Space-mean speed;
- Vehicle classification;
- Estimate of each vehicle load;

- Traffic flow per time for each direction;
- Number of passing maneuvers.

The data will be collected on six sections representing three levels of grade and two levels of passing-sight distance. On each section, the data will be collected on free-flow, medium, and heavy traffic.

The methodology originally proposed for performing this experiment requires the use of a Super-8 movie camera set up to simultaneously photograph the traffic and a stopwatch. The camera would be able to shoot a single frame, each time the shutter was released by a vehicle passing over a road tube placed across the roadway. This methodology has been field tested, and it was found that the repeatability of reading the stopwatch was very low. Therefore, methods for improving the methodology are being sought. Alternatives being investigated include the use of a stopwatch which is easier to read,and use of induction loop detectors to automatically record vehicle headways on magnetic tapes which can be mechanically reduced.

(9) *Operating-Speed Calibration (TB-9)*

The purpose of this experiment is to provide independent data for calibrating and verifying the SOFOT model. The methodology for this experiment wil be identical to TB-8.

(10) *Wet/Dry (TBS-1)*

The purpose of this satellite study is to determine the effect of rainfall on free speed. The methodology for this experiment will be identical to experiments TB-1 and TB-2. Data for this experiment will be collected when the crews are set up for either TB-1 or TB-2, and it is raining.

(11) *Surface Types (TBS-2)*

The main experiments are restricted to one gravel type, laterite, because this is the predominant gravel type in the main study area. It is possible that other gravel types, with the same roughness as laterite will have a different effect on free speeds. Therefore, the purpose of this satellite study is to determine the effect of gravel type on free speeds.

(12) *Deceleration (TBS-3)*

The purpose of this satellite study is to investigate the deceleration rates drivers use when approaching a curve or a slower vehicle. Because this is a satellite study, no work has been performed toward developing a methodology.

(13) *Dust Effect (TBS-4)*

It has been hypothesized that the amount of dust a vehicle stirs up when traveling a gravel road can have a direct effect on the speed of vehicles on the road. Thus, if there is sufficient time, a small experiment will be performed to quantify how dust affects vehicle speeds.

b *Fuel-Consumption Experiments*

The fuel-consumption experiments will provide the data required for modeling fuel consumption as a function of the roadway characteristics. Four main fuel-consumption experiments have been defined. One of these experiments has been completed, two are currently in progress, and the fourth has not yet been started.

Unlike the speed-measurement experiments, where the general vehicle population can be sampled for the development of relationships, fuel-consumption data must be taken from measurements made with a fleet of test vehicles. Thus the project purchased nine vehicles covering seven classes representing the types of vehicle produced in Brazil. As shown by Table D.5, the vehicles used for fuel-consumption measurements are a Volkswagen 1300, two Volkswagen Kombis, a Ford F400 (gasoline), a Ford F4000 (diesel), two Mercedes Benz L-1113/42, a Mercedes Benz 0-362 bus, and a Scania 110/38.

Each of these vehicles has been fitted with a reservoir type fuel meter, a distance measuring instrument, and a split-second hand

TABLE D.5 - TEST VEHICLE DESCRIPTION

VEHICLE	FUEL	BRAKE HORSE-POWER	TARE WGT. (KG)	GROSS WGT. (KG)	LOAD*		
					EMPTY	HALF FULL	FULL
Volkswagen 1300	Gasoline	48	780	1,160	0	130	280
Volkswagen Kombi	Gasoline	60	1,195	2,155	0	280	550
Ford F-400	Gasoline	169	2,277	6,000	150	1,730	3,510
Ford F-4000	Diesel	102	2,444	6,000	0	1,540	3,325
Mercedes Benz L-1113/42	Diesel	147	6,395	18,500	1730	5,985	11,970
Scania 110/38 Articulated	Diesel	285	13,420	40,000	0	13,300	26,600
Mercedes Benz 0-362 Monobloco	Diesel	147	7,500	11,500	0	1,010	2,250

* The loads given do not include the weight of the driver and observer, which is approximately 140 kg.

stopwatch. The basic design of the fuel meters was developed at the Kenya Road Study [Ref. 5], but the design has been greatly modified to better suit the conditions encountered on this project.

(1) *Steady-State Fuel Consumption (FC-1)*

The purpose of experiment FC-1 is to collect fuel-consumption data for vehicles traveling on grades at constant speed. This is the largest of the fuel-consumption experiments. The sampling frame is the same as for experiments TB-1 and TB-2. Fuel-consumption measurements are made in both the positive and negative directions.

Test sections 1-km long with a 500-m transition on each end are sought, but there are cases where it was not possible to find sections with the desired characteristics of sufficient length. Thus, some sections only 700-m long have been used.

The testing procedures is for the driver to enter the transition section at the proper speed and gear for the run and maintain constant speed for the entire length of the section. As the vehicle passes the marker indicating the start of the transition section, the observer switches on the DMI. When the DMI reads 500 m, the observer switches on the fuel meter and starts the stopwatch. When the DMI reads 500 m plus one half the length of the section, the observer stops one hand of the stopwatch. When the DMI reads 500 m plus the length of the section, the observer stops the stopwatch and the fuel meter. The vehicle is stopped and the observer records the data and primes the fuel meter for the next run.

Using this procedure, it is possible to compute the space-mean speed for each half and the entire run. Thus, checks can be made to ensure that the vehicle was driven at a constant speed. The drivers have been carefully trained and it is unusual for a run to be more than 2 km/h off the desired speed.

Data have been collected in this experiment for more than a year now, and only four rough gravel sections are required for completing this experiment. This report contains regression equations developed from the data for smooth paved and unpaved sections. The work on the rough paved sections was not completed in time to be reported.

(2) *Momentum (FC-2)*

A readily observable driving pattern is for a driver to accelerate on a negative grade to build up momentum for climbing a positive grade. Work performed by Sawhill (Ref. 6) shows that fuel consumption is up to 50% lower when momentum is used to climb a hill rather than using constant speed. Thus a pilot study will be performed on three sections where conditions are favorable for using momentum for climbing a positive grade.

Data will be collected using the camera boxes and the fuel meter. The driver will enter the section at a speed higher than the steady-state speed, and try to maintain speed. The vehicle will decelerate due to gravity. As the vehicle enters the section, the observer switches on the camera box and the fuel meter; when the drivers signals the observer that steady-state speed has been reached, the observer switches off the fuel meter and camera box. The fuel reading is recorded on the information screen form and some photos are taken to make a permanent record of the fuel consumption on the film.

From these data it will be possible to determine the deceleration rate of the vehicle and the fuel consumption. Runs will be made with a range of entry speeds from the maximum entry speed down to 10 km/h above the steady-state speed. Thus it will be possible to determine the effect of entry speed on fuel consumption and the deceleration rate.

Data are currently being collected on one 7% and one 6% section. A suitable 4% section is being sought to complete the experiment.

(3) *Curvature Experiment (FC-3)*

Sawhill (Ref. 6) has shown that for very small radius curves, fuel-consumption can be significantly affected. The purpose of this experiment is to determine if this also accurs on Brazilian highways. Therefore, fuel-consumption tests were made on one section of extreme curvilinear alignment on a gravel road. The methodology for this experiment is the same as for experiment FC-1.

As discussed later, an analysis of the data from this experiment showed that the effect of horizontal curvature on fuel consump tion is minimal. Therefore, this factor will not be investigated further.

(4) *Fuel-Consumption Calibration* (FC-4)

This experiment will be conducted in a manner similar to the free-speed calibration experiment. In addition to tachographs, the vehicle will be fitted with positive-displacement fuel meters. These meters can continuously measure the fuel consumed over long routes. The vehicles will be run over routes of known characteristics and the data from these runs will be compared to the output from TAFA. By taking fuel readings at intermediate points, it will be possible to test the calibration of the model.

In order to test out the methodology for this experiment, tachographs have been installed in two of the vehicles and the positive-displacement fuel meters have been installed in one vehicle. Thus, the capability to perform the experiment was demonstrated. However, no actual data have been collected.

(5) *Tuned VS. Untuned* (FCS-1)

During the main fuel-consumption experiments, the test fleet will be kept tuned at all times. Prof. Rebelo of the Centro Técnico Aeroespacial, sampled 320 diesel trucks in 1972 and determined that over 60% were out of tune. This could significantly affect fuel consumption. Thus, the purpose of this satellite study, is to determine the fuel consumption of untuned vehicles. If this study is perfomed, the sampling frame and methodology of experiment FC-1 can be used.

(6) *Curvature Study* (FCS-2)

This study was to be performed if the results of experiment FC-3 showed that curvature had a significant effect on fuel consumption. The results of experiment FC-3 show that it is not necessary to perform this experiment.

(7) *Sag Curves* (FCS-3)

Currently it is proposed to ignore the effect of sag curves in the model by assuming that the tangent portions of the grades can be extended to the point of intersection. However, if the calibration experiment shows that this is causing unaceptable errors, then it may be necessary to measure the fuel consumption of vehicles traversing sag curves. If this study is performed, a methodology similar to experiment FC-2 will be used.

(8) *Acceleration* (FCS-4)

The purpose of this experiment is to measure the fuel-comsuption rate of vehicles while accelerating. Currently the fuel consumption of the vehicles is being measured as they perform experiment TB-3. This will provide some data about the fuel-consumption rate of vehicles while accelerating, but it does not provide any data for an intermediate speed change such as would be used in a passing maneuver. Therefore, if this study is performed, measurements will be made for specific speed changes which are representative of passing maneuvers.

(9) *Large Cars* (FCS-5)

In order to increase the inference space of the fuel-consumption test for passenger vehicles, GEIPOT lent the project two of its executive type of passenger cars. The cars were a 198 HP Dodge weighing 1495 kg and a 138 HP Opala weighing 1046 kg. The tests were run empty and with a 350-kg load. Using the methodology developed for experiment FC-1, fuel consumption was measured on five smooth paved sections and one smooth gravel section, in both the positive and negative direction. This work has been completed, but the data were not available in time for the analysis to be included in this report.

4 PRELIMINARY ANALYSES

Even though only one of the experiments has been completed at this time, it is possible to report partial results for several experiments. These analyses represent only a portion of the total amount of data currently available. Analyses have been performed for experiments TB-2, FC-1, and FC-3. In addition, analysis of the impact of the speed-limit enforcement law has been performed.

a *Preliminary Analysis on TB-2*

The purpose of this analysis was to develop a preliminary regression equation which would predict the free speeds on negative grades. The analysis was performed in November 1976 with a modification and update done in March 1977. The data were collected before the enforcement of the 80-km/h speed-limit law, and the radar meters were in view of the drivers. Because of the possible effects of the exposed radar on these data and the effect of the speed-limit enforcement program on future observations, the analysis presented here will have to be modified. The analysis and results are described simply to explain the types of relationships that will be developed in the future. They are not to be accepted as final since the speed-limit and exposed-radar effects are not explained in these equations.

(1) *Background*

The sampling frame used for this study is given in Table D.6. A total of six smooth paved sections were used in the experiment. On each section spot speeds of vehicles were collected at five stations 500-m apart. Eleven separate vehicle classes were used for classification of the observed vehicles as well as four load classifications. A total of more than 17,000 vehicles were recorded.

(2) *Analysis*

It was impossible to observe many of the vehicle classes under various load conditions on all of the sections and at all of the stations. Of particular difficulty were the truck classes. In order to ensure that data were available for all classes, all sections, and at all stations, new vehicle classes were defined by grouping the original load and vehicle class combinations. The decision on how to define these new classes was based on available sample sizes and vehicle type and weight similarities. The new classes are defined as follows:

TABLE D.6 - SAMPLING FRAME FOR FREE-SPEEDS-ON-NEGATIVE-GRADES PILOT STUDY

		GRADE														
		1					2					3				
REPLICATES	1	STATION					STATION					STATION				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
	2	STATION					STATION					STATION				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5

1 = Cars
2 = Buses, All Loads
3 = Utilities, Empty
4 = Utilities, Half and Full Load
5 = Trucks, Empty
6 = Trucks, Half and Full Load

As a preliminary analysis procedure, the mean spot speeds were analyzed "as if" they were all estimated from equal sample sizes. The exact methodology for this procedure is described in Scheffé (Ref. 7), and Anderson and McLean (Ref. 8). This unweighted analysis was valuable in a number of ways (Refer to Table D.7):

- The repeat error mean square was very large in comparison to the mean square for grades indicating that there are fixed environmental factors contributing to the size of the repeat mean square. Therefore, the repeat effects should be considered fixed unquantifiable factors, not as error terms. The error term used for testing higher factor interactions should be the within pooled error of the variances of the means in each cell, ε ;
- In addition to the size of the repeat mean square, less than 1% of its total was contributed by the difference between the repeats in the lowest level of grade. A great deal of this nonhomogeneity can be caused by the unquantifiability of the environmental effects, such as driver behavior, trip length, trip purpose, etc. Part of this nonhomogeneity could be caused by the unequal sample sizes in the cells;
- Examination of the variances of the original spot speeds showed great homogeneity in cells where the sample sizes were large enough to give good estimates of the variances. This implies that the "relative reliability" of the estimates of the means in each cell is dependent on the sample sizes. Therefore, under the assumption that the variances of the spot speeds in each cell are equal, the regression analysis applied to the mean spot speeds should be weighted in relation to the square root of the sample sizes;
- The analysis-of-variance table showed that the significant effects to be used in the regression analysis were vehicle class, station, grade and possibly the interactions grade x class or grade x station. The means of each of these

TABLE D.7 - ANALYSIS-OF-VARIANCE TABLE FOR THE UNWEIGHTED MEAN SPOT SPEEDS ON NEGATIVE GRADES BEFORE SPEED-LIMIT ENFORCEMENT PROGRAM

SOURCE	df	MEAN SQUARE
G	2	1081.1*
R(G)	3	692.2
C	5	801.6*
G x C	10	68.7*
R(G) x C	15	51.1
L	4	329.5*
G x L	8	121.3*
R(G) x L	12	49.5
C x L	20	23.9
G x C x L	40	8.7 }
R(G) x C x L	60	10.1 } 9.2 pooled within error
Within Error (ε)	48	8.5 }

Where G = Grade in Percent

R = Repeat Sections within Grades

C = New Vehicle Class

L = Station

ε = Within Error

* Possible significant effects that can be used to develop a regression function.

significant factors were plotted. The plots indicated a number of different functions that could be used in developing the equations;

- Newman-Keuls test was run on the means of the factor stations and grade x station to determine which of the individual means were significantly different. This procedure further defined possible relationships between the mean spot speeds and the position of the vehicles on the negative grades.

Weighted regression analysis was performed on the functions and the following equation represents the best fit of the functions tried.

$$S=59.3+7.3\{18.6-(G-3.8)^2\}^{.5} - 3.25C+.56L+.240\ L^{G/2.6}$$

where S = mean spot speed
L = station (1, 2, 3, 4, 5)
1 = is equivalent to 2000 meters up a negative grade
2 = is equivalent to 1500 meters up a negative grade
3 = is equivalent to 1000 meters up a negative grade
4 = is equivalent to 500 meters up a negative grade
5 = is equivalent to the bottom of a negative grade
C = new vehicle class (1, 2, 3, 4, 5, 6)
G = grade in percent

The equation is graphically presented in Figures 13 through 15.

b Effect of the Speed-Limit Enforcement Program

Free-speed data from four negative grade sections have been collected with the radar units in view before and after the speed-limit law. The four sections have grades of 1.3%, 3.6%, 6.0%, and 6.1%. As a preliminary examination, it is possible to compare the effects of the speed-limit law on the speed patterns of the four sections.

(1) Analysis

The Analysis-of-Variance layout used for this experiment is given in Table D.8. The grades of 6 and 6.1% are used as repeat sections and the various error terms in the analysis are calculated from dif-

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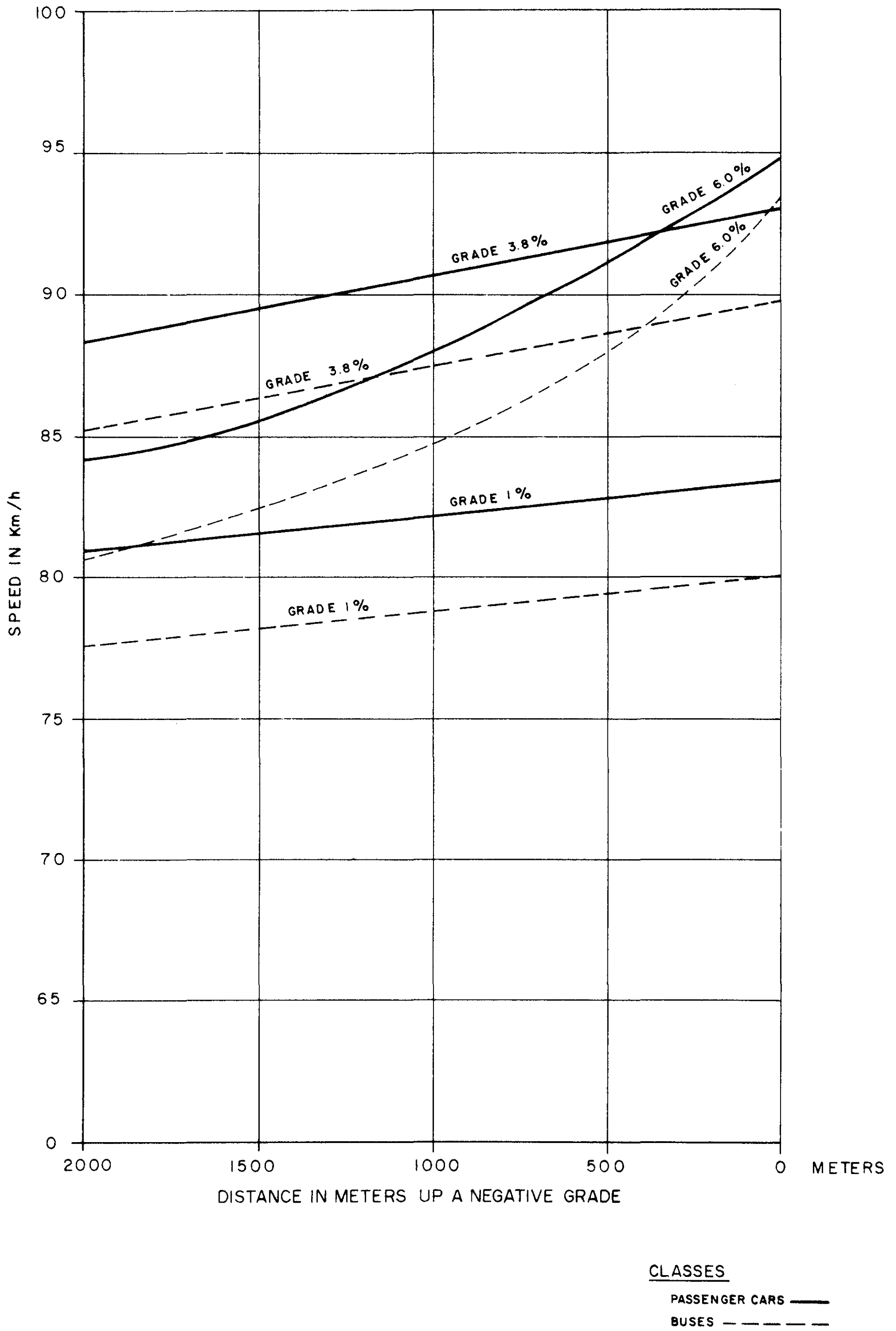

FIG. 13

FREE SPEED RELATED TO DISTANCE

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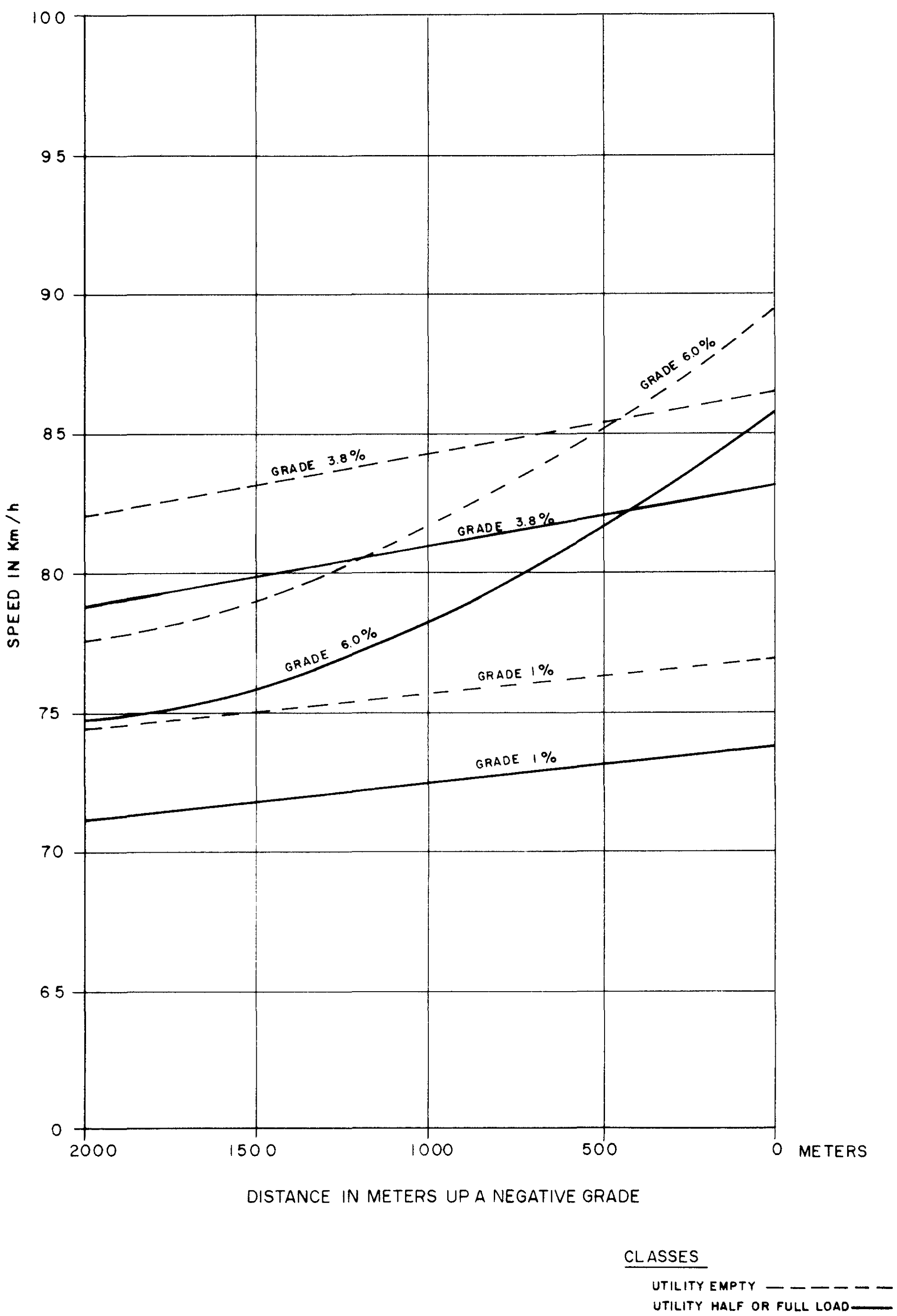

FIG. 14

FREE SPEED RELATED TO DISTANCE

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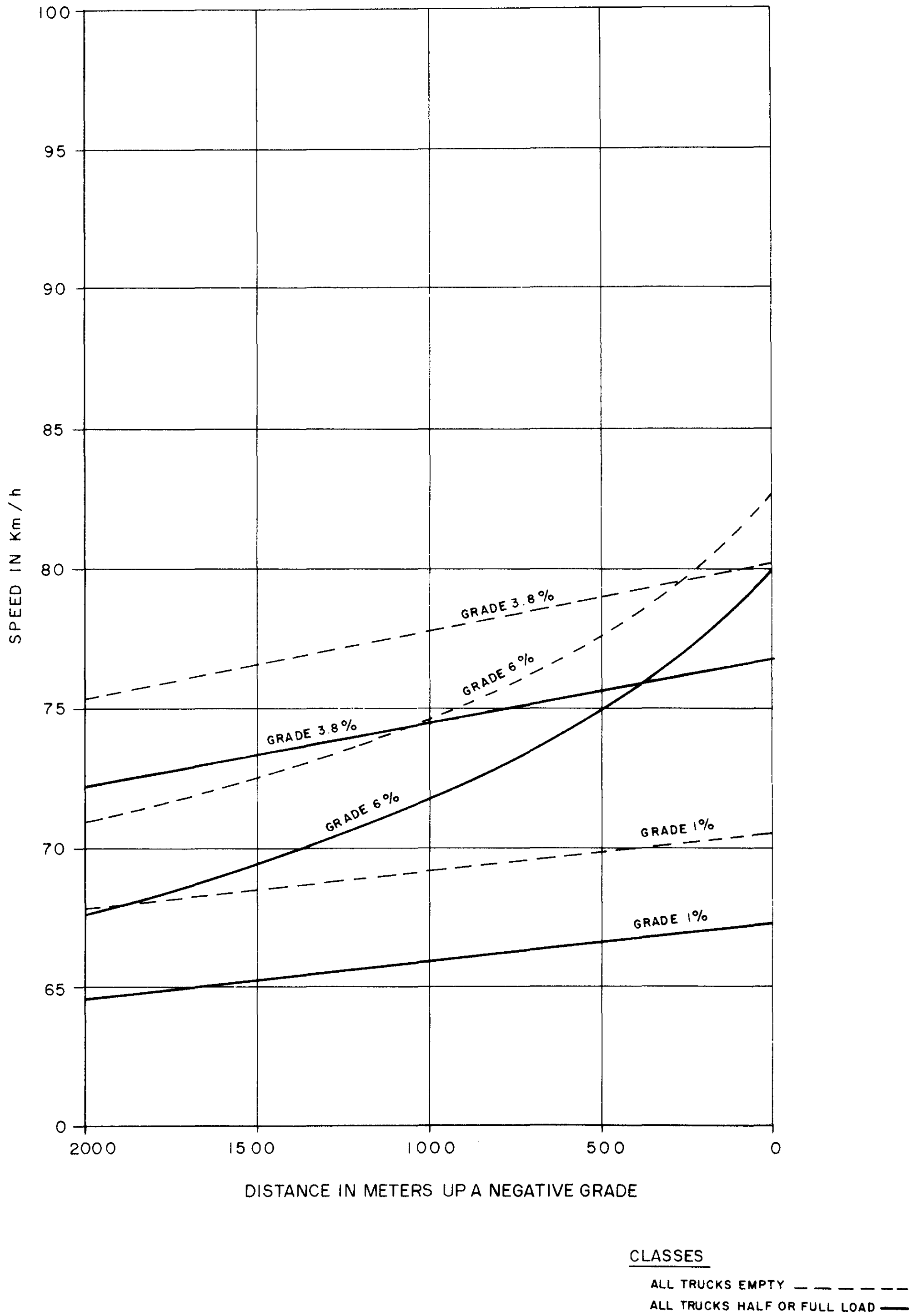

FIG.15

FREE SPEED RELATED TO DISTANCE

TABLE D.8 - ANALYSIS-OF-VARIANCE LAYOUT TO TEST EFFECT OF SPEED-LIMIT ENFORCEMENT

Grade G	2	
Repeat Grades R(G)	1	
Limit L	1	where
GL	2	G = effect of the three levels of grade
LR(G)	1	
Station S	2	
GS	4	R = repeat grade effect
SR(G)	2	
LS	2	L = effect of the speed limit law
GLS	4	
SLR(G)	2	
C	5	S = effect of the distance from the base of the grade; three stations are analyzed here; each is 500 meters apart
GC	10	
CR(G)	5	
LC	5	
GLC	10	
LCR(G)	5	
SC	10	C = effect of the different vehicle classes
GSC	20	
SCR(G)	10	
GSC	10	
GLSC	20	
LSCR(G)	10	
	143	

ferences in their speed patterns. Although the other two smaller grades do not have repeat sections, previous analysis indicates that the repeat errors are larger for steeper grades. Therefore, tests made with the error term from a 6% grade are conservative in the sense that the true errors should be less than or equal to the errors used here.

Analysis of the results indicates that the speeds measured after the speed-limit law are significantly lower than those measured before the law. The effect of the law is much more pronounced on the steeper grades where speeds are in general higher. For this reason the GL interaction is significant. The interactions LS and LC are not significant since the mean speeds decrease evenly at all stations and for all classes.

(2) *Conclusions*

The preliminary analysis of these data indicates that the speed-limit law has reduced speeds significantly on negative grades when the radar units are visible. A large mass of free-speed data was collected within three months after initiation of the speed-limit law with the radar visible. Recommendations are being considered now for further work, so that adjustments can be made on these reduced speeds.

c *Steady-State Fuel Consumption (FC-1)*

The analysis of the steady-state fuel consumption experiment is presented primarily to demonstrate the types of relationships which are being developed. The relationships presented are only temporary since more data will be collected and more work is required to refine the analysis.

In performing this analysis, some of the data available have not been used. Data for the Ford F4000 have been rejected because fuel meter irregularities resulted in unreliable data for two test sections. The runs on these sections are being repeated and will be used in future analysis. Due to time restrictions and computer limitations, it was not possible to develop relationships for the Mercedes Benz bus operating on negative grades.

Fuel consumption is analyzed and discussed in units of mililiters per second. This form of the dependent variable will be used in the Time and Fuel Algorithm. In many cases, runs were made in more than one gear for a given situation. When this occurred the mean fuel consumption for all gears was analyzed.

The factors and levels analyzed are described in Table D.9. Not all combinations are possible, so the analysis does not involve predictions for every situation.

(1) *Analysis Approach*

It would be a difficult if not impossible task to develop one general equation for such a wide variety of conditions and for so many vehicles. Different equations were therefore developed for positive and negative grades and paved and unpaved roads. Four equations were developed for each vehicle, with the exceptions that the VW-1300 and the Kombis were analyzed together and the MB 0-362 bus was not analyzed for negative grades. Thus, 18 separate regression equations were developed.

Two major benefits arise from using such a large number of equations. First, since the number of observations in each combination is reduced to between 50 and 250, a much closer first examination can be made of the influence of the various factors and interactions. Second, since the number of observations is small, nonlinear regression programs can be utilized which enables a much wider range of equation forms to be examined.

The first problem was to determine which main factors and intercations were significant for each equation. In order to test the effects correctly, certain intricacies of the design and data collection had to be recognized. Since data from a maximum of three vehicles are used to develop each equation, various error components must be separated within the analysis. These various error components affect the predictive power of the equation by causing the within error terms in regression to be underestimated. The inferences are therefore limited since the value of the prediction has been overrated by the small error value.

The repeat vehicle error and the interaction error components were separated and used to test the main effects and interactions of the factors speed, grade, and load. Two repeat vehicle types were

TABLE D.9 - FACTORS AND LEVELS OF FUEL-CONSUMPTION ANALYSIS

Factors	Levels
Vehicles	VW-1300, 2 Kombi 15, Ford-400, 2 MB-1113, MB-0362 Bus, Scania
Surface Type	Paved, Unpaved
Grades	0, 2, 4, 6, 7, 8%
Sign of Grade	+, -
Speeds	10, 20, 30, ..., 120 km/h
Load	Empty, Full

tested, a Kombi and a MB-1113. The assumption was made that VW.Kombi and Ford-400 repeat errors are homogeneous and that MB-1113.MB 0-362 bus, and Scania repeat errors are homogeneous. The Kombi error was used to test effects for the gasoline vehicles and the MB-1113 was used to test effects for the diesel vehicles. Limited inferences have to be placed on the error terms since they reflect differences between only two vehicles in each case. However, without the repeat vehicles no error terms could be estimated.

(2) *Analysis-of-Variance Results*

Four sets of analysis-of-variance were run on the data to test for significant effects. The sets used were Volkswagen and Kombis on positive grades, trucks and bus on positive grades, Volkswagen and Kombis on negative grades and trucks and bus on negative grades. The main effects and interactions were tested using the error term described above. Gravel and paved sections were analyzed separately.

For the Volkswagen and Kombis on positive grades, the main effects speed, load, grade, and class all proved to be significant. In addition, many of the interactions showed strong influences. The load x speed, grade x speed, and class x speed interactions were all significant. The fuel consumption differences between the levels of the load, grade, and class factors increased with increasing speed. The interaction load x grade was also significant. Fuel consumptions in the laden state were not significantly different from the fuel consumption in the empty state, when the vehicles operated on zero percent grades. However, the differences between the fuel consumption empty and laden, increased with increasing grade. The fuel consumption differences between the Volkswagen and Kombi also increased as grade increased, causing the class x grade term to be significant.

The nonlinear model that produced the lowest residual error and had the simplest form was:

$$\text{Fuel/sec} = A_0 + (A_1 + A_2C + A_3I)^{A_4S} \qquad (1)$$

where $A_0 - A_4$ = coefficients

C = dummy-vehicle class value: 1 = Volkswagen, 2 = Kombi

I = interaction term which consists of a load factor, a class factor and a grade term.

S = true speed of the vehicle.

Inspection of the function shows that the influences of the main effects as well as the interaction effects are explained by the model. The actual equations for the paved and unpaved situations are presented in Table D.10 with the other equations.

The same procedures were used for the analysis of the bus and trucks on positive grades. Each of these vehicles were analyzed separately using the error terms described previously. Similar main effects and interactions were significant for all the vehicles in this category for both the paved and unpaved fuel data. The same influences that affected the fuel consumption of the Volkswagen and Kombis were also significant for the trucks and bus. The main effects speed, load, and grade, were all significant in each case. The interactions load x speed, grade x speed, load x grade were also significant for these vehicles. It was also found that although the fuel-consumption relationships for the Ford and Mercedes were similar; the relationship for the Scania was different, since it appeared more linear. For this reason two functions were tested. The nonlinear model (2) is applied to the Ford-400, the Mercedes Benz 1113, and the Mercedes Benz 0.362 bus. The linear model (3) is used for the Scania. The two functions are presented below:

$$\text{Fuel/sec} = (A_0+A_1L+\exp(A_2\text{Grade}(1+A_3L)))^{A_4S} \qquad (2)$$

where A_0-A_4 = coefficients

L = dummy load value (0=EMPTY, 1 = FULL)

G = percent of the grade

S = true mean speed

$$\text{Fuel/sec} = A_0+A_1L+A_2I \qquad (3)$$

where A_0-A_2 = coefficients

L = dummy load value (0=EMPTY, 1 = FULL)

I = interaction of load, speed, and grade factors

The equations for the paved and unpaved test sections are given in Table D.10.

The fuel-consumption regression equations for positive gra-

TABLE D.10 - FUEL CONSUMPTION REGRESSION EQUATIONS FOR POSITIVE GRADES

Volkswagen and Kombi Unpaved

$$F = -.53 + (1.1 + .189\ C + .0153(C + .4)(L + 1.7)\ G)^{.035}\ V$$

$S = .05$

Volkswagen and Kombi Paved

$$F = -.62 + (1.14 + .17\ C + .009(C + .4)\ (L + 2.5)\ G)^{.036}\ V$$

$S = .05$

Ford-400 Unpaved

$$F = .84 + (.554 + e^{(.066\ G(1+1.15\ L))})\ .05\ V$$

$S = 1.01$

Ford-400 Paved

$$F = .8 + (.65 + .24\ L + e^{(.11\ G(1+1.27\ L))})\ .0344\ V$$

$S = .82$

MB-1113 Unpaved

$$F = (.95 + .45\ L + e^{(.21\ G(1+1.96\ L))})\ .0343\ V$$

$S = .09$

MB-1113 Paved

$$F = (1.52 + .627\ L + e^{(.32\ G(1+1.32\ L))})\ .0236\ V$$

$S = .16$

MB-Bus Unpaved

$$F = (1.36 + .167\ L + e^{(.3\ G(1+.44\ L))})\ .0245\ V$$

$S = .32$

MB-Bus Paved

$$F = (2.3 + .24\ L + e^{(.5\ G(1+.31\ L))})\ .015\ V$$

$S = .30$

Scania Unpaved

$$F = 1.02 - .3\ L + .072(L+1)\ V + .03(L+1)^{1.45}\ G\ V$$

$S = .30$

Scania Paved

$$F = 1.35 - .403\ L + .054(L+1)^{1.32}\ V + .026(L+1)^{1.32}\ G\ V$$

$S = .54$

where C = Class, 1=Volkswagen, 2=Kombi
G = Grade in Percent
V = Velocity in Km per hour
L = Load factor, 0=Empty 1=Full
F = Fuel in ml per second
S = Standard error of the equation

des are presented in Figures 16 through 27

For the Volkswagen and Kombies, the same main effects and interactions that were significant for the positive paved sections were also significant for the negative paved sections. The influences, however, are different in some cases. The most obvious difference is related to the effect of the load. For negative grades less than 2%, the empty vehicle consumes less than the laden vehicle assuming all other effects are held constant. However, for both the Volkswagen and the Kombis, the influence of the load changes as the negative grade increases from 2 to 4%. For negative grades of more than 4% the ladened vehicle consumes less than the empty vehicle.

For negative unpaved sections, all load effects proved to be non-significant. For this reason different models were used for the paved and unpaved equations for the Volkswagen and Kombis. The function for the paved case is much more complicated since it has to account for the load effects. Since there are many unique functions for the negative grades, the general forms are not presented for each case. Table D.11 presents all equations in their final forms.

The load effect for the truck on negative grades was similar to that for the lighter vehicles. For flat sections, the laden vehicle consumed more than the empty vehicle. As the grade becomes steeper the load effect reverses.

A major difference in the effect of speed occurred for the Scania data. In general all of the equations reflect an increase in fuel consumption per second with increasing speed. The speed influence reverses itself for the Scania operating on negative grades.

On the negative unpaved sections the influence of speed reverses for grades of four percent. At the four-percent level, the empty vehicle consumes more than the laden vehicle and increasing speed causes decreasing fuel consumption. On the negative paved sections, the influence of speed reverses for grades of two percent. At the two-percent level, increasing speed causes decreasing fuel consumption, and the empty vehicle consumes more than the laden vehicle. Table D.11 contains the equations for the trucks for negative grades. Each of the functions is a non-linear form with the exception that the Scania equation is intrinsically linear. Figures 28 through 36 present the equations for fuel consumption on negative grades in graphical form.

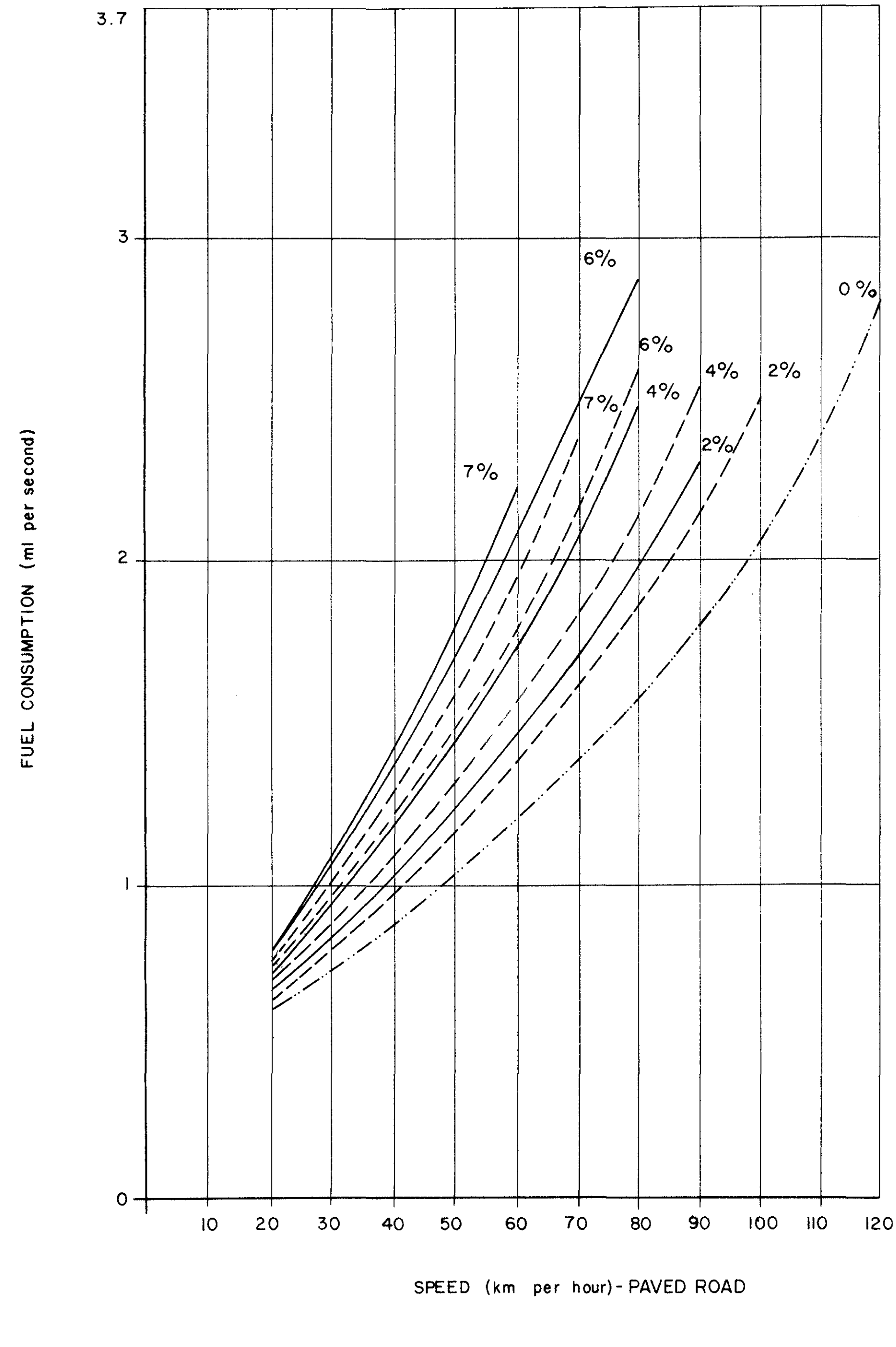

FIG. 16

FUEL CONSUMPTION - VOLKSWAGEN 1300 - POSITIVE GRADE

MT-GEIPOT

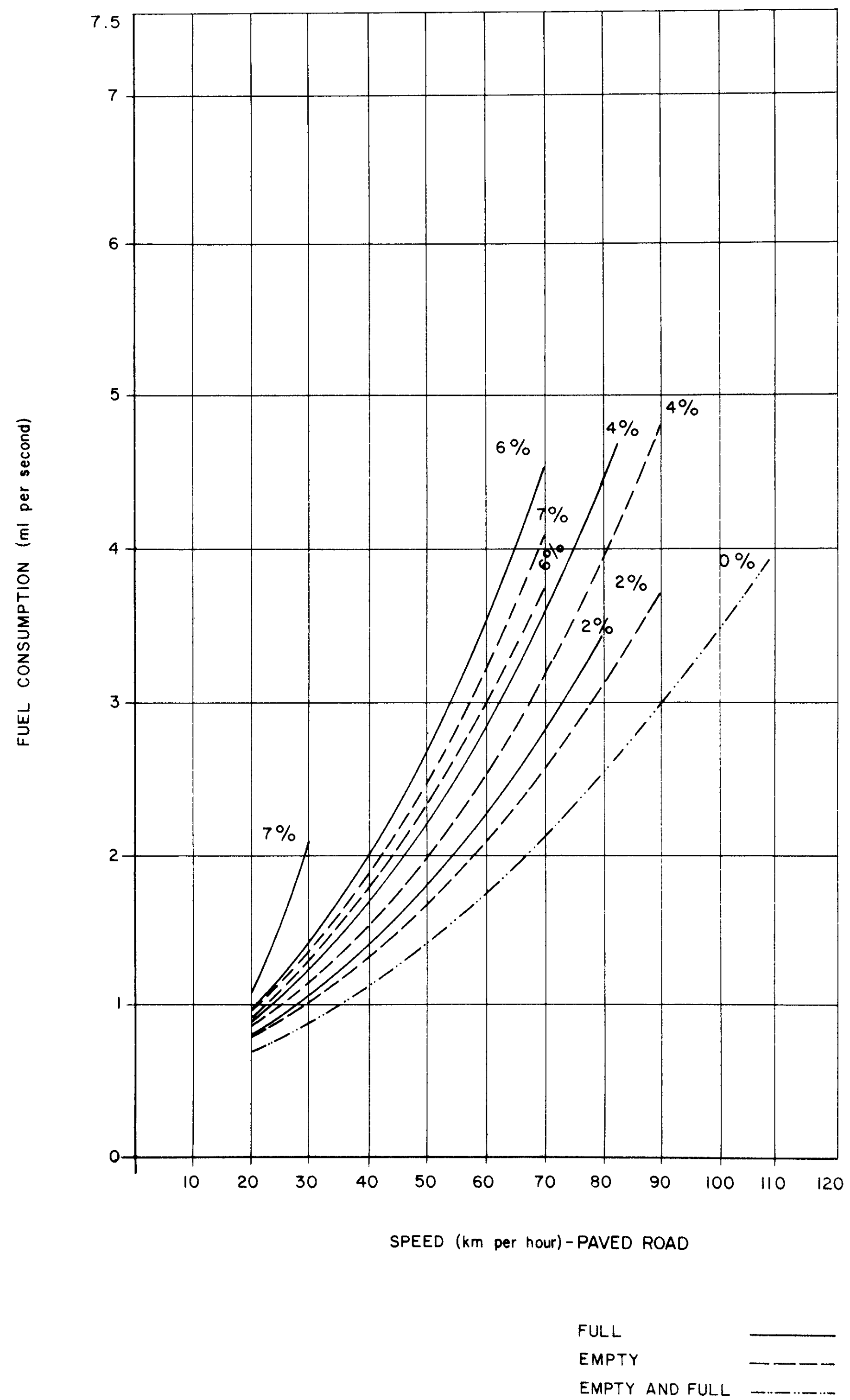

FIG. 17

FUEL CONSUMPTION - KOMBI - POSITIVE GRADE

MT-GEIPOT

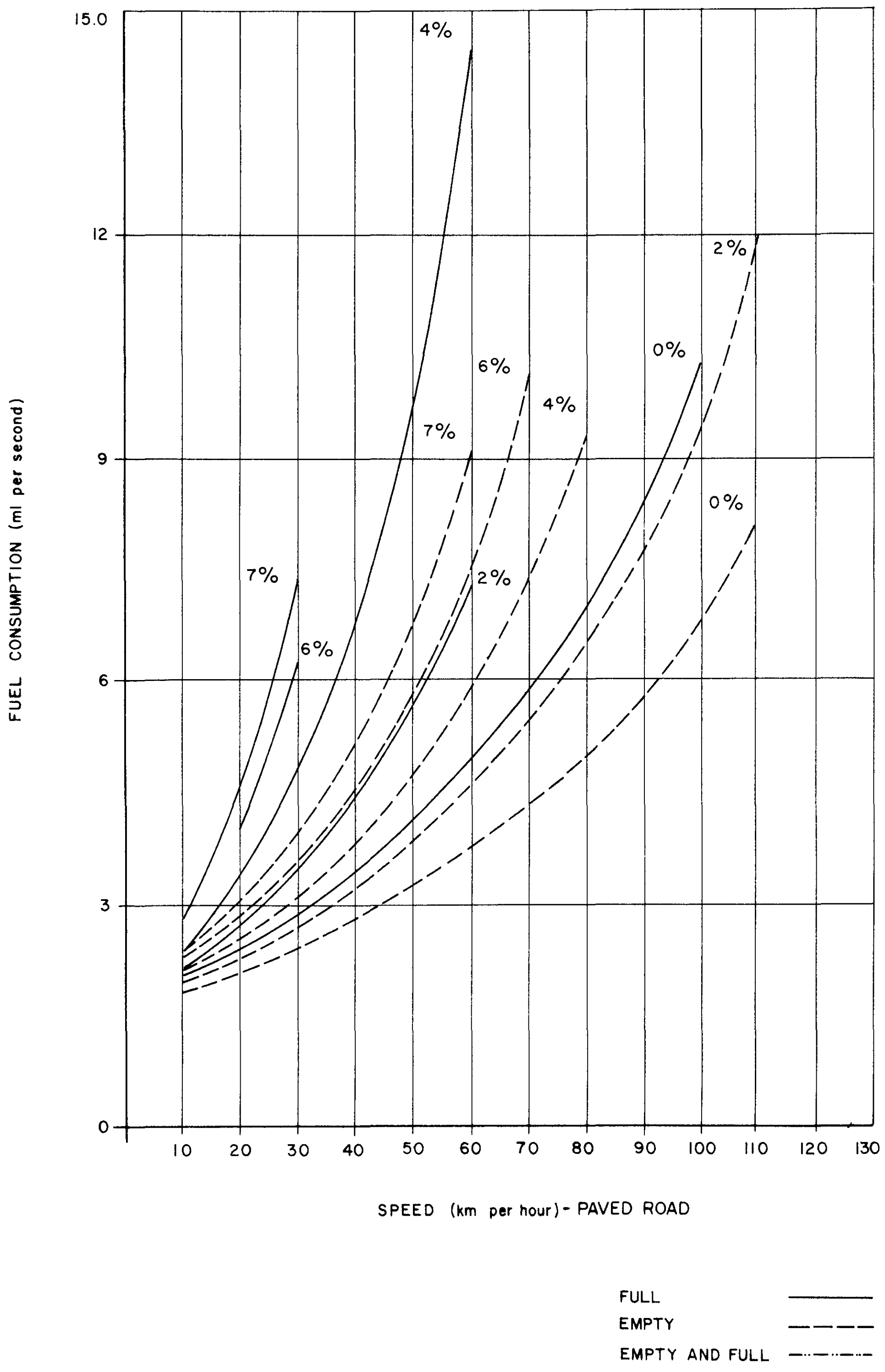

FIG.18

FUEL CONSUMPTION - FORD 400 - POSITIVE GRADE

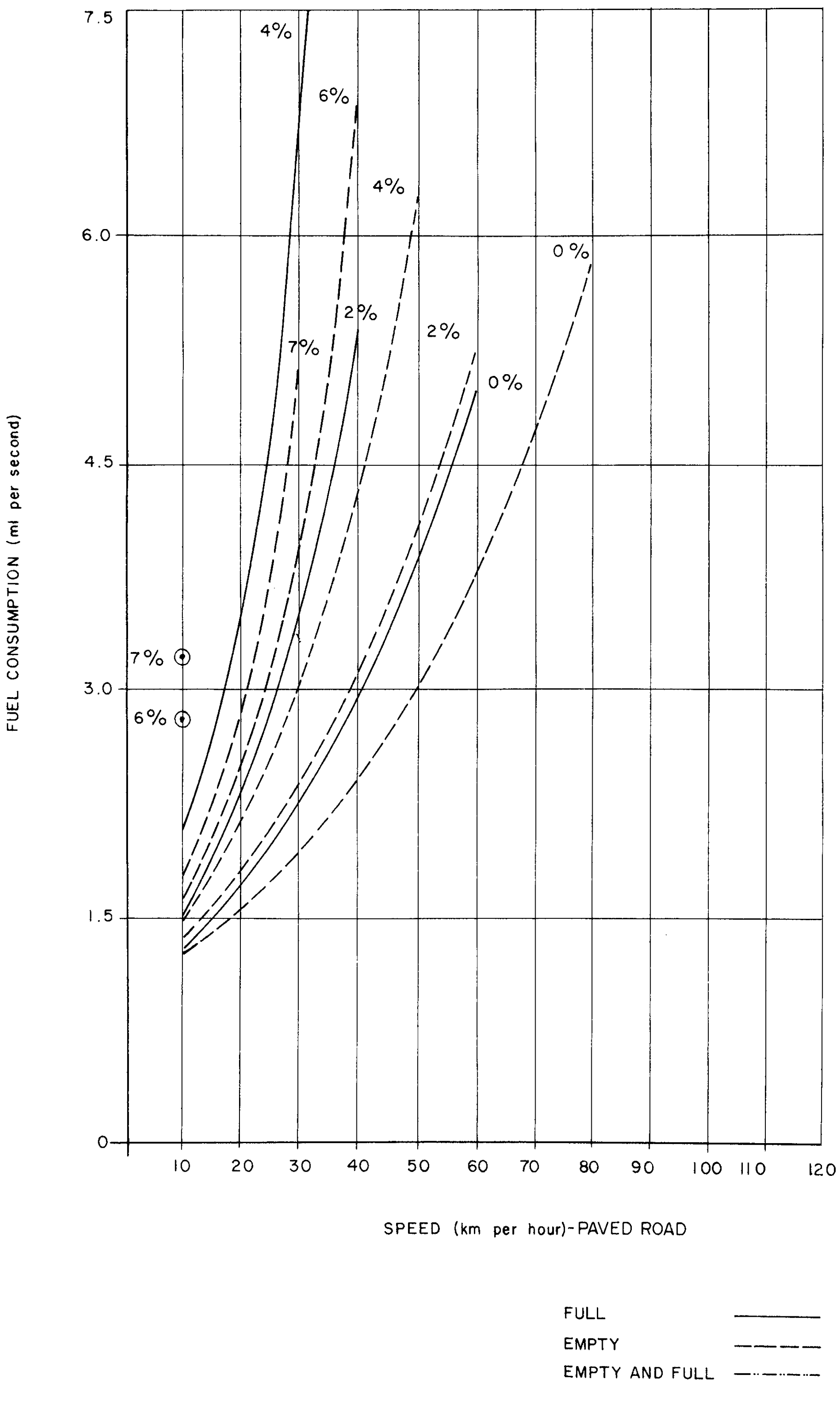

FIG. 19

FUEL CONSUMPTION - MERCEDES BENZ 1113 - POSITIVE GRADE

MT-GEIPOT

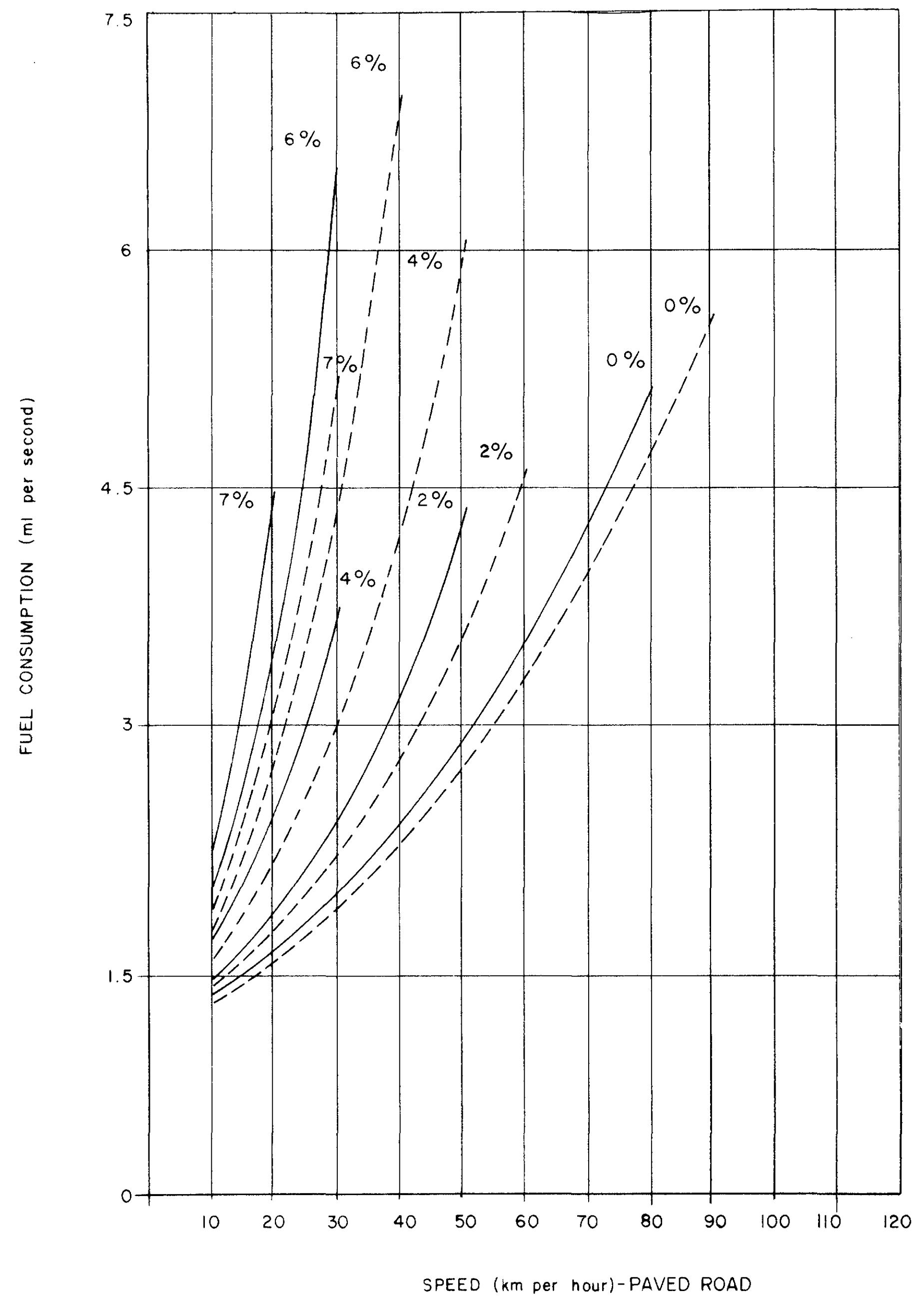

FIG.20

FUEL CONSUMPTION-BUS MERCEDES 0-362-POSITIVE GRADE

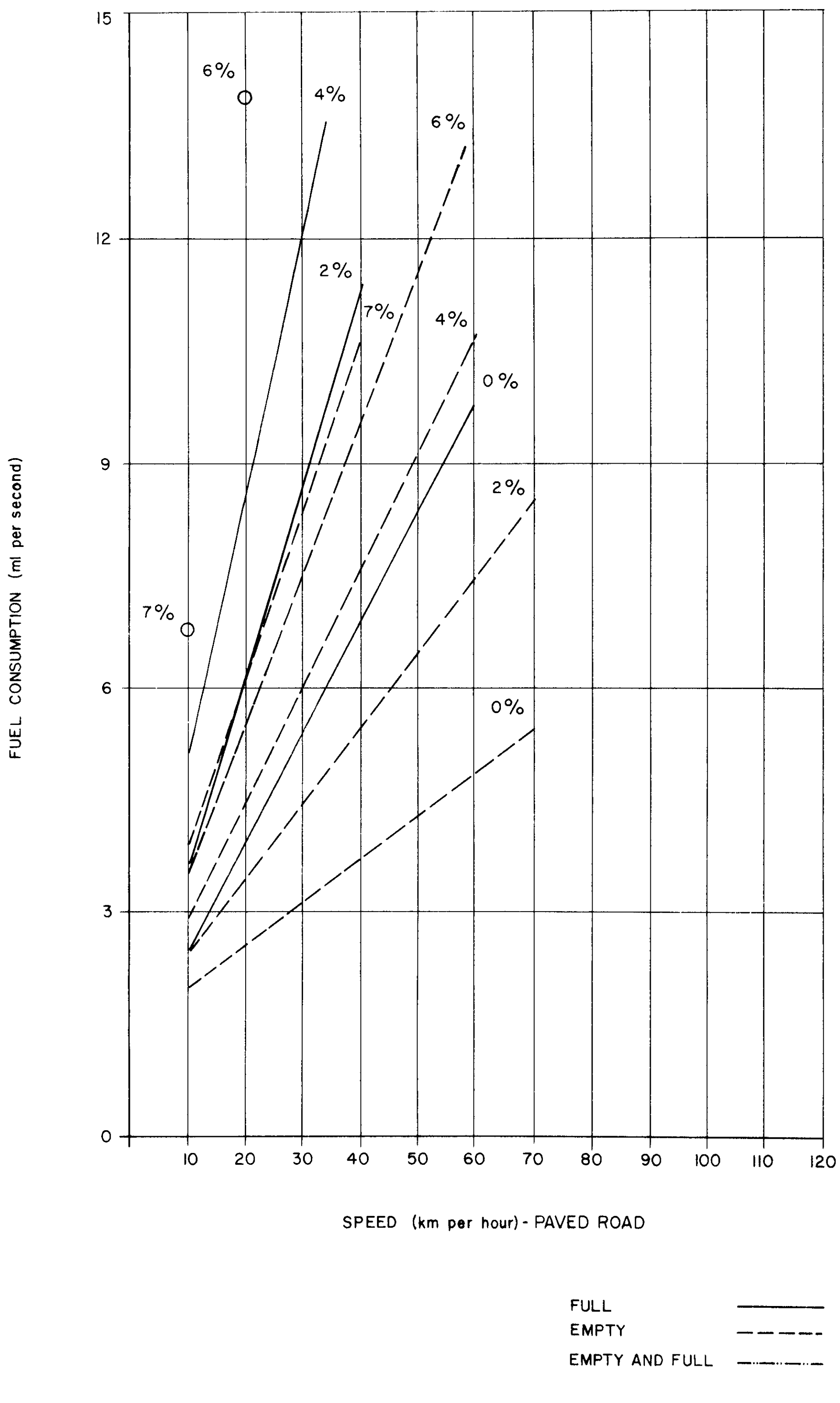

FIG. 21

FUEL CONSUMPTION - SCANIA - POSITIVE GRADE

MT-GEIPOT

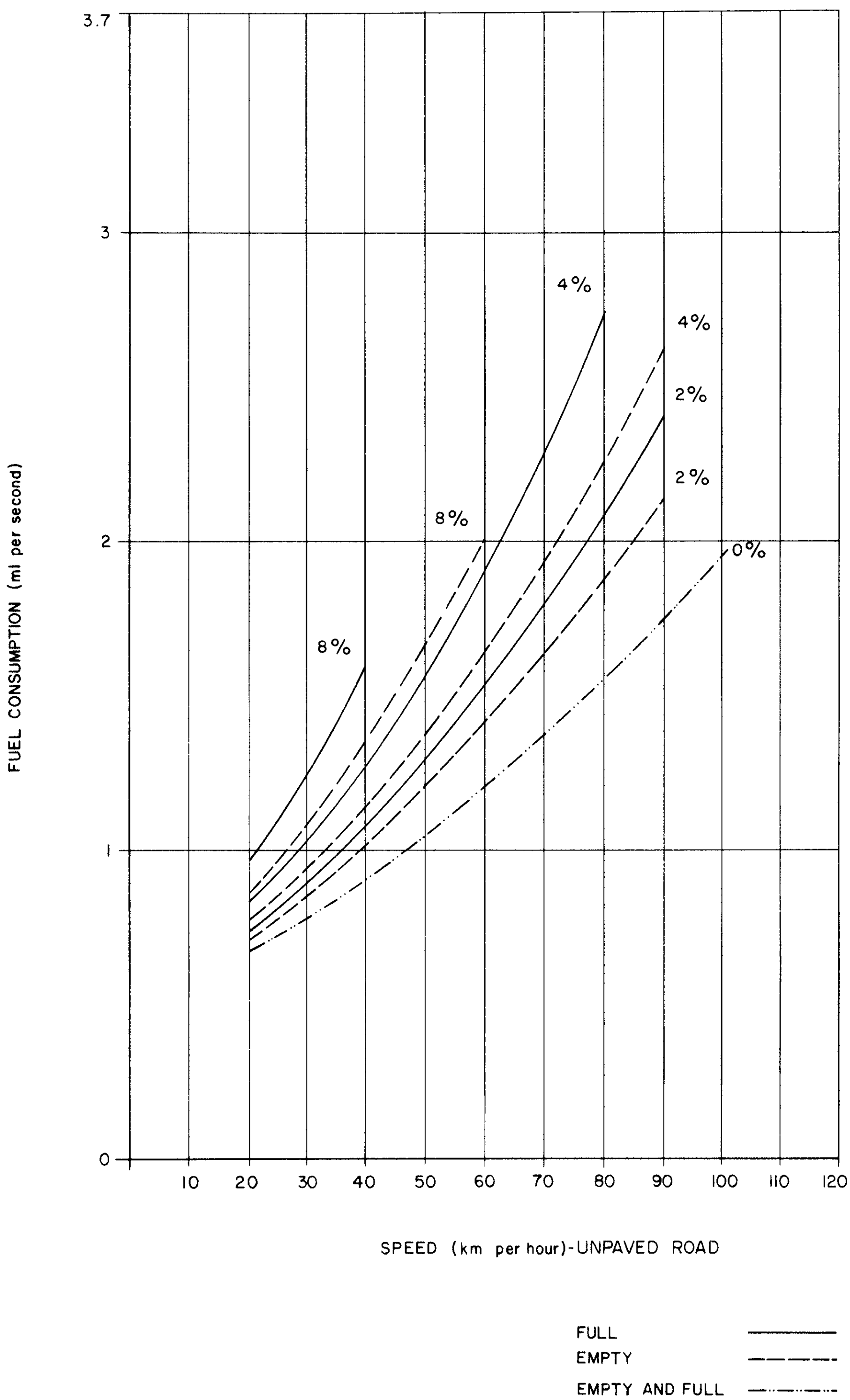

FIG. 22

FUEL CONSUMPTION - VOLKSWAGEN 1300 - POSITIVE GRADE

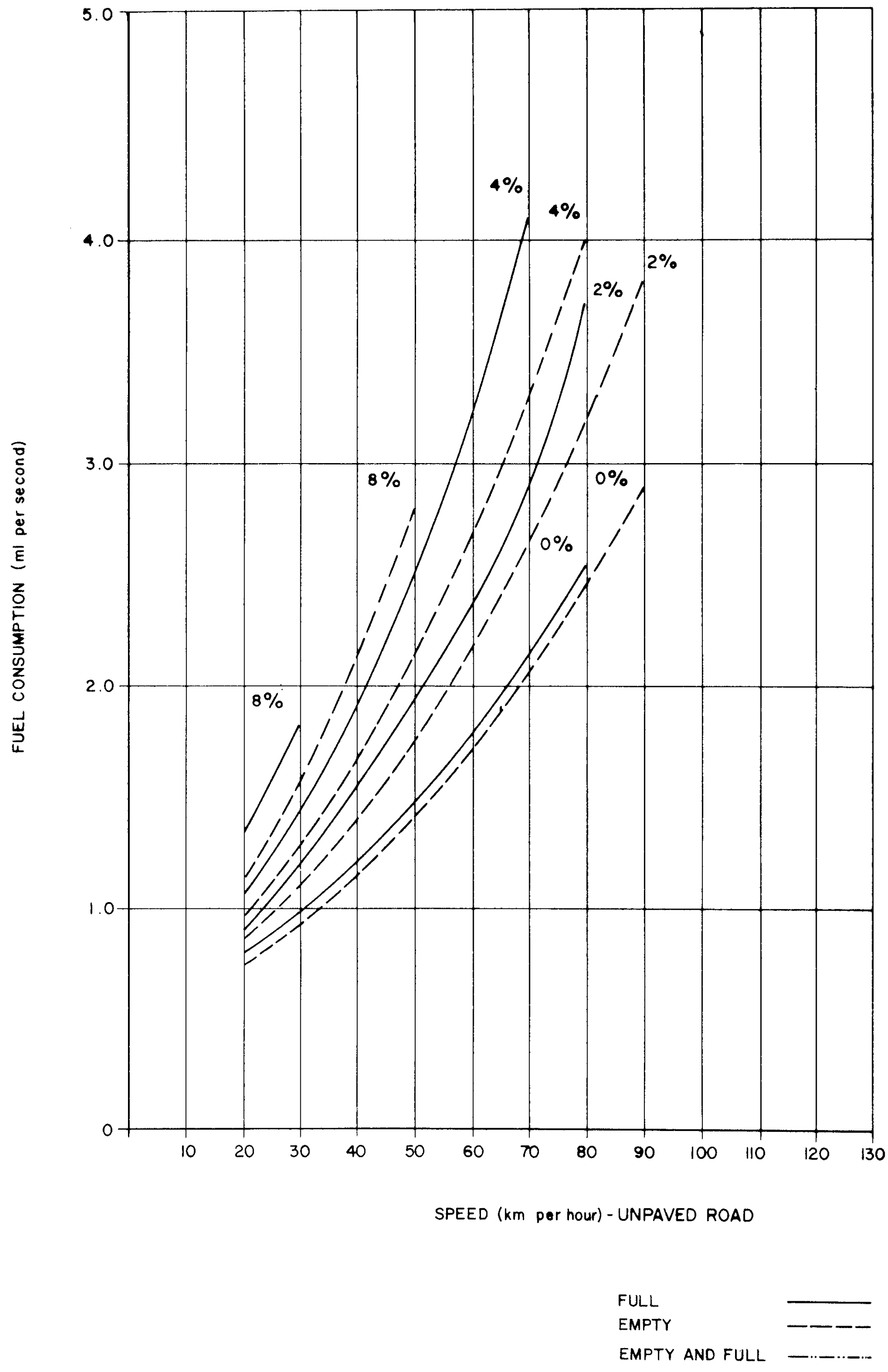

FIG. 23

FUEL CONSUMPTION - KOMBI - POSITIVE GRADE

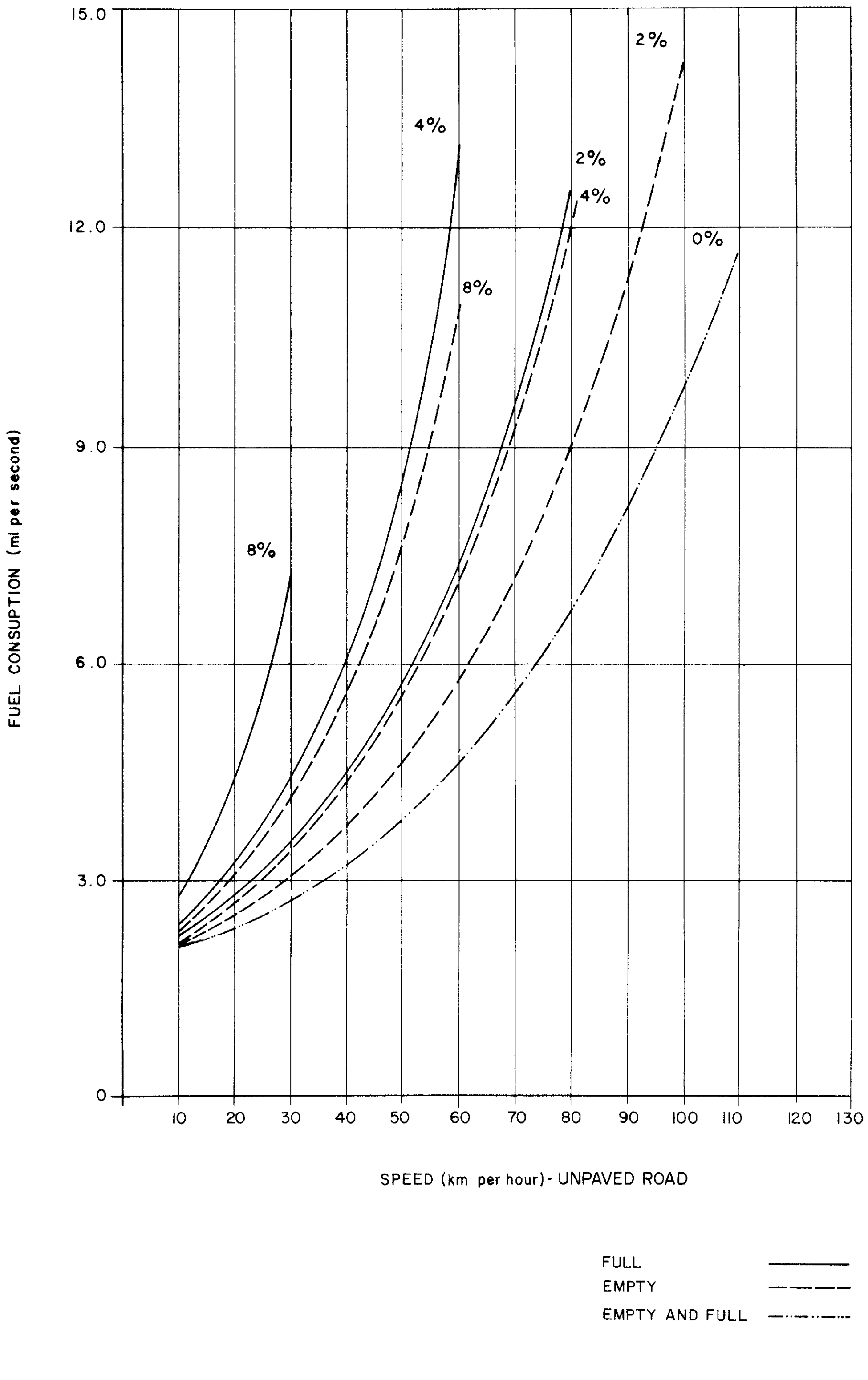

FIG. 24

FUEL CONSUMPTION - FORD 400 - POSITIVE GRADE

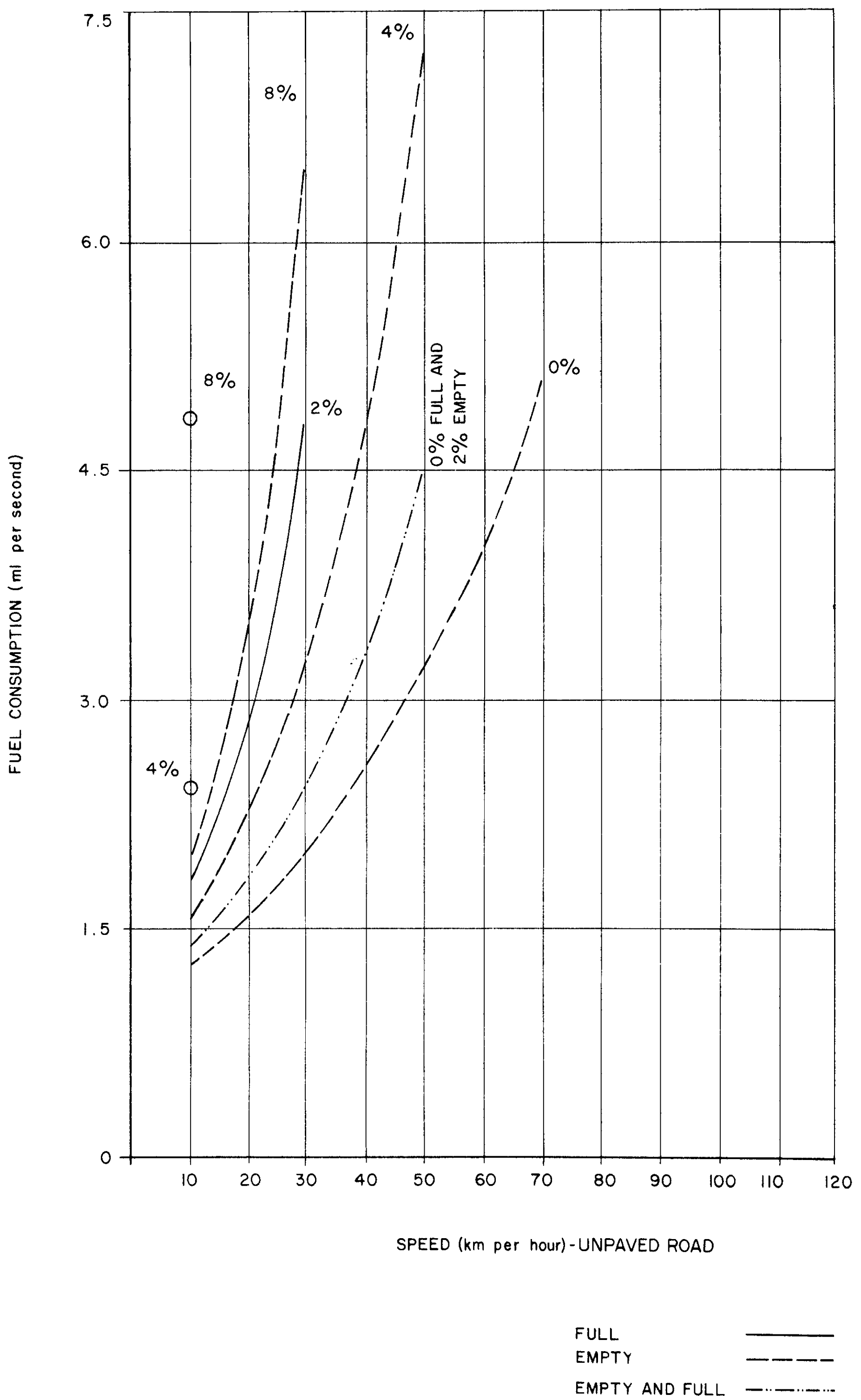

FIG. 25

FUEL CONSUMPTION - BUS MERCEDES 0-362 - POSITIVE GRADE

MT-GEIPOT

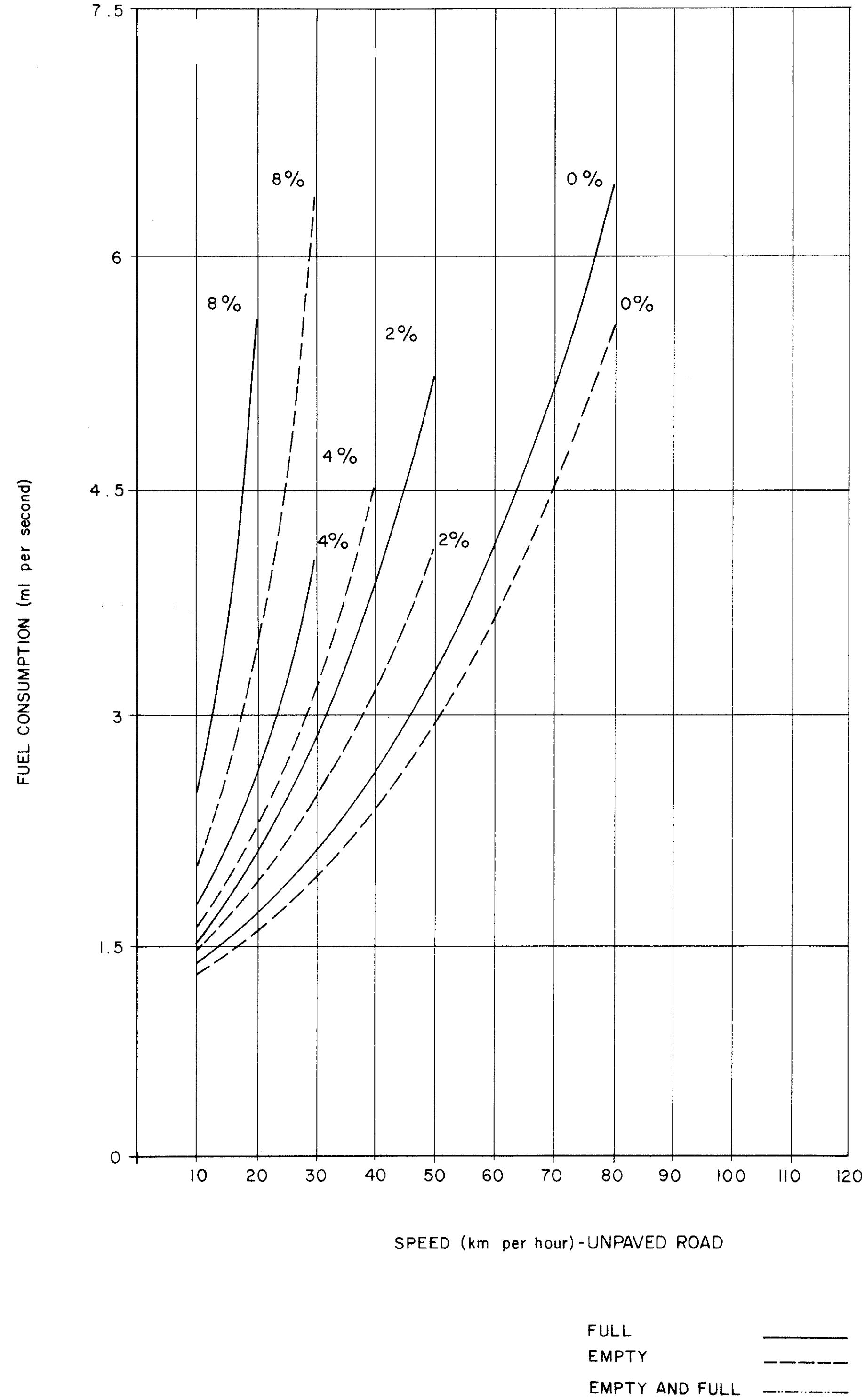

FIG. 26

FUEL CONSUMPTION - BUS MERCEDES O-362 - POSITIVE GRADE

MT-GEIPOT

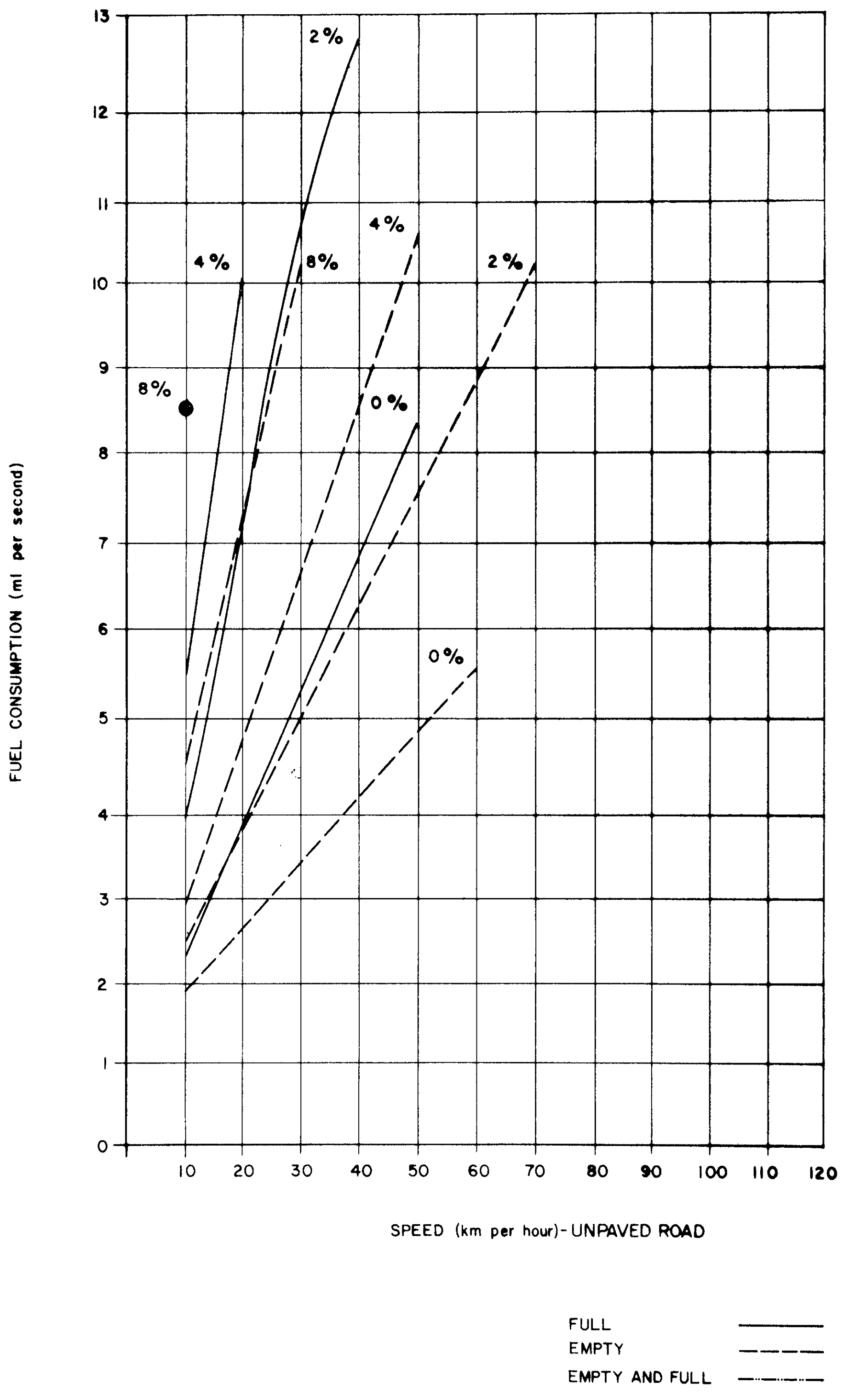

FIG. 27

FUEL CONSUMPTION - SCANIA - POSITIVE GRADE

TABLE D.11 - FUEL CONSUMPTION REGRESSION EQUATIONS FOR NEGATIVE GRADES

Volkswagen and Kombi Unpaved

$$F = -.87 + (1+1.88(C + .5)(e^{(.214\ G)}))^{.009\ V}$$

$S = .04$

Volkswagen and Kombi Paved

$$F = -1 + (1+(.065 + .042\ C)(e^{(-.016\ G^2)}) + .003(3-G)\frac{L}{C})^{.107\ V}$$

$S = .07$

Ford-400 Unpaved

$$F = \frac{1.77}{(1+G)^{.5}} - 1 + (1+e^{(.814 + .07(L+1)^2(.827-G))})^{.0178\ V}$$

$S = .56$

Ford-400 Paved

$$F = \frac{1.91}{(1+G)^{.5}} - 1 + (1+e^{(1.38 + .1(L+1)^2(1.26-G))})^{.01\ V}$$

$S = .27$

MB-1113 Unpaved

$$F = \frac{1.264}{(1+G)} - 1 + (1+e^{(.597 + .253(L+1)^2(.684-G))})^{.02\ V}$$

$S = .11$

MB-1113 Paved

$$F = \frac{1.09}{(1+G)} - 1 + (1+e^{(.519 + .213(L+1)^2(1.08-G))})^{.0180\ V}$$

$S = .14$

Scania Unpaved

$$F = \frac{2.068}{(G+1)^{.5}} (e^{(1.765 + .522(L+1)(.863-G))})^{.0091\ V}$$

$S = .36$

Scania Paved

$$F = \frac{2.343}{(G+1)^{.5}} (e^{(.879 + (L+1)(.79-G))})^{.0086\ V}$$

$S = .14$

where C = Class, 1=Volkswagen, 2=Kombi
G = Grade in Percent
V = Velocity in km per hour
L = Load 0=Empty 1=Full
F = Fuel in ml per second
S = Standard error of the equation

MT-GEIPOT

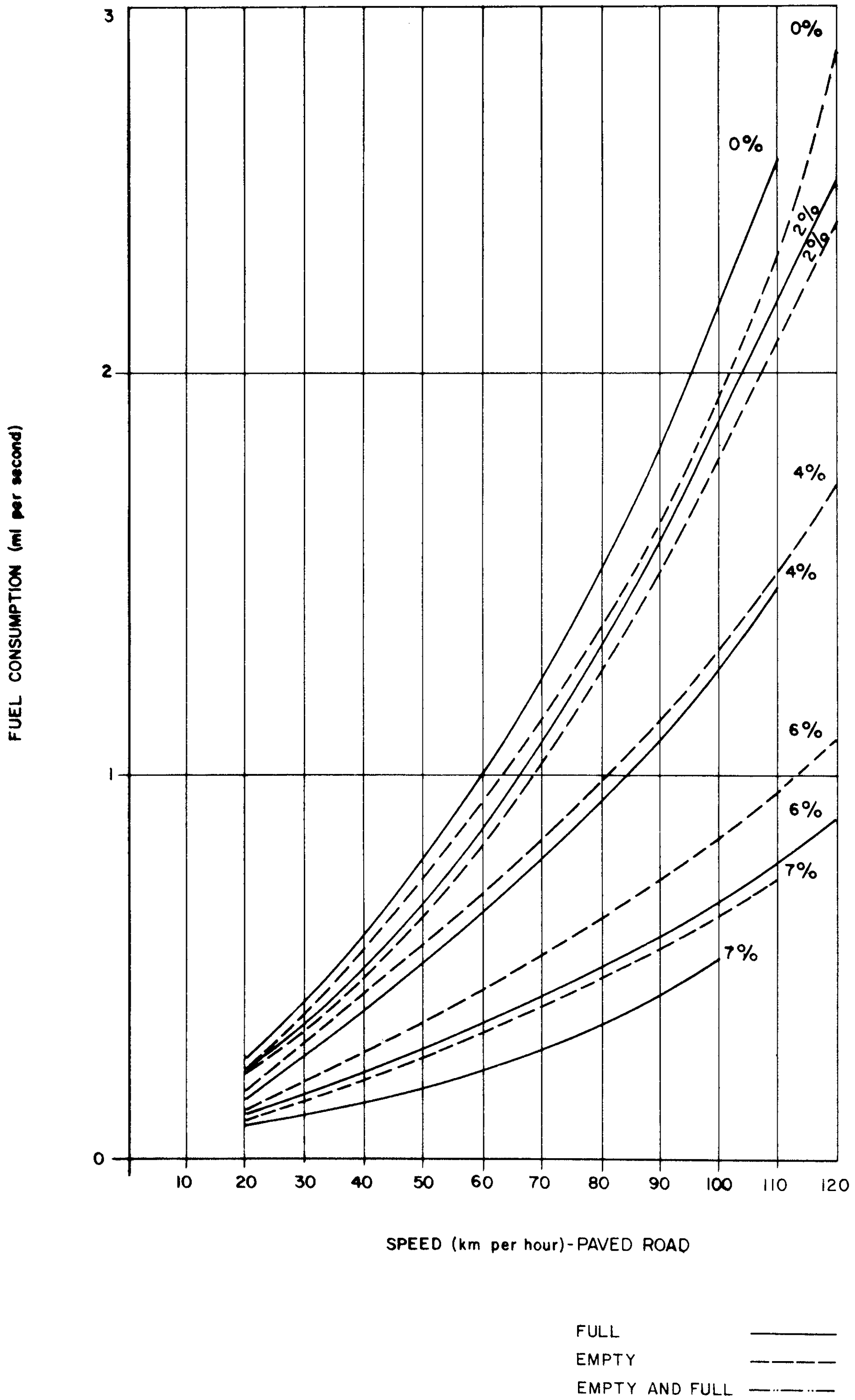

FIG. 28

FUEL CONSUMPTION - VOLKSWAGEN 1300 - NEGATIVE GRADE

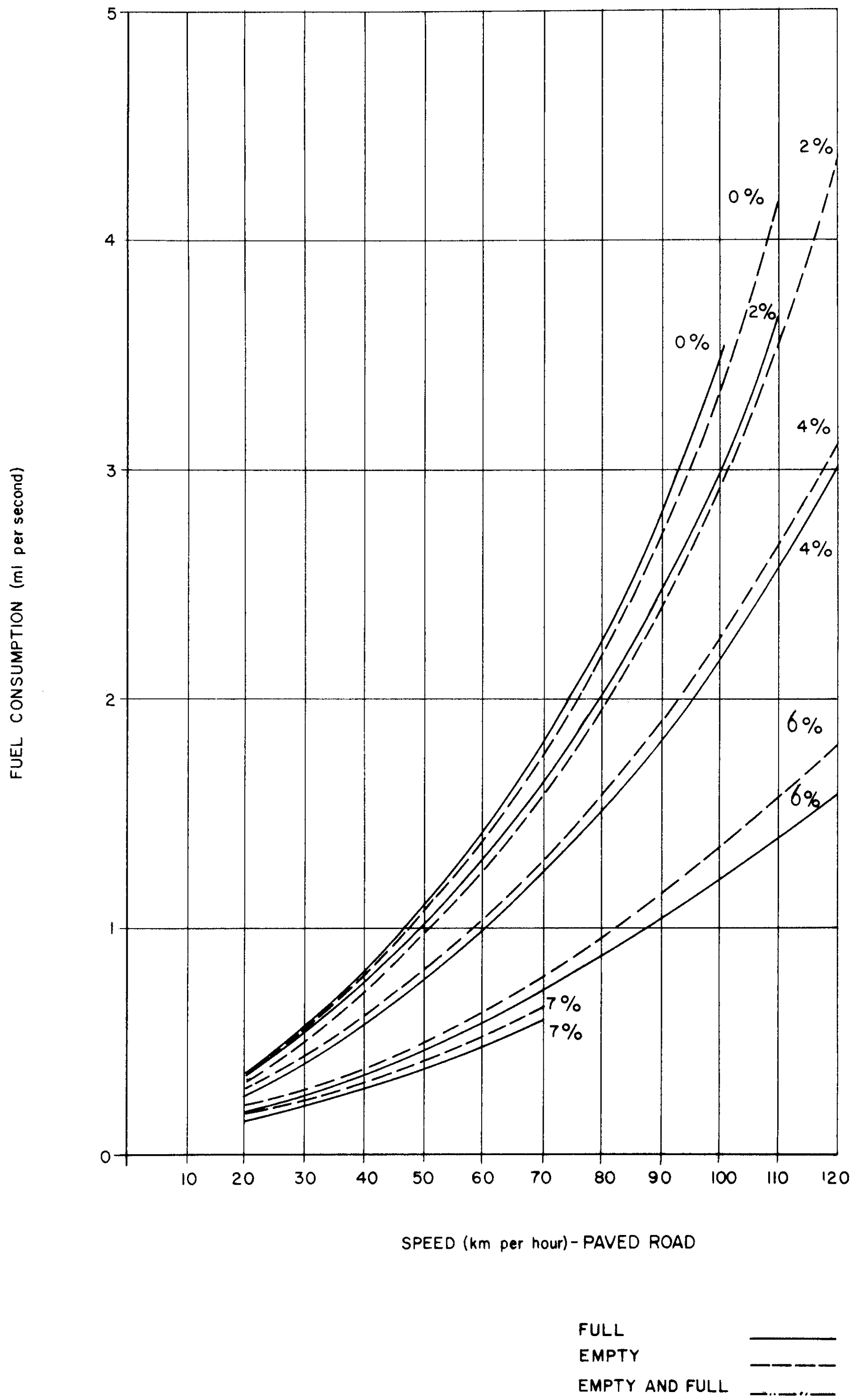

FIG. 29

FUEL CONSUMPTION - KOMBI - NEGATIVE GRADE

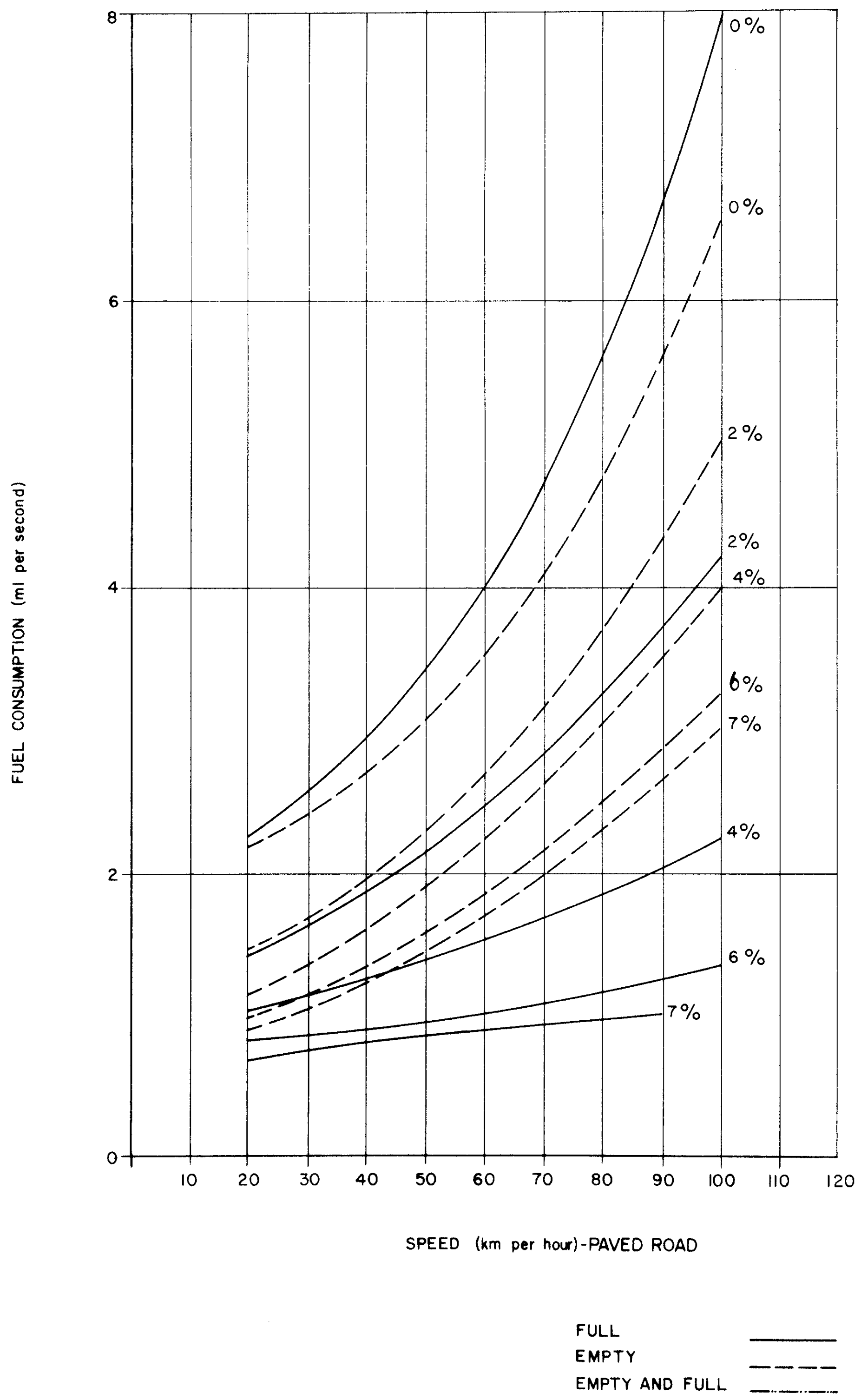

FIG.30

FUEL CONSUMPTION - FORD 400 - NEGATIVE GRADE

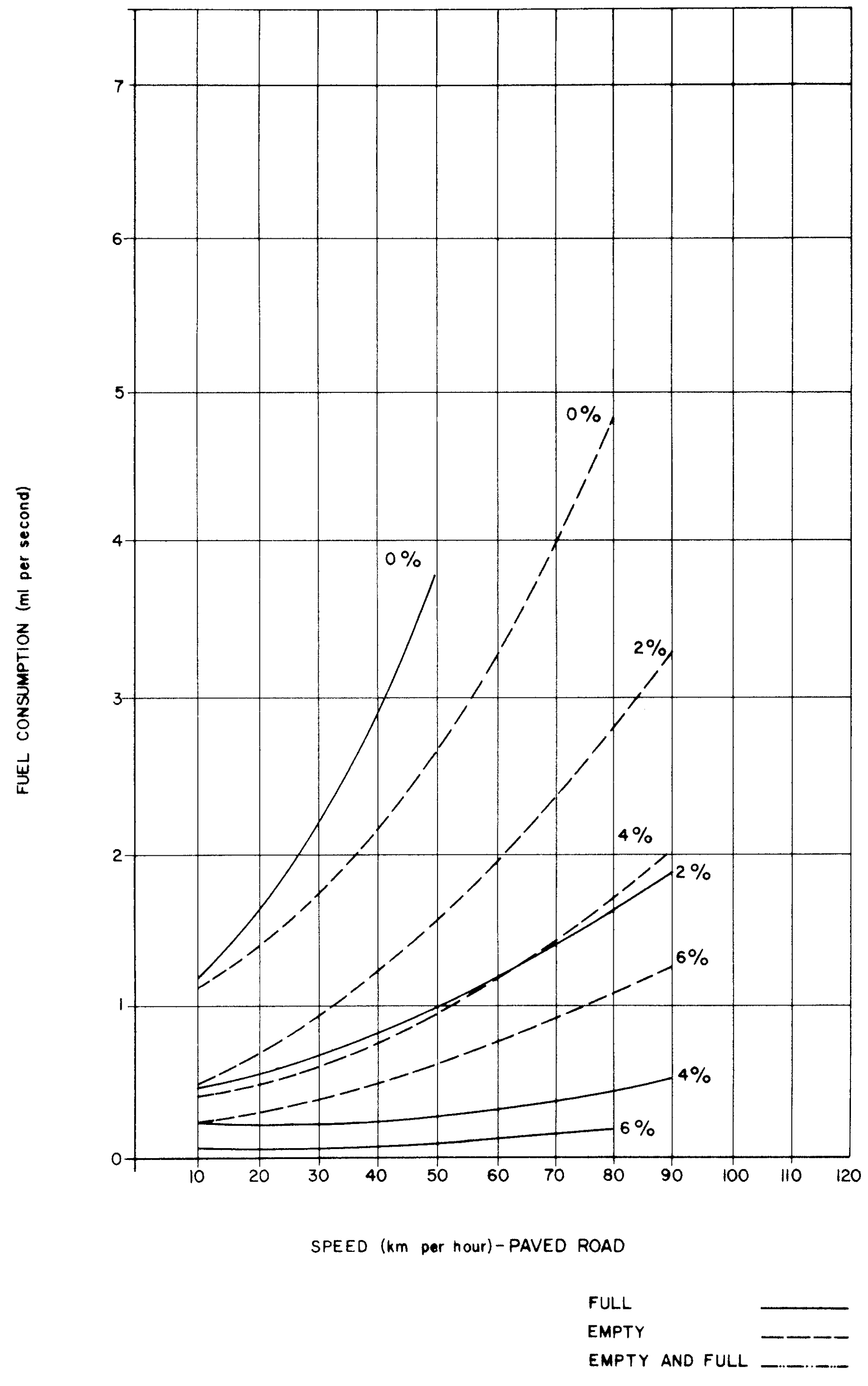

FIG. 31

FUEL CONSUMPTION - MERCEDES BENZ - 1 113 - NEGATIVE GRADE

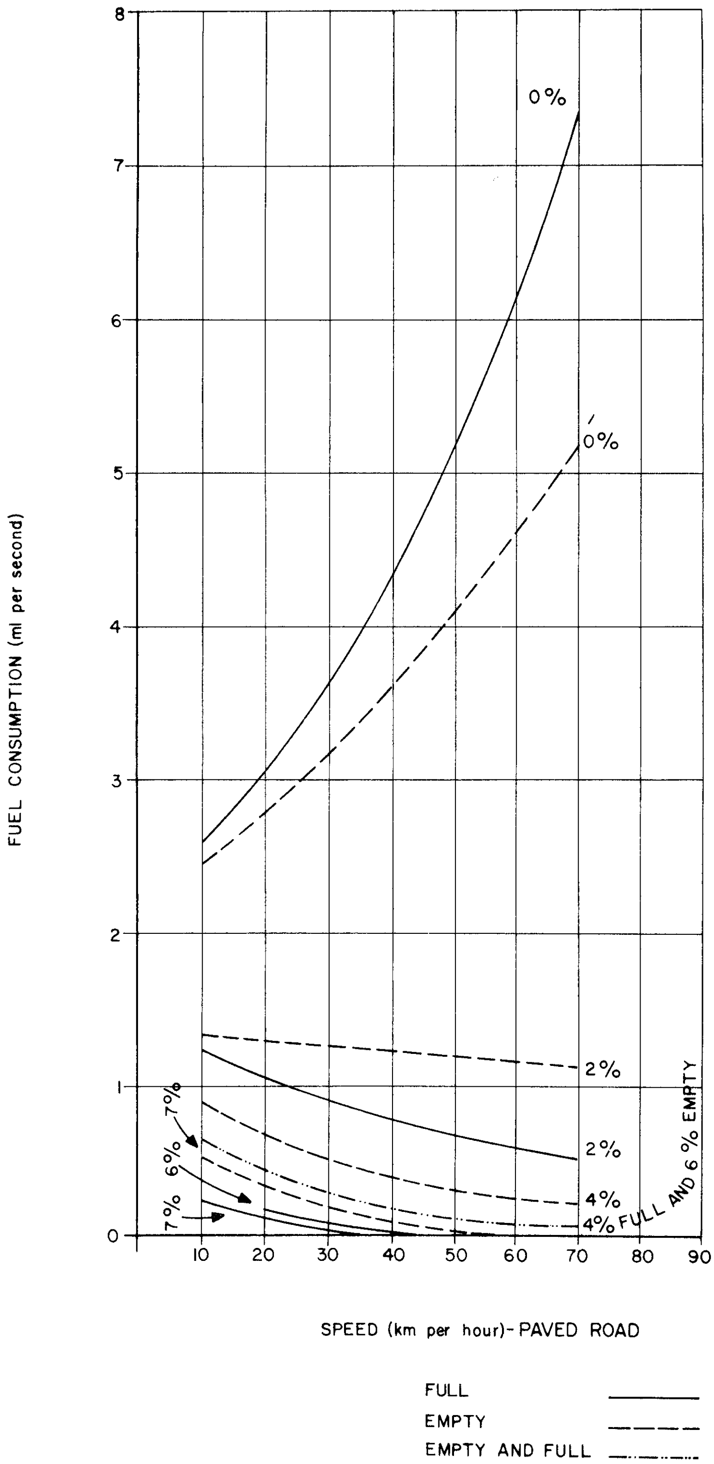

FIG. 32

FUEL CONSUMPTION - SCANIA - NEGATIVE GRADE

MT-GEIPOT

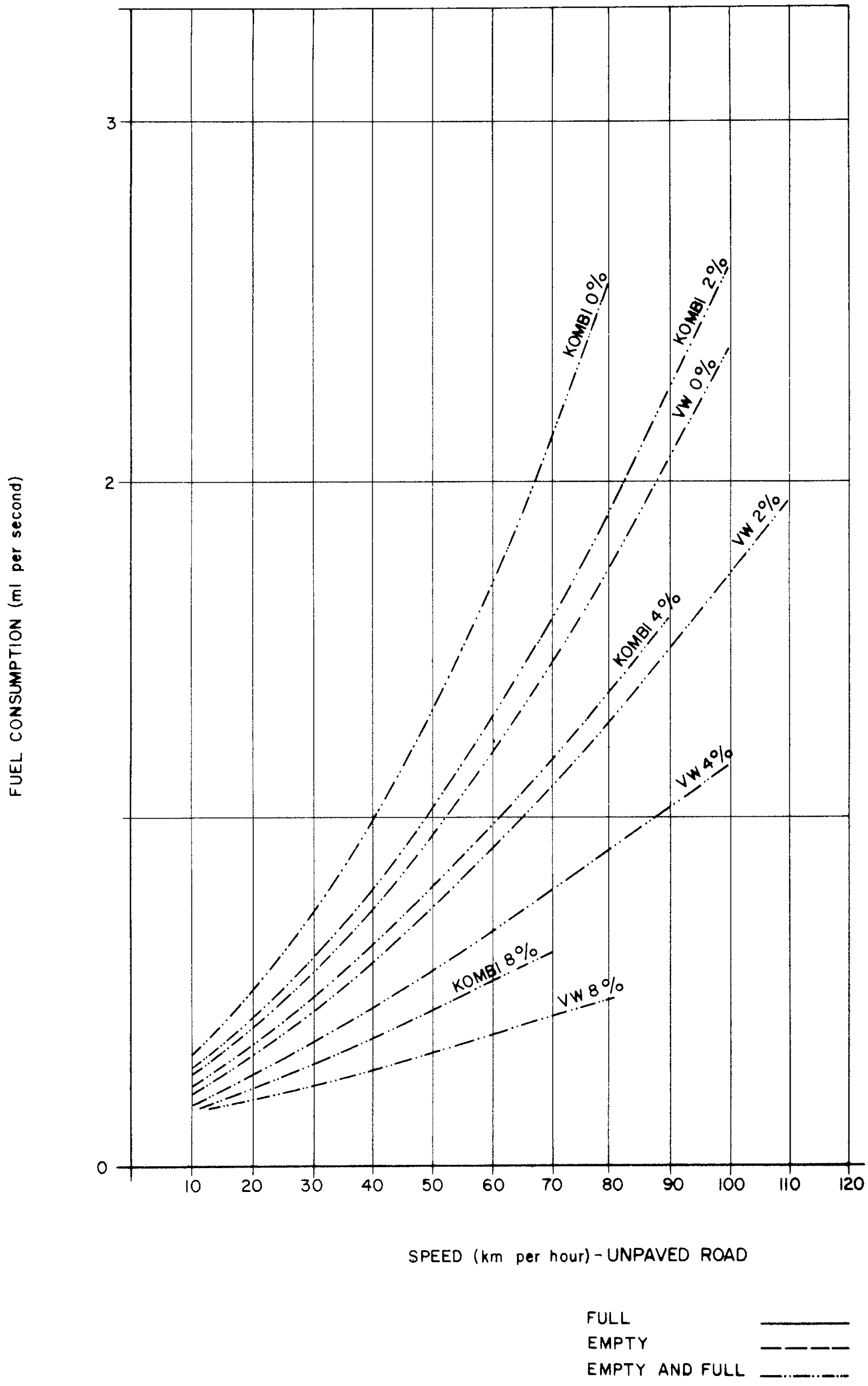

FIG. 33

FUEL CONSUMPTION - VOLKSWAGEN AND KOMBI - NEGATIVE GRADE

MT-GEIPOT

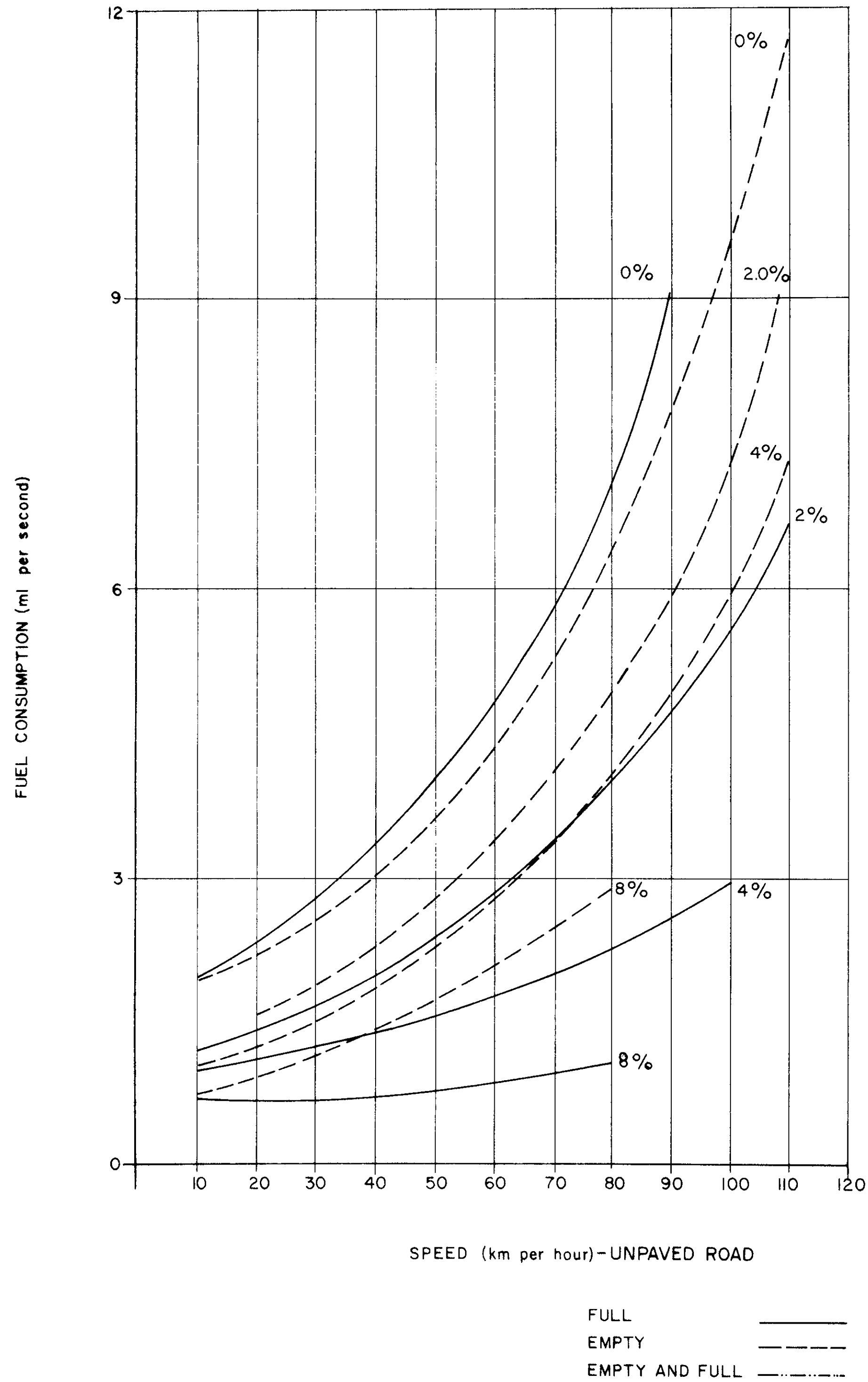

FIG. 34

FUEL CONSUMPTION - FORD 400 - NEGATIVE GRADE

MT-GEIPOT

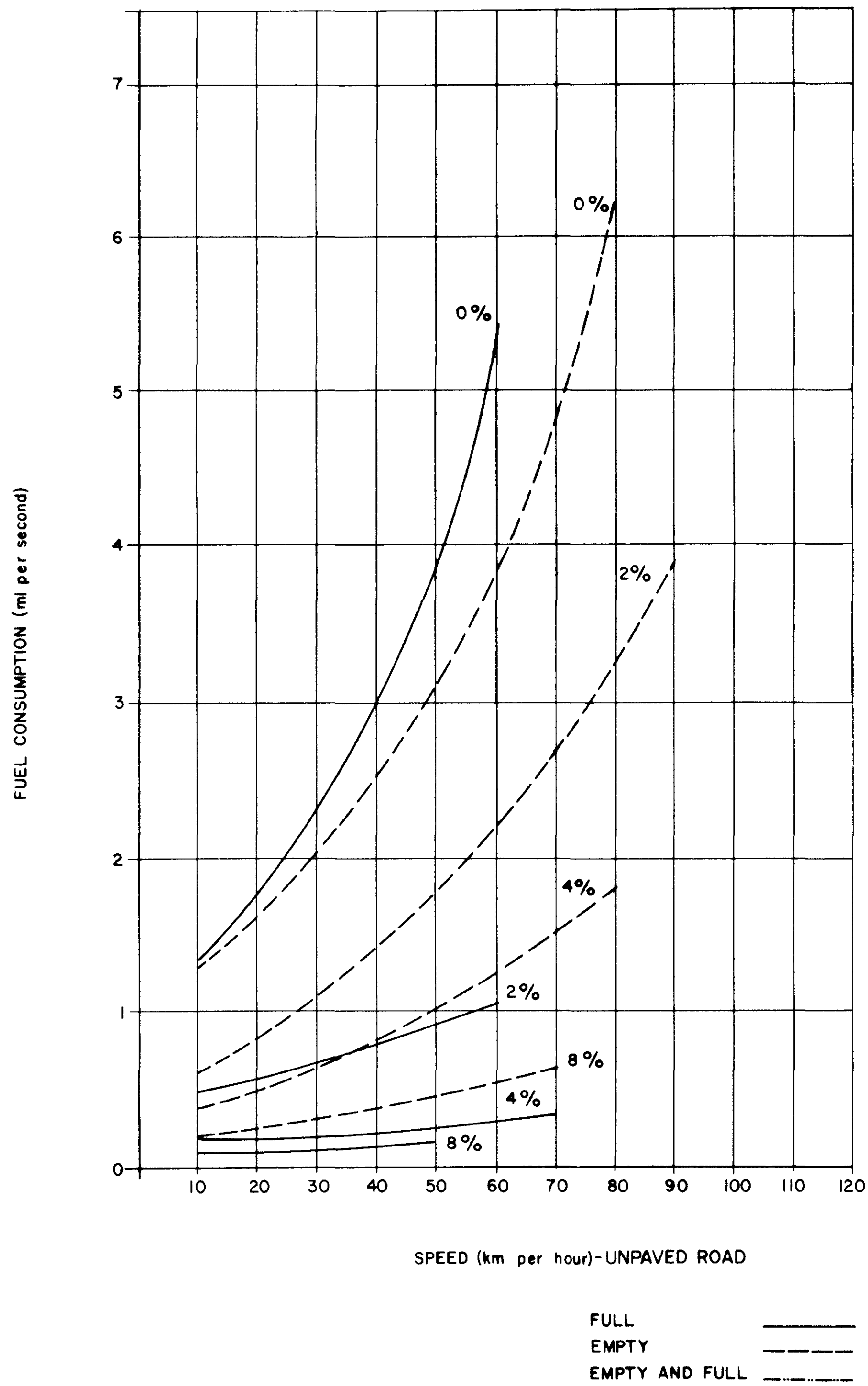

FIG. 35

FUEL CONSUMPTION - MERCEDES BENZ 1113 - NEGATIVE GRADE

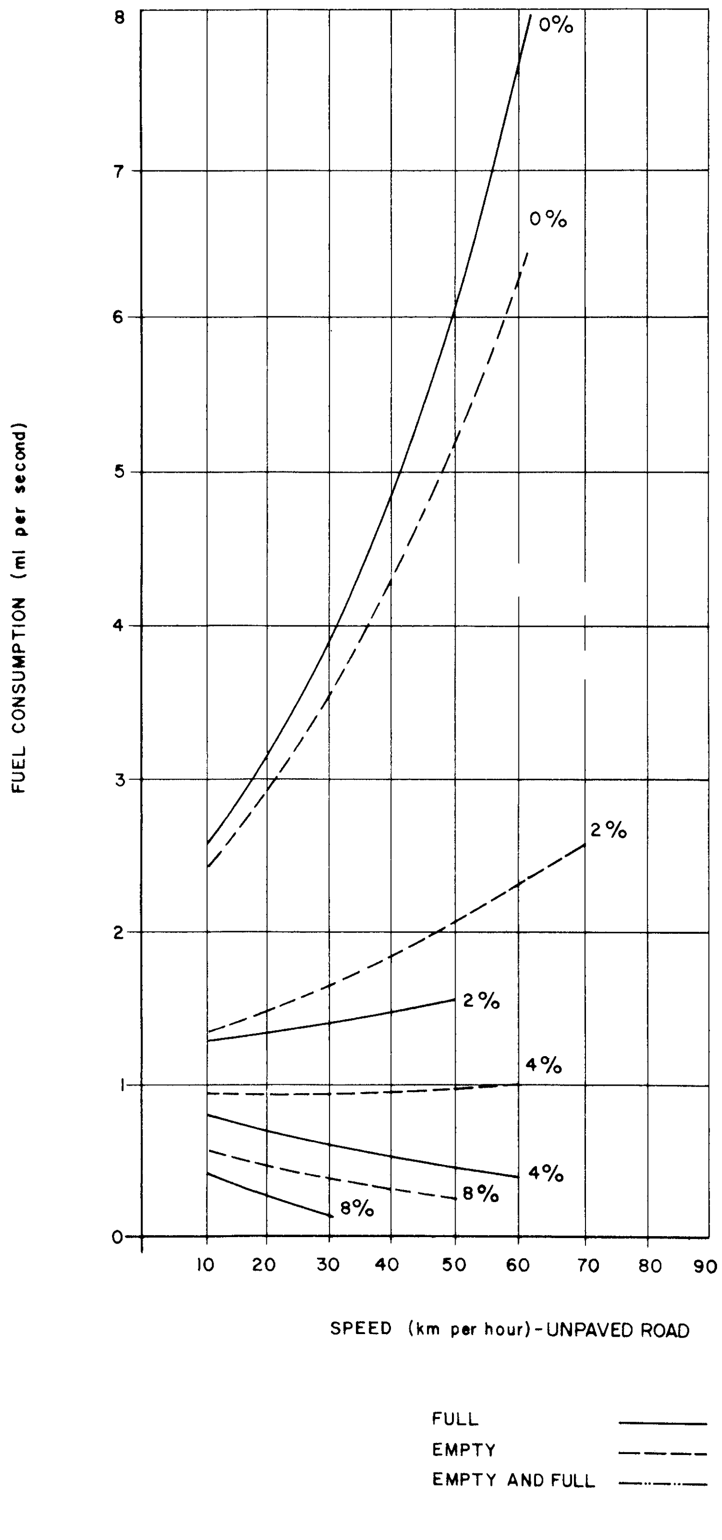

FIG. 36

FUEL CONSUMPTION - SCANIA - NEGATIVE GRADE

(3) *Summary of FC-1 Analysis*

Eighteen regression models are presented. They are the result of preliminary analysis of 20,000 steady-state fuel-consumption measurements. The equations are not in final form since the analysis reflects only a portion of the overall steady-state fuel-consumption experiment. The preliminary analysis using non-linear regression techniques offered a range of possible regression models. However, further refinements and modifications are required on the equations. Due to lack of actual analysis time, many possible improvements could not be accomplished. Certain problems with high coefficient correlations and large coefficient errors have not been satisfactorily eliminated from some of these preliminary non-linear equations. Such problems should be addressed before any of the functions are utilized for predictions.

The preliminary analysis effort has been very useful. The final analysis objective are much closer to realization due to the analysis performed on the data presented here.

d *Fuel Consumption on Curves (FC-3)*

It has been demonstrated in previous literature (Sawhill, Ref. 6) that small radius curves can significantly affect fuel consumption. The purpose of this experiment is to examine the effects of extreme curvelinear alignment on fuel consumption. Eight test vehicles provided the data collected on the two 8% gravel sections. Test runs were made in both directions in the empty and laden condition. Since one of the sections was a tangent and the other had a very small radius curve, fuel consumption differences could be compared between the two horizontal curvature extremes. The factors and levels of the experiment are presented in Table D.12.

(1) *Analysis-of-Variance Approach*

Data collected from the four gasoline and the four diesel vehicles operating in the positive and negative directions provided four groups of data. These four groups were analyzed separately. Since a limited number of vehicles were tested, various error terms must be separated within each analysis. The assumption was made that Volkswagen,

TABLE D.12 - FACTORS AND LEVELS OF THE EXPERIMENT

Factors	Levels
Vehicles	Volkswagen 1300, 2 Kombies, Ford-400, 2 Mercedes Benz 1113, Mercedes Benz 0-362 Bus, Scania
Loads	Empty and Full
Horizontal Curvature	70-meter radius curve and tangent
Speeds	10-50 km/h
Grades	+8%, -8%

Kombi and Ford-400 repeat errors are homogeneous and that Mercedes Benz 0-362 bus, and Scania repeat errors are homogeneous. Two Kombis and two Mercedes Benz 1113 trucks provided estimates of these errors. The Kombi errors were therefore used to test differences in the gasoline vehicle group and the Mercedes Benz 1113 errors were used to test differences in the diesel vehicle groups. Table D.13 presents an example of an Analysis-of-Variance layout.

Restrictions must be placed on the inferences of this experiment because only four gasoline vehicles and four diesel vehicles were tested. In addition, since only two vehicles provide error estimates, the error terms have very few degrees of freedom. Therefore,whenever possible, error terms are pooled and the appropriate pooled errors are used to test the main effects and interactions.

(2) *Analysis of Results*

In the positive grade case for gasoline vehicles, the error terms RH, RHL(c), RH5L(c) were not significantly defferent. Therefore, the pooled error with four degrees of freedom was used to test all horizontal curvature effects. None of the horizontal curvature effects were significant at the 10% confidence level. For the negative grades the various error terms of the gasoline vehicles were not homogeneous. The two repeat Kombis operated very similarly on the two sections. For each vehicle the mean fuel consumption on the curved section was about 3% above the fuel consumption on the tangent section. These similar statistics produced an extremely small RH error term. Other error terms, although larger than RH were also relatively small. The factors and interactions were tested without pooling the error terms. The F statistic calculated for each case, therefore, contains only one degree of freedom in the denominator. With this limitation, the tests showed that all intercation terms that contained horizontal curvature were not significant at the 10% level. But the main factor horizontal curvature was tested by the RH interaction and was significant at the 5% level.

The repeat error from the two Mercedes Benz trucks was used to test the horizontal curvature factor and interactions for the diesel vehicles. For both the positive and negative grades, the repeat errors were relatively large in comparison to other effects. One of the Mercedes trucks consumed less fuel on the tangent than on the curved

TABLE D.13 - EXAMPLE ANALYSIS-OF-VARIANCE TABLE USED TO ANALYZE FUEL CONSUMPTION FOR GAS AND DIESEL VEHICLES

Source	df	
Class (C)	2	
Repeat Vehicle (R)	1	
Load within Class L(C)	3	
RL	1	
Speeds (S)	4	(depending on the direction of the grade this value could be as low as 1)
CS	8	
RS	1	
SL (C)	12	
RLS	1	
Horizontal Curve (H)	1	
CH	2	
RH	1	
HL (C)	3	
RHL	1	
∫SH	4	
CSH	8	
SHR	1	
HSL (C)	12	
HSLR	1	

section and the other vehicle consumed less on the curved section than the tangent. The influence of the horizontal curvature was therefore reversed from one vehicle to the next, causing the repeat errors to be relatively large. Pooling was performed where possible, and all the main effects and interactions of horizontal curvature were not significant at the 10% level for positive and negative grades.

(3) *Summary of FC-3 Analysis*

It is difficult to make firm conclusions about the results of the analysis-of-variance procedures because of the limited degrees of freedom in the error term and because of the inference restrictions. The experiment cannot be viewed as a definitive study of the effect of horizontal curves on grades. However, within the scope of this experiment, the effect of horizontal curves appears to be minimal. Since this test was conducted using extreme conditions of horizontal curvature and grade, and for these conditions the largest mean difference in fuel consumption was only 3%, it may be concluded that it is not economical to experiment further on the effects of curves on fuel consumption. Therefore, the satellite study to further investigate the effect of horizontal curves on fuel consumption, FCS-2, will not be conducted.

5 SUMMARY

The road user costs and traffic experiments have been in progress for 16 months. During this time, over 130,000 pieces of data have been collected. Currently, there are five traffic-behavior and two fuel-consumption experiments in progress. One fuel-consumption main experiment and one satellite study have been completed. However, as explained earlier, there is still a lot of work to be performed. One fuel-consumption and three traffic-behavior main experiments have not been started.

Figure 37 shows the work schedule proposed for finishing the experimental program. The fuel consumption testing is scheduled to be completed by May 1978. At this time, it will be necessary to train the fuel-consumption crew to perform three of the traffic-behavior experiments. Since radar units are not required for performing these experiments, the radar crew can simultaneously perform other traffic-

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WORK PLAN AND SCHEDULE

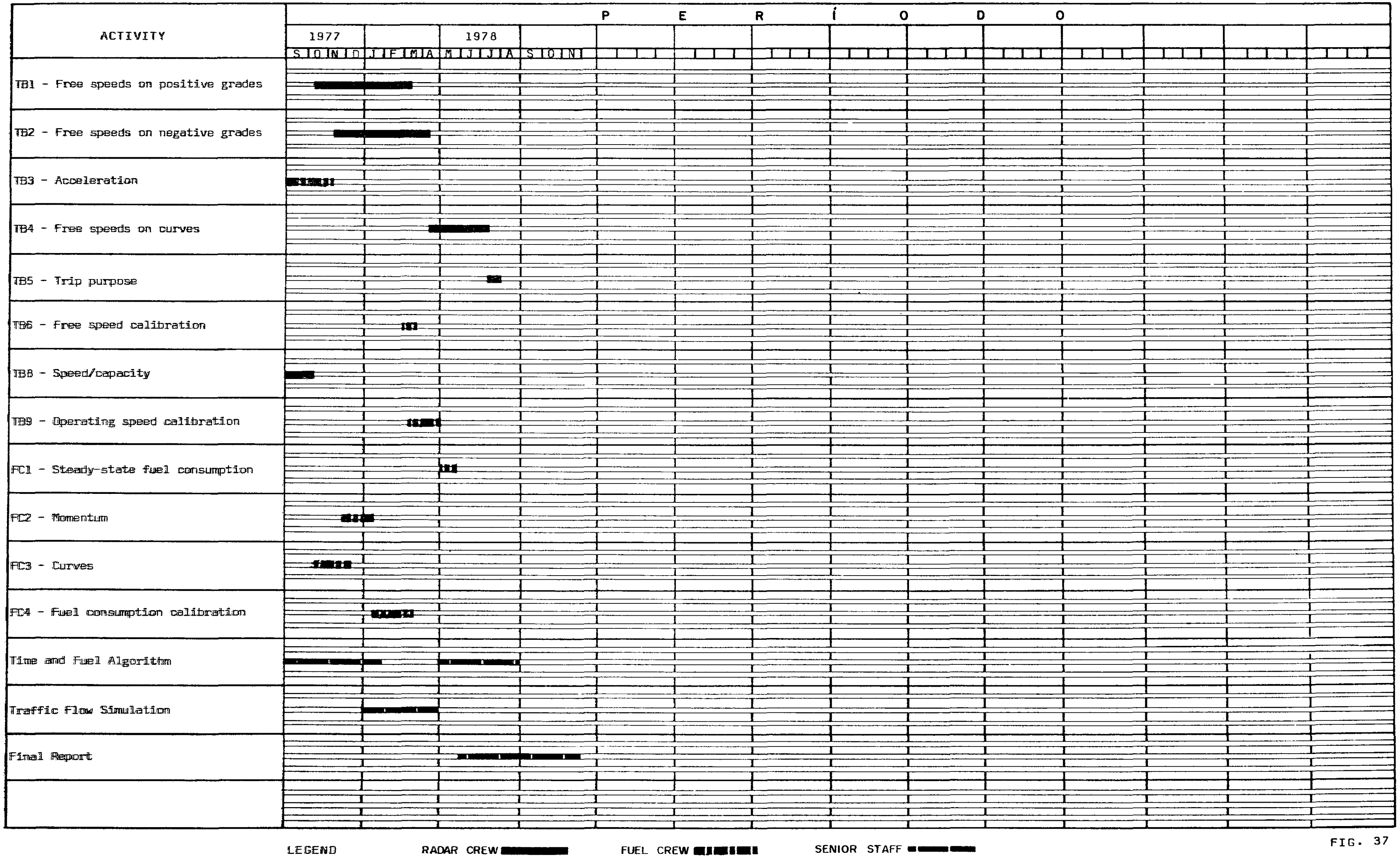

FIG. 37

behavior experiments. By using both crews to work on these experiments, it should be possible to complete the traffic-behavior experiments by the end of July 1978. This time schedule does not allow for the performance of satellite studies.

As shown by the schedule, the senior staff of the group has three main activities scheduled. Modeling of the Time and Fuel Algorithm is scheduled in two phases. The first phase, ending in January 1978, will be the basic development and programing. Because the results from the traffic-flow simulation model and the analysis of some of the experiments will not be completed by this time. a second phase is scheduled for incorporating these results into the algorithm.

Implementation of the traffic-flow simulation model is scheduled for the first four months of 1978. At this time, it will be necessary to have Mr. Russ Kaesehagen return to the project for a period of about one month. This is necessary because Mr. Kaesehagen has done some development work on the model since leaving the project.

Six months have been scheduled for writing the final report. As the work plan shows, there is overlap between the end of the experiments, the modeling of TAFA, and the writing of the final report. This indicates that the Road User Costs and Traffic Experiments Group is working on a very tight schedule and that minor delays in the collection or analysis of the data will lead to the elimination or reduction in scope of some of the later experiments.

CHAPTER E

PAVEMENT AND MAINTENANCE STUDIES

1 *OBJECTIVES*

The pavement and maintenance studies are directed towards understanding pavement performance in Brazil, i.e., how pavements constructed with different materials and at different times perform under different traffic loadings. Concurrently, the influence of alternate maintenance standards on the pavement's performance is being studied, which is a very important aspect since very little information is available on the impact of alternate maintenance levels on the pavement's future performance.

The primary objective of the studies of this Group will be to quantify a model of pavement performance which predicts the condition of a roadway as a function of:

- Structural variables such as material properties and layer thicknesses;
- Traffic volume and composition;
- Climate;
- Maintenance;
- Age and rehabilitation for paved roads.

The model will be applicable to paved as well as unpaved roads.

There is an identified need to establish rehabilitation policies through an evaluation of the tradeoffs among different designs and stage-construction strategies for a variety of maintenance standards. The pavement and maintenance studies are expected to produce some of the relationships needed for this evaluation. They can also from the basis for a continued and expanded study encompassing a wider range of pavement designs and materials over an extended time period. It will be difficult to develop complete pavement performance relationships for pavements with ten to 20-year life spans within the study period. The experimental designs adopted permit the analysis of roads of different ages in cross sectional analysis. However, equally important is the formulation of a sound basis for continued research in the future. The construction of the special maintenance and rehabilitation experiments clearly fall into this latter category. It will be impossible to evaluate these sections to destruction in the remaining 15 months of the project because the asphaltic concrete sections, for example, could have a life of up to 10 years:

2 ORGANIZATION AND STUDY PROCEDURES

The approach being used for determining a pavement deterioration relationship is to monitor a number of variables describing pavement behavior, distress and performance on a number of test locations selected on existing roads. Each test location is divided into two sub-sections which will receive different maintenance levels. The sub-sections are 320m in length, with an 80m transition between the sub-sections. In some cases, the section lengths are reduced on unpaved roads where the sub-sections on curves are only 80m in length. This is because extreme geometric conditions need to be investigated and curves with radii of less than 250m seldom have a length of more than 240m. Besides monitoring pavement behavior, distress and performance, the characteristics of the pavement materials, traffic distributions and vehicle weights are being determined.

A variety of activities need to be performed in fulfilment of the stated objectives. During the initial term of the project, a functional organization was developed to perform these activities. This organization structure is illustrated in Figure 38, but because of the graphic deficiency of this type of diagram, all the interrelationships between the different engineers and field crews cannot be shown. Because of the varied nature of the work, the field crews travel independently, and this makes organization, programming and control extremely time consuming.

The characterization and determination of the properties of the materials used on each of the test sections comprise an important part of the study. Since the project does not possess the capability of carrying out the field material testing, a consultant was hired to perform this work. The project maintains a full-time supervisor with the consultant's team, besides the regular visits of the supervising engineer. To control the work, a soils laboratory was set up which is capable of executing all the laboratory tests necessary, including such sophisticated tests as the determination of the resilient modulus of undisturbed subgrade samples and bituminous surfacing samples.

3 SCOPE OF THE STUDIES

The pavement and maintenance studies are basically proceeding as was envisaged in the Inception Report with various refinements

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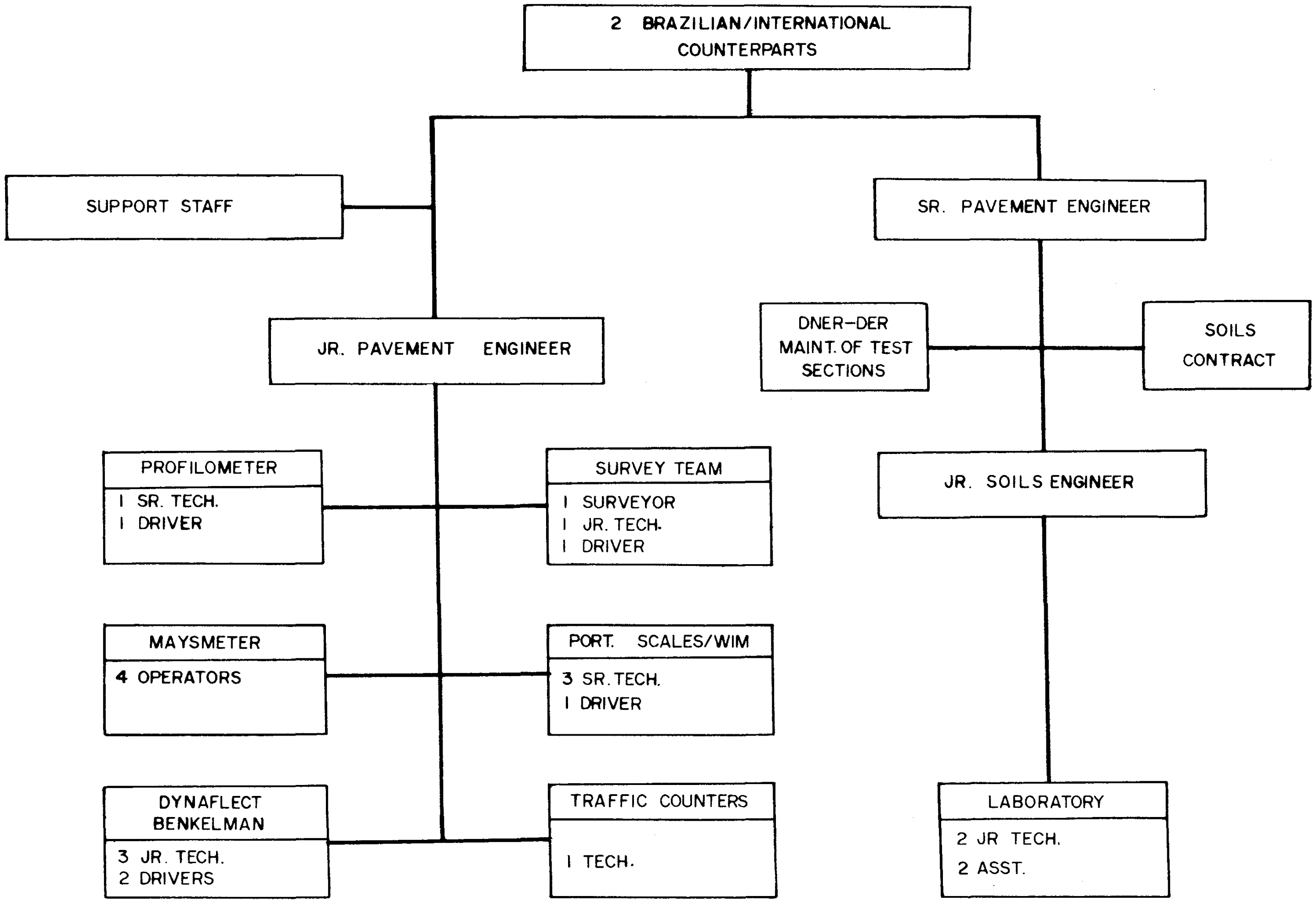

FIG. 38

ORGANIZATION OF THE PAVEMENT AND MAINTENANCE STUDY GROUP being made in response to field conditions as necessary.

The special experimental pavement which was proposed to be constructed of different paved and unpaved sections on the same stretch of road, and designed to supplement the pavement study. will probably not be constructed because of the unavailability of project funds, and the inability to find a sponsor. However, during discussions with the different road departments, an interest was expressed for the construction of special maintenance and rehabilitation experimental sections, rather than for the construction of a special experimental pavement. This outlook by the road departments is not surprising considering that a large proportion of the roads were constructed during the last ten years, and these roads are now reaching the stage where they need attention. The discussions have led to the construction of special surfacing sections on a road of the Departamento de Estradas de Rodagem of Minas Gerais (DER-MG), near Juiz de Fora, and currently under discussion is the construction of a similar experiment in conjunction with the Departamento de Estradas de Rodagem of São Paulo (DER-SP).

The special surfacing experiments are designed to determine the performance of the pavement following the application of the different surfacing types as a maintenance or rehabilitation operation. Performance will be evaluated by measuring riding quality, behavior will be monitored in terms of deflection, and distress will be related to cracking and patching. These results will be compared to control sections receiving no treatment.

The selection of the roads on which the special surfacing experiments are constructed are based on the premise that, besides the one at Juiz de Fora, further experiments will be constructed in the future. The design factorial, which considers the two factors of traffic and original surfacing type, is a simple 2 X 2 matrix as shown in Table E.1.

To optimize between the costs of construction and length of section required for obtaining meaningful results, it was decided to construct 200-m sections. Only the central 160m is used for evaluation purposes, and the 20m on either side remains as a transition.

At the Juiz de Fora experiment, four different maintenance and rehabilitation treatments were used:

- Asphaltic concrete: three different sections were constructed with layer thicknesses of 4 cm, 8 cm and 12 cm;

TABLE E.1 - THE DESIGN MATRIX FOR THE SELECTION OF ROADS ON WHICH SPECIAL EXPERIMENTAL SECTIONS ARE CONSTRUCTED

		Traffic (ADT)	
		High	Low
Original surfacing type	Surface treatment		Juiz de Fora experiment
	Asphaltic concrete		

- Cold Mix: 4-cm thick layer was used;
- Slurry seal: two types of slurry seal, a fine graded slurry with all the aggregate passing nº 4 sieve, and a coarse graded slurry with the material passing the 1/2-inch sieve, were used;
- Surface treatment: a double and a single surface treatment were employed.

The surfacings used at Juiz de Fora will serve as an example for future experiments. It is envisaged that the same technique will be used on sections to be constructed by each collaborating agency,and other surfacing types may be included depending on local practices.

The special surfacing experiments are very important to an understanding of alternative rehabilitation and maintenance policies. Construction of such sections is normally postponed because it takes such a long time before conclusions can be made.

A complete evaluation of some of these surfacings could require from five to 10 years, which is beyond the time span of the project. Nevertheless, construction of these experiments should continue until the end of the project, when they can become part of other highway research projects in Brazil.

a *Testing Completed*

Each field crew has specified functions to be performed at regular time intervals. Since the pavement performance study is time-based, the numerous results which have already been obtained present a disjointed picture which does not yet permit an overall analysis. Tables E.2 and E.3 summarize the different tests already performed on the two types of road sections. The different sections have been stratified by the type of experiment.

The survey crew is responsible for locating and marking the sections, measuring the geometrical characteristics, and on unpaved roads, for measuring gravel loss. The majority of the paved road sections have been located, and ultimately there will be about 50 unpaved sections under observation. The difference in the number of unpaved sections marked and the number on which gravel-loss measurements are being made is due to some sections requiring regravelling to give a wearing course thickness of at least 15 cm.

TABLE E.2 - STATUS OF TESTING ON PAVED ROAD SECTIONS AT 1 AUGUST 1977

	Paved Road main factorial	Paved Road star points	Satellite study soil cement bases	Juiz de Fora special sections
Section location	43	19	9	15
Condition survey 1st Cycle	43	19	9	15
2nd Cycle	4			
Deflection survey				
Benkelman beam and Dyna-flect 1st Cycle	43	19	2	15
2nd Cycle	40	17		
3rd Cycle	20	6		
Seasonal measurements cycle nº	12			
Roughness measurements				
Profilometer 1st Cycle	42	19	2	15
2nd Cycle	15	4		
Maysmeter 1st Cycle	43	19	2	15
2nd Cycle	15	5		
Portable scales	23	9	1	
Material tests	17	4		
Traffic classification counts	6	1		
Maintenance Required	18	5	4	
Completed	13	4		

TABLE E.3 - STATUS OF TESTING ON UNPAVED ROAD SECTIONS AT 1 AUGUST 1977

	Unpaved Road main factorial	Unpaved Road star points
Section location	13	6
Gravel loss measurements at 3-4 monthly intervals	10	2
Roughness measurements Maysmeter at 2 weekly intervals	10	3
Portable scales	8	
Surfacing material characterization tests	13	6
Traffic classification counts	4	

The roughness measuring system comprises the Profilometer and the Maysmeters. The Profilometer serves as the roughness base for the research, so correlations must be developed between the Profilometer and the different Maysmeters. A calibration course consisting of 20 paved road sections covering the range of road roughness of paved roads in the vicinity of Brasilia was established. The crews in this sector are responsible for the calibration and control verification of all the Maysmeter, including those used on the user costs surveys routes.

To check whether the Maysmeters are in calibration, they are run over the calibration sections at regular intervals. The Profilometer also regularly measures these calibration sections to detect changes in the pavement condition. The Profilometer has completed the first cycle of roughness measurements on the paved road sections, with the exception of a few sections with soil-cement bases which were marked recently, and is currently performing the second cycle. The Maysmeters also are conducting the second cycle of measurements on the paved roads The roughness of 13 unpaved sections are being measured at about fortnightly intervals. Besides the roughness measurements for the Pavement Study Group, the two Maysmeters allocated to this section have also been heavily occupied, initially measuring the routes travelled by the vehicles of the user costs surveys, and more recently carrying out measurements for the fuel and speed studies.

Deflection measurements may be used as a surrogate for pavement strength. The two types of measuring devices being used are the Dynaflect and the Benkelman beam. To develop a correlation between the two instruments, measurements are taken concurrently. Indications are that it may be difficult to develop a reliable correlation between the two instruments, so both devices are used to measure all the paved road sections. A second cycle of measurements is almost complete on the paved sections. Besides the regular measurements on all the sections, ten sections in the Federal District are being used to develop a seasonal correction factor for deflection, which is absolutely essential for meaningful analysis of the deflection data. During a one-year period, 12 measurements have been made.

An important aspect of the pavement performance study is the influence of axle loads on paved and unpaved road performance. It is necessary to obtain information on axle loads and traffic distribution on Brazilian highways. Portable scales and a dynamic weigh-in-motion system are available for collecting axle-load data. The portable scales are used to measure axle loads over five-day periods during daylight hours. Results have been obtained at 48 sites. On the heavily trafficked roads it is difficult and dangerous to obtain measurements with the portable scales, whereas at night it is impractical. For these reasons, the weigh-in-motion system is utilized. It measures all the vehicles without stopping them, and it can be used at night or during the day. Results have been obtained at two sites, and four additional site installations are planned, all located on some of the most heavily trafficked routes in Brazil.

To establish the frequency of axle loadings, traffic counts are being taken. Simple counters needing daily or weekly readings are generally used on unpaved roads. Recording traffic counters have been installed to monitor seasonal variations in traffic flow, and ten of these permanent traffic counters have been installed at strategic locations in the State of Goiás. They are used to supplement and correct manual classification counts which are only taken over a seven-day period. These traffic counters need regular visits for verification and adjustment. In the States of Minas Gerais and São Paulo, the DNER is installing similar equipment. We plan to use their data, while the data gathered by the project can also be used to their advantage. At 11 locations, manual traffic classifications counts have been taken, and it is envisaged that the assistance of the road departments will be obtained to complete the counts. In some cases this may not be necessary since regular count points are located close to the sections. Preliminary results relating to seasonal variation in traffic flow at two sites are discussed below.

Material characterization is also an important aspect of the study. All the laboratory tests are currently being executed in our soils laboratory, while the field testing is being executed by consultants. Field density, field CBR, field moisture contents and layer thicknesses have been measured on 21 paved road sections. Samples have been taken of each layer for laboratory testing, which consists of determining a grading analysis, Atterberg limits and laboratory CBR and density. Material characterization has been performed on the surfacing material of the 19 unpaved sections which have been selected.

Condition surveys are used to establish those sections requiring maintenance. The sections are located in different regions, which means that the procedure of applying the slurry seal and correcting bad distortions need to be explained afresh, and a new team needs to be trained. Up to the present time, maintenance has been applied to

17 of the paved road sections. This work is essential for addressing the objective of determining the influence of maintenance level on future pavement performance.

4 TRAFFIC VOLUMES

Traffic information is needed in the development of pavement performance relationships and to support the development and use of the model. Support activities such as traffic counting are some times insufficient, and therefore should be part of the study effort.

Manual traffic classifications counts are being obtained at all the pavement study sections. However, in many cases seasonal variations will bias these results. It is therefore essential to establish variation in traffic flows during the year. DNER is at present installing permanent traffic counters at strategic locations in the States of Minas Gerais and São Paulo. In the State of Goiás the project decided to install ten permanent traffic counters to give complete coverage of the study area in Goiás. The installations are on all the major paved routes in the southern part of Goiás, as shown in Figure 39.

a *Equipment and Data Reduction*

The permanent counters are print-punch traffic recorders, which are activated by induction loops. The equipment is installed at highway police posts which are located on the major routes or at gas stations. Initially only two installations were made, using batteries as an electrical source. The batteries discharged in about one week on the more heavily trafficked routes, and as police posts and gas stations have an electrical supply it was decided to install battery chargers with the counters at those sites.

The analog-digital system has attached to it a teletype unit which roads the paper tapes generated by the traffic counters. This system functions very satisfactorily and permits the paper tapes to be copied directly onto magnetic tape which can be processed by any computer.

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LOCATION OF PERMANENT TRAFFIC COUNTERS IN THE STATE OF GOIÁS

6 *Analysis of the Data*

The traffic counter data have been processed from the initial two sites: Counter CO-1 installed on BR-040 linking Brasilia and Luziânia, and counter CO-2 located on BR-060 linking Brasilia and Anápolis. The average daily traffic (ADT) per week for the period that was measured is presented in Figures 40 and 41 for the two counters. The average daily distribution is shown in Figures 42, 43 and 44.

The traffic counters record traffic in each of the two directions, and punch the result hourly. For the period January to June 1977, the hourly traffic is presented in Figures 45 and 46.

Only limited data from the eight other traffic counters are currently available because the recent installation of these counters. In the future, data from the ten traffic sites will be used to develop seasonal weightings which will be used to expand our limited manual counts at each test section. This information also will be used in adjusting traffic volumes obtained from non-recording counters, presently being installed throughout the State of Goiás study areas, to develop traffic on user survey routes. Further, traffic counter information will be used in developing volume distribution relationships needed to use the Brazil Roadway Investment Analysis Model.

5 *AXLE LOADS*

Accurate axle-load data are very important in the determination of pavement performance relationships; therefore, axle-load distributions and average load equivalency results for the pavement test sections are being determined from vehicle weighings measured with portable scales and the weigh-in-motion system.

This information must be developed during the study because of the lack of current data. On some of the more heavily trafficked routes there are weighing stations, but at these sections only those vehicle which appear to be laden to capacity, or overladen, are weighed. Consequently, any sample taken from these results are biased because of the sampling technique used.

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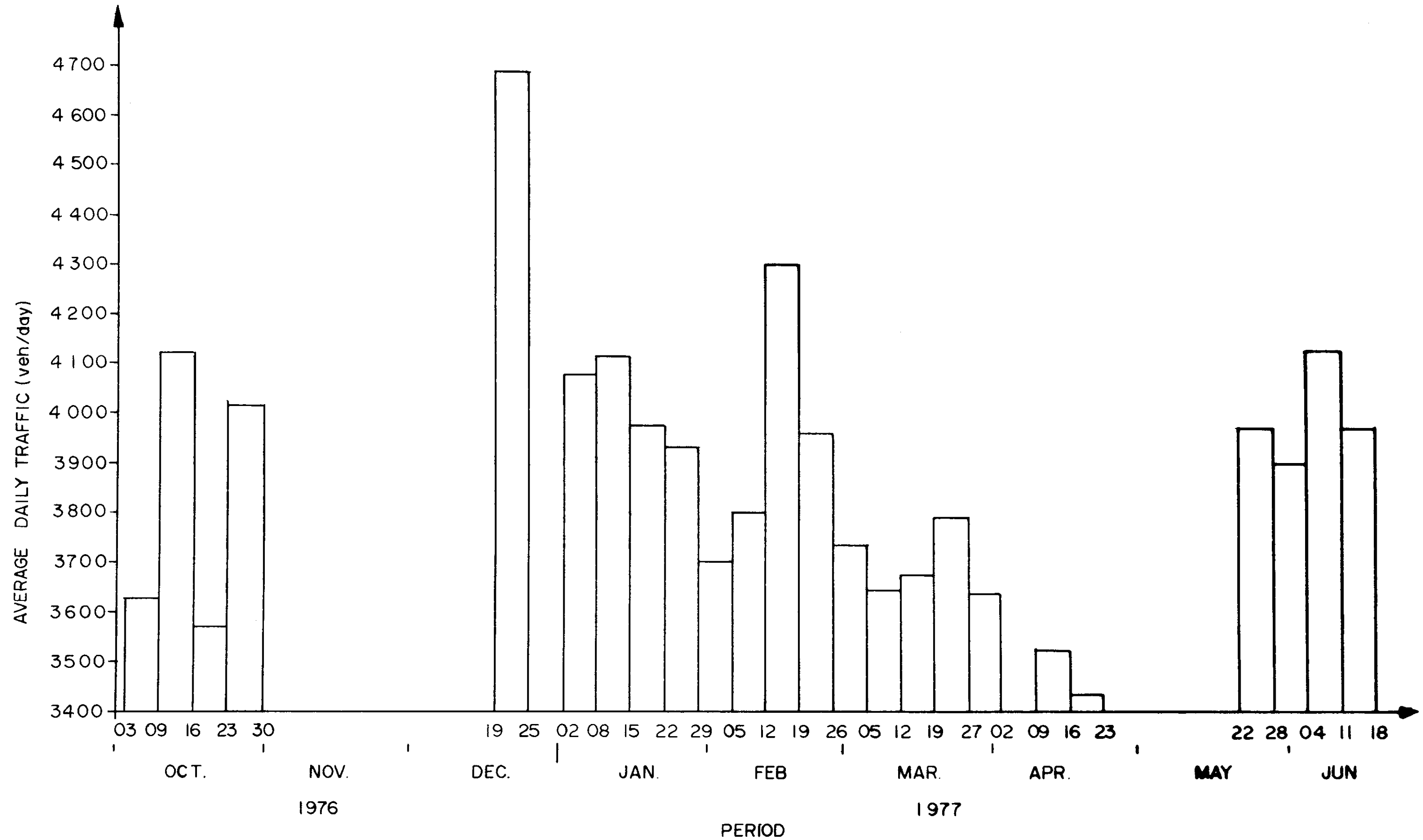

FIG. 40

AVERAGE DAILY TRAFFIC PER WEEK - BR- 040 BRASÍLIA-LUZIÂNIA (COUNTER C-01, BOTH DIRECTIONS)

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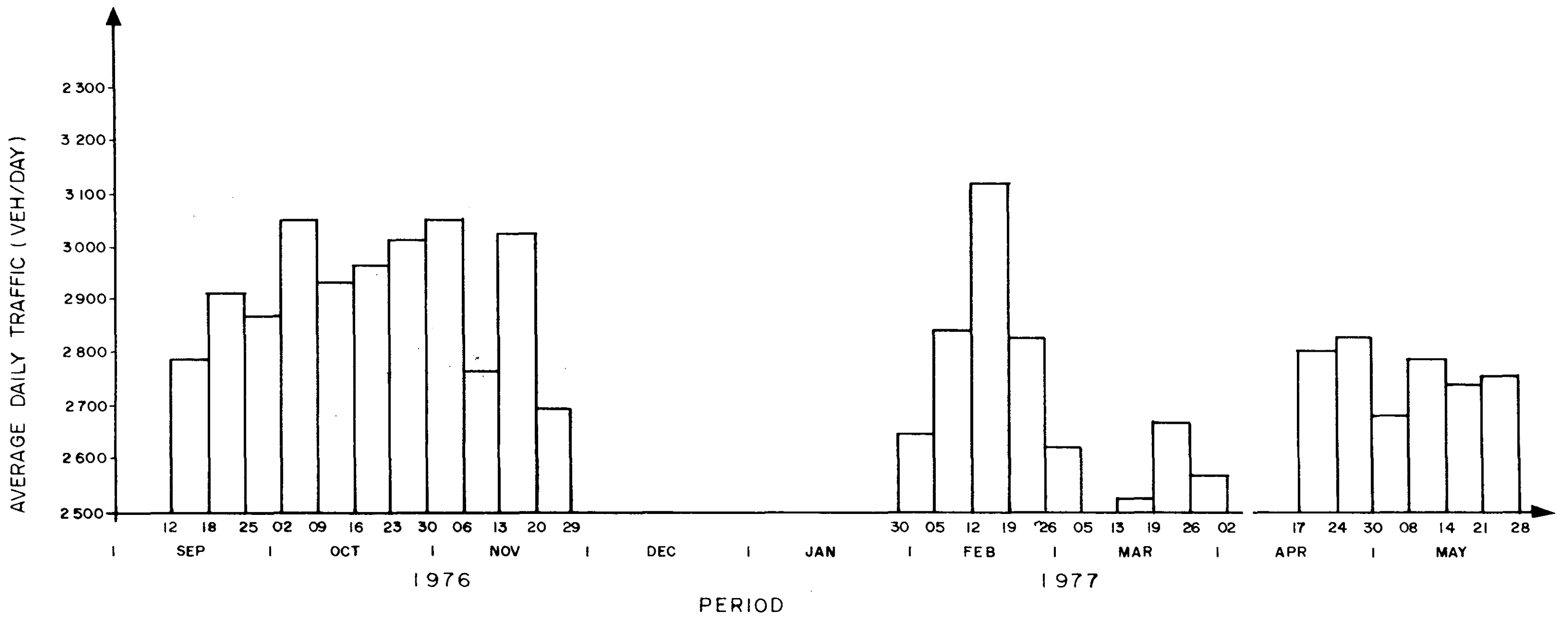

FIG. 41

AVERAGE DAILY TRAFFIC PER WEEK - BR-040 BRASÍLIA-LUZIÂNIA (COUNTER CO-1, BOTH DIRECTIONS)

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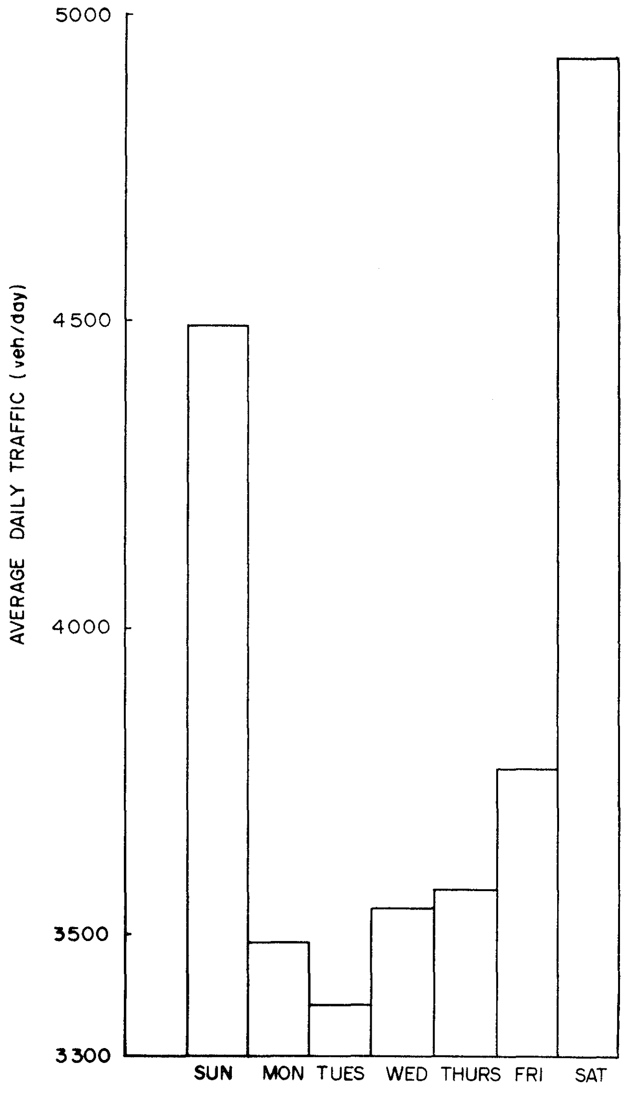

FIG. 42

AVERAGE DAILY DISTRIBUTION OF TRAFFIC (COUNTER CO-1, JAN./JUN-77)

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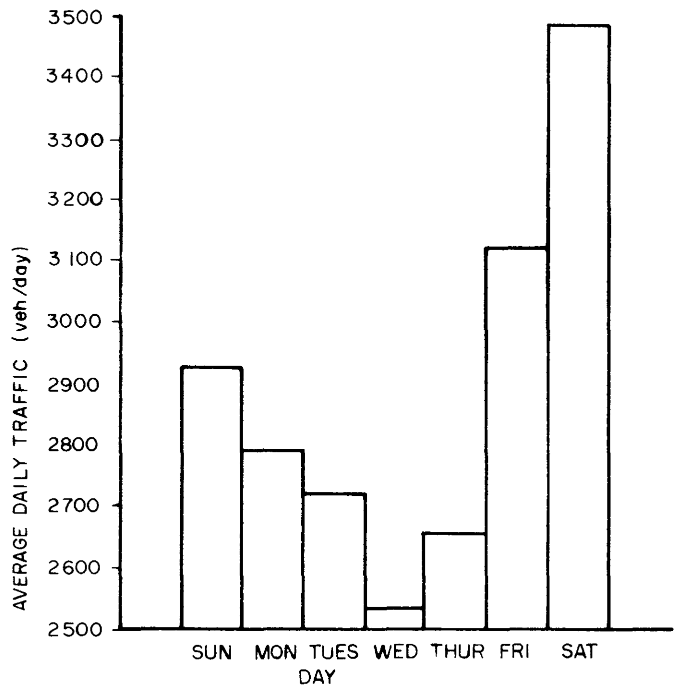

FIG.43

AVERAGE DAILY DISTRIBUTION OF TRAFFIC (COUNTER CO-2, SEP./NOV. 77)

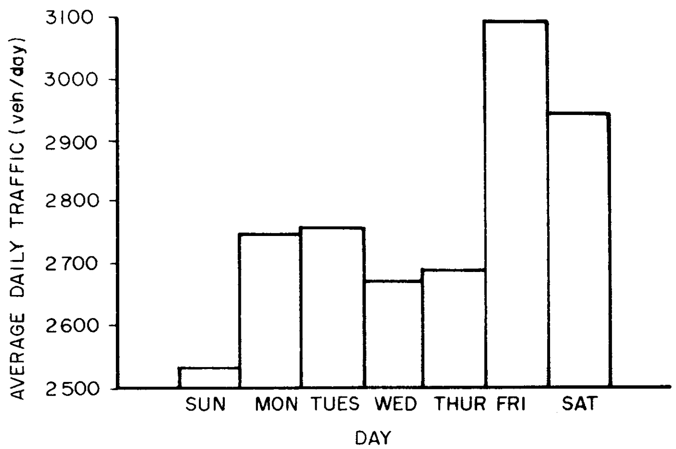

FIG. 44

AVERAGE DAILY DISTRIBUTION OF TRAFFIC (COUNTER CO-2, JAN./MAY 77)

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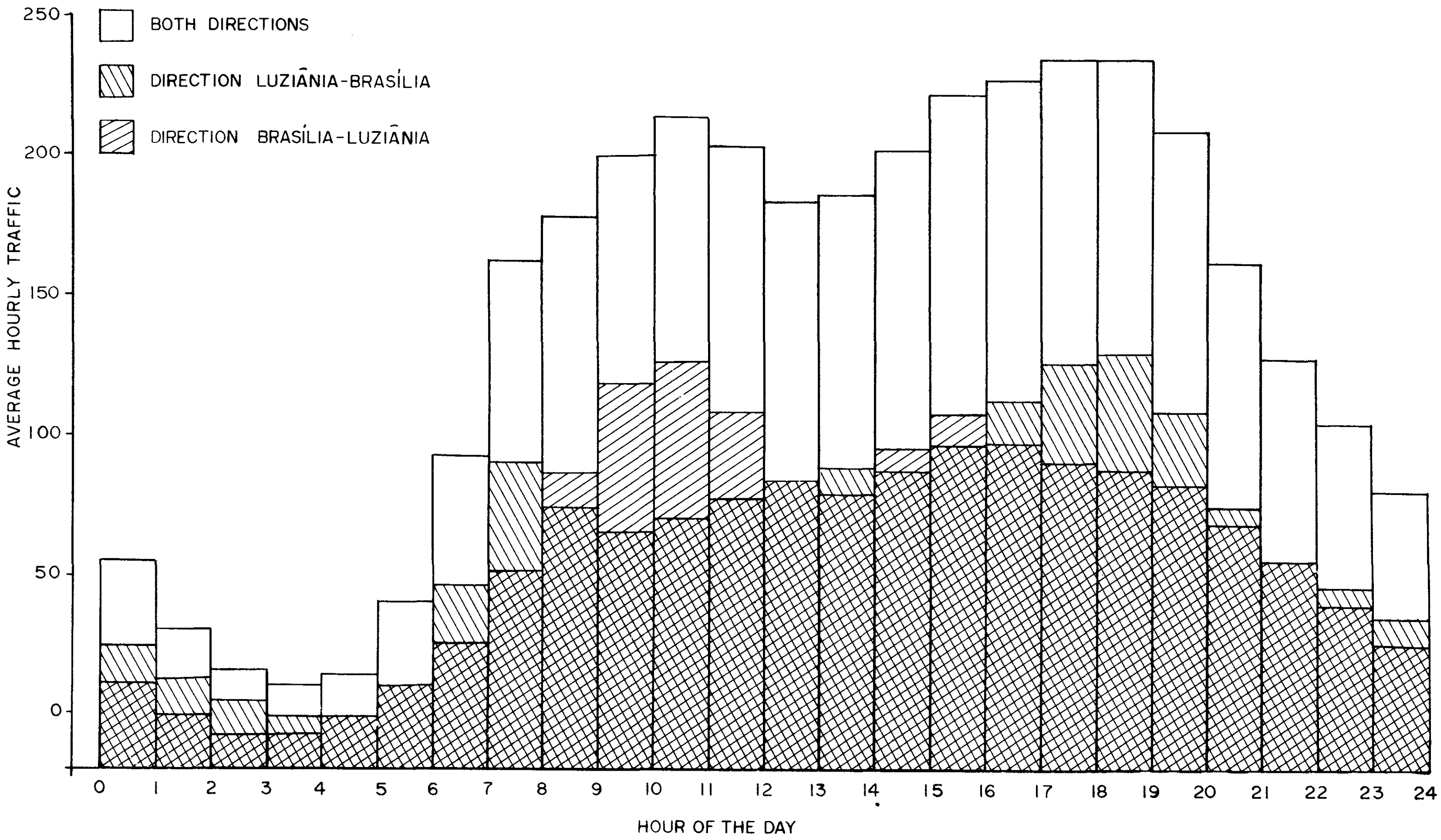

FIG. 45

HOURLY DISTRIBUTION OF TRAFFIC AT COUNTER CO-1 (JANUARY/JUNE 1977)

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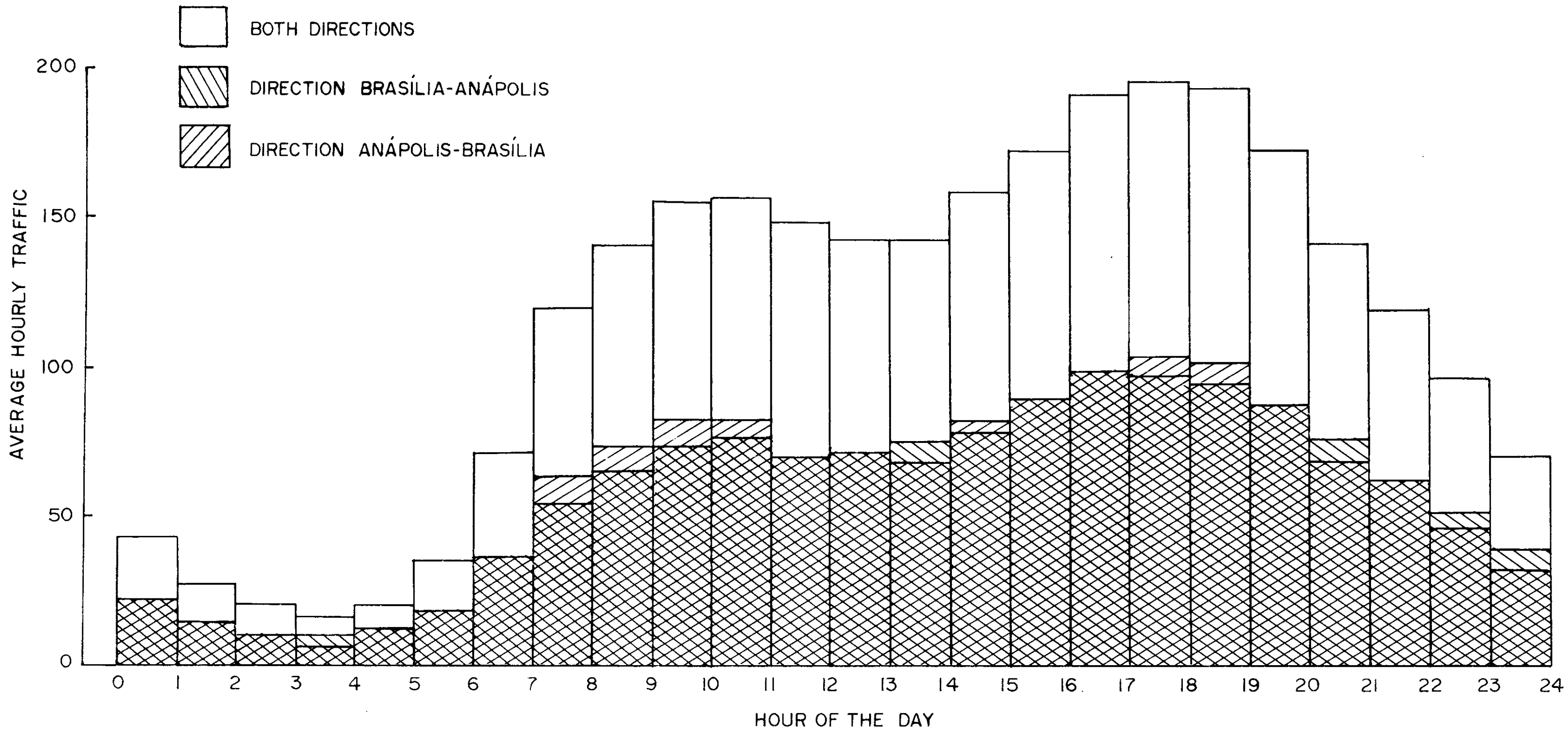


FIG. 46

HOURLY DISTRIBUTION OF TRAFFIC AT COUNTER CO-2 (JANUARY/MAY 1977)

a *Collection with Portable Scales*

Vehicle wheel weights are obtained using two portable scales. A level stretch of road (grade less than 1 percent) with good sight distance is selected in close proximity of the pavement study section. The scales are then placed on the roadway and one lane is blocked off to permit measurements as shown in Figure 47, with the two wheels of each axle being weighed simultaneously, and an entry made in a special form (Exhibit 4). The classification of vehicles is based on axle configuration, vehicle size and type; a schematic representation of the classification is presented in Figure 11. At each site, measurements are obtained during a 5-day period, generally from Monday to Friday. Because of safety considerations and to facilitate reading the scales, measurements are only conducted during daylight hours.

On roads carrying less than about 800 vehicles per day, vehicles travelling in both directions can be handled with the scales located in one lane. For roads carrying heavier traffic it is necessary to measure only one direction per day, while the other direction is measured on the following day. Vehicles are sampled during peak hours to minimize delays and thereby maintain the goodwill of long-distance haulers. Thus no more than two vehicles are kept waiting at any single time.

b *Portable Scale Results*

Data are keypunched directly from the field sheets and then processed by a verification program which checks for errors in field measurements and keypunching. A program was developed to calculate the frequency distributions of the axle loads in terms of the front axle, and single, tandem and triple rear axles. The frequency distributions have been tabulated and they are presented in Appendix A for each section that was measured.

c *Axle Load Distributions*

To facilitate the investigation of the severity of overloading on roads, the percentage of axles laden above the legal limits set by the DNER have been extracted from Appendix A, and they are presented in Table E.4. The legal limits which are in force are the fol-

FIG. 47

AXLE WEIGHING WITH PORTABLE SCALES

MT-GEIPOT · PICR

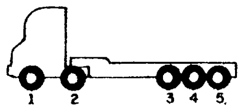
FICHA DE CAMPO · BALANÇAS PORTÁTEIS

FOLHA Nº | DATA

OPERADOR

INSTRUÇÕES DO PERFURADOR

CAMPOS NUMÉRICOS DEVEM SER PERFURADOS ALINHADOS A DIREITA.



RODOVIA	SEÇÃO	CAR-GA	SEN-TIDO	CLAS-SE	VEIC	ANO FABR	CARGA POR RODA (LIBRAS) ESQ. 1	DIR. 1	ESQ. 2	DIR. 2	ESQ. 3	DIR. 3	ESQ. 4	DIR. 4	ESQ. 5	DIR. 5	ESQ. 6	DIR. 6

DUPLICAR COLUNAS 1-8 INCLUSIVE

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78

FICHA

EXHIBIT 4 - Portable Scale Field Recording Form

TABLE E.4 - PERCENTAGES OF AXLES OVERLADEN MEASURED WITH THE PORTABLE SCALES ON THE PAVEMENT STUDY SECTIONS

Section Number	Direction	Front Axle % (Nº obs)	Single Rear Axle % (Nº obs)	Tandem Rear Axle % (Nº ob)	Triple Rear Axle % (Nº obs)
001	BR020-Barragem	0.0	27.3	-	-
		(11)	(11)	-	-
	Barragem-BR020	0.0	0.0	-	-
		(10)	(10)	-	-
002	Brasília-Unaí	2.5	8.5	30.0	-
		(81)	(71)	(10)	-
	Unaí-Brasília	3.1	45.8	27.3	-
		(129)	(118)	(11)	-
002	Brasília-Unaí	0.0	4.9	0.0	-
		(68)	(61)	(7)	-
	Unaí-Brasília	0.0	58.2	80.0	-
		(60)	(55)	(5)	-
003	Formosa-Sobradinho	1.3	5.3	22.6	100.0
		(151)	(131)	(22)	(2)
	Sobradinho-Formosa	1.1	10.4	10.2	0.0
		(190)	(163)	(49)	(0)
004	BR060-Gama	2.5	74.6	70.0	0.0
		(81)	(71)	(10)	(0)
	Gama-BR060	0.0	0.0	5.6	0.0
		(72)	(58)	(18)	(1)
004	BR060-Gama	0.0	75.0	100.0	-
		(25)	(24)	(1)	-
	Gama-BR060	0.0	0.0	25.0	-
		(30)	(26)	(4)	-
006	Brasília-Luziânia	0.8	10.5	21.6	37.0
		(364)	(267)	(93)	(27)
	Luziânia-Brasília	1.3	38.6	20.4	75.6
		(450)	(303)	(83)	(29)

TABLE E.4 - (CONT'D)

Section Number	Direction	Front Axle % (Nº obs)	Single Rear Axle % (Nº obs)	Tandem Rear Axle % (Nº obs)	Triple Rear Axle % (Nº obs)
007 & 008	Sobradinho-Formosa	1.2 (326)	17.1 (246)	7.6 (132)	0.0 (1)
	Formosa-Sobradinho	0.4 (280)	9.9 (213)	12.0 (100)	100.0 (1)
007 & 008	Sobradinho-Formosa	0.7 (143)	18.4 (109)	15.7 (51)	0.0 (1)
	Formosa-Sobradinho	0.8 (128)	2.2 (89)	17.2 (52)	100.0 (1)
009	Brasília-Anápolis	0.6 (357)	6.0 (215)	13.2 (98)	40.0 (10)
	Anápolis-Brasília	1.6 (434)	54.8 (279)	33.5 (129)	47.7 (23)
010	Taguatinga-Brazlândia	2.2 (272)	3.2 (255)	2.6 (39)	- -
	Brazlândia-Taguatinga	2.2 (182)	0.6 (164)	10.3 (29)	- -
011	Taguat.-B.Descoberto	0.0 (273)	0.8 (264)	0.0 (19)	- -
	B.Descoberto-Taguat.	0.0 (211)	40.4 (208)	0.0 (3)	- -
201	Unaí-BR020	0.0 (2)	0.0 (2)	- -	- -
	BR020-Unaí	0.0 (5)	0.0 (5)	- -	- -
202	Unaí-BR020	0.0 (7)	0.0 (7)	0.0 (0)	- -
	BR020-Unaí	0.0 (8)	68.6 (7)	0.0 (1)	- -
203	EPCT-Papuda	0.0 (41)	0.0 (39)	0.0 (2)	- -
	Papuda-EPCT	0.0 (55)	58.2 (55)	0.0 (0)	- -

TABLE E.4 - (CONT'D)

Section Number	Direction	Front Axle % (Nº obs)	Single Rear Axle % (Nº obs)	Tandem Rear Axle % (Nº obs)	Triple Rear Axle % (Nº obs)
204	Border-DF/GO-BR020	0.0 (28)	9.6 (21)	85.8 (7)	- -
	BR020-Border-DF/GO	0.0 (29)	6.7 (15)	0.0 (16)	- -
021 022	Cristalina-Catalão	4.6 (65)	7.5 (40)	20.9 (24)	0.0 (2)
	Catalão-Cristalina	8.0 (87)	32.7 (52)	20.1 (35)	66.5 (12)
024	Rio Verde-Goiânia	2.5 (159)	17.5 (109)	4.0 (50)	58.3 (12)
	Goiânia-Rio Verde	3.0 (170)	35.9 (117)	37.1 (54)	33.3 (9)
025 033	Inhumas-Goiânia	1.0 (385)	18.6 (295)	6.4 (140)	0.0 (2)
	Goiânia-Inhumas	1.1 (369)	10.2 (323)	10.0 (89)	40.0 (5)
026	Uruaçu-Ceres	3.3 (217)	26.8 (119)	10.8 (104)	87.5 (8)
	Ceres-Uruaçu	3.2 (280)	45.9 (144)	18.6 (118)	77.7 (9)
029	BR153-Goianésia	0.0 (114)	17.1 (70)	2.3 (44)	0.0 (3)
	Goianésia-BR153	1.9 (104)	35.5 (76)	21.4 (28)	100.0 (1)
030	Border-MG/GO-Catalão	4.2 (385)	26.1 (199)	28.4 (109)	63.9 (36)
	Catalão-Border-MG/GO	2.4 (169)	7.0 (101)	17.3 (52)	28.5 (14)

TABLE E.4 - (CONT'D)

Section Number	Direction	Front Axle % (Nº obs)	Single Rear Axle % (Nº obs)	Tandem Rear Axle % (Nº obs)	Triple Rear Axle % (Nº obs)
031	Anápolis-Brasília	6.5	58.1	61.6	66.7
032		(122)	(86)	(34)	(3)
	Brasília-Anápolis	2.6	10.9	11.7	30.0
		(190)	(118)	(43)	(10)
034	BR452-C.Dourada	1.0	12.0	9.6	0.0
035		(96)	(75)	(21)	(1)
	C.Dourada-BR452	0.0	11.8	4.3	0.0
		(91)	(68)	(23)	(0)
251	Anápolis-Corumbá	2.2	16.7	48.4	75.0
252		(90)	(60)	(31)	(4)
	Corumbá-Anápolis	1.5	34.1	71.3	100.0
		(65)	(44)	(21)	(3)
101	Paracatú-Unaí	0.0	4.1	0.0	-
		(94)	(73)	(21)	-
	Unaí-Paracatú	0.0	16.5	14.3	-
		(107)	(79)	(28)	-
105	Uberlândia-Patrocínio	1.1	11.9	12.1	100.0
		(276)	(185)	(91)	(3)
	Patrocínio-Uberlândia	0.4	23.6	18.4	0.0
		(282)	(203	(76)	(1)
106	Patrocínio-Guimarânia	2.5	31.6	9.1	0.0
		(122)	(98)	(33)	(4)
	Guimarânia-Patrocínio	1.2	14.1	8.0	50.0
		(82)	(57)	(25)	(2)

TABLE E.4 - (CONT'D)

Section Number	Direction	Front Axle % (Nº obs)	Single Rear Axle % (Nº obs)	Tandem Rear Axle % (Nº obs)	Triple Rear Axle % (Nº obs)
107	Araxá-Border-MG/SP	1.3	46.0	6.7	66.6
		(76)	(63)	(15)	(3)
	Border-MG/SP-Araxá	0.0	4.8	0.0	0.0
		(94)	(82)	(18)	(11)
109	Ent.BR365/BR040-J. Pinheiro	2.8	25.3	33.1	31.7
		(181)	(99)	(69)	(19)
	J.Pinheiro-Ent.BR365/ BR040	3.1	22.9	29.4	86.8
		(277)	(109)	(109)	(15)
110	Paracatú-Border-MG/GO	5.1	25.8	41.9	66.6
		(78)	(31)	(43)	(3)
	Border-MG/GO-Paracatú	2.2	30.8	39.1	61.6
		(92)	(39)	(46)	(13)
118	Capinópolis-C.Dourada	2.0	2.3	12.5	-
		(5)	(43)	(8)	-
	C.Dourada-Capinópolis	0.0	0.0	0.0	-
		(35)	(33)	(2)	-

lowing:

Front axle	5000 kg
Single rear axle	10000 kg
Tandem rear axle	17000 kg
Triple rear axle	25500 kg

Class 1 and 3 vehicles are not included in Table E.4 and the percentages of overladen axles are given in terms of the number of medium and heavy vehicle axles which were measured. In most cases, less than 3 percent of the front axles are oveladen, althought in some cases, such as for sections 021 and 022, up to 8 percent have been recorded. These results support the theory that truck drivers prefer to keep the front axle lightly laden because it is easier to steer and not as tiring.

From 10 to 35 percent of the single rear axles are overladen, depending on the type of road traffic. Some cases have been recorded in which from 40 to 80 percent of the single rear axles were overladen. These are associated with the sand, gravel or ore haul routes. Sections 002, 004, 009, 011, 203, 031, 032, 251, 252 and 107 fall in this category. A trend similar to the single rear axles is apparent for the tandem rear axles on the sand, gravel and ore routes. The percentage of overladen axles lies between about 5 and 20. This reduction in the number of overladen axles compared to the single rear axles could be ascribed to the fact that vehicles with tandem rear axles are generally used for long-haul transport, and consequently they would pass at least one of the weigh bridges, which are located along the main haul routes. Although the sample sizes of vehicles with triple rear axles are relatively small, 30 percent or more are overladen.

(1) *Load Equivalency Computations*

The AASHTO method of traffic load equivalency calculation has been adopted by the project (Ref. 9). In the AASHTO method a variety of factors can be used depending on the pavement section which is defined by the structural number (SN). An investigation of the first ten pavement cross-sections measured showed that the majority had an SN in the vicinity of 3. Consequently, the tabulated results for SN of 3 are used in all the calculations. Also used is a terminal serviceability index of 2.0.

The equations which were used are the following with the standard single axle load of 18000 *lb* (8.2t):

- Single Axles: Equivalency factor $= \left(\frac{W}{18000}\right)^{4.32}$

- Tandem Axles: Equivalency factor $= \left(\frac{W}{33220}\right)^{4.14}$

where W = axle or axle group weight in pounds.

The AASHTO method does not take into consideration three axles in a group, the so-called triple axle. An analysis by Austin Research Engineers (Ref. 10) indicated that subgrade compressive strains can be used to predict equivalency factors. This fact was used to derive equivalency factors for triple axles, and the resulting equation is:

- Triple Axles: Equivalency factor $= \left(\frac{W}{50560}\right)^{4.22}$

for a terminal serviceability of 2.0. The verified data cards are processed by the calculation program which uses the above equations. Ref. 9 suggests that axle-load intervals be used to facilitate calculations. Since the data is in a format which permits the calculation of the equivalency factors for each axle, it was decided to calculate equivalency factor for each axle and thus enhance some accuracy.

(2) *Analysis of Equivalent Axles*

The average number of equivalent axles per vehicle and sample size per vehicle class per section in both directions are grouped per state and presented in Table E.5. Initially, standard deviations were also calculated, but verification of the weight distributions on the front and rear axles of class 4 vehicles on section 007, shown in Figures 48 and 49 , indicated that particularly the rear-axle distributions are non-normal, and thus standard deviations do not have any meaning.

Returning to Table E.5 , it can be seen that on some sections the average equivalent axles have been calculated for class 3 vehicles, and the results are either 0.000 or 0.0001. After the initial measurements on a few sections, it was decided to discontinue measuring this vehicle class because the results are smaller than the accuracy of measurements on the heavier trucks. This result also applies to class 1 vehicles (passenger cars), and consequently these two classes of vehicles have no influence on the structural performance of pavements. It should be borne in mind that these two vehicle classes do play an important part in the performance of surfacings, such as surface treatments

TABLE E.5 - NUMBER OF EQUIVALENT AXLES PER VEHICLE FOR SECTIONS LOCATED IN DISTRITO FEDERAL

SECTION NUMBER DATE	ROAD Nº	DIRECTION	AVERAGE NUMBER OF EQUIVALENT AXLES PER VEHICLE (NUMBER OF MEASUREMENTS PER SAMPLE)											
			VEHICLE CLASS											
			2	3	4	5	6	7	8	9	10	11	12	13
001 05/05 - 07/05/76	EPCT	BR 020 - Barragem		0.000 (8)	1.91 (11)									
		Barragem - BR 020	0.06 (1)	0.000 (3)	0.02 (9)									
002 10/05 - 17/05/76	BR 251	Unaí - Brasília	0.43 (13)	0.001 (9)	2.32 (105)	0.93 (11)								
		Brasília - Unaí	0.46 (6)	0.000 (10)	0.58 (64)	1.05 (10)		0.10 (1)						
002 27/12 - 29/12/76	BR 251	Unaí - Brasília	0.44 (4)		2.79 (51)	1.76 (5)								
		Brasília - Unaí			0.24 (61)	0.19 (7)								
003 18/05 - 21/05/76	BR 020	Formosa - Brasília	0.27 (51)	0.001 (44)	0.52 (75)	0.78 (21)	4.75 (2)		19.06 (1)		7.25 (1)			
		Brasília - Formosa	0.26 (63)	0.000 (48)	1.25 (99)	0.78 (28)		0.15 (1)						
004 24/05 - 28/05/76	DF - 20	BR 060 - Gama		0.000 (9)	3.53 (71)	2.48 (10)		0.05 (1)						
		Gama - BR 060		0.000 (5)	0.08 (56)	0.33 (14)		0.10 (1)	0.14 (1)					

TABLE E.5 - NUMBER OF EQUIVALENT AXLES PER VEHICLE FOR SECTIONS LOCATED IN DISTRITO FEDERAL (CONT'D)

SECTION NUMBER DATE	ROAD Nº	DIRECTION	AVERAGE NUMBER OF EQUIVALENT AXLES PER VEHICLE (NUMBER OF MEASUREMENTS PER SAMPLE)											
			VEHICLE CLASS											
			2	3	4	5	6	7	8	9	10	11	12	13
004 04/10 - 08/10/76	DF - 20	BR 060 - Gama			3.65 (24)	1.75 (1)								
		Gama - BR 060			0.06 (26)	0.58 (4)								
006 07/06 - 11/06/76	BR 040	Brasília - Luziânia	0.47 (28)	0.001 (20)	0.50 (197)	0.81 (100)	2.08 (4)	0.86 (4)	4.10 (25)	0.21 (2)		6.04 (1)	1.36 (2)	0.11 (1)
		Luziânia - Brasília	0.64 (39)	0.001 (29)	2.35 (215)	1.25 (157)	1.50 (4)	4.98 (6)	7.45 (29)	2.84 (2)		0.11 (1)		4.46 (2)
007 and 008 14/06 - 18/06/76	BR 020	Brasília - Formosa	0.35 (60)	0.000 (106)	1.36 (178)	0.68 (85)	0.01 (1)	4.36 (3)	6.97 (1)			0.25 (1)		
		Formosa - Brasília	0.38 (58)	0.000 (85)	0.42 (132)	0.84 (77)	5.72 (10)	0.20 (2)	12.88 (1)					
007 and 008 28/09 - 01/10/76	BR 020	Brasília - Formosa	0.43 (24)		1.44 (77)	1.00 (37)	0.01 (1)	4.05 (2)	6.97 (1)			0.25 (1)		
		Formosa - Brasília	0.40 (32)		0.29 (55)	0.94 (39)		0.25 (1)	12.88 (1)					
009 28/06 - 02/07/76	BR 060	Brasília - Anápolis	0.60 (11)	0.000 (24)	0.28 (183)	0.39 (148)	1.78 (4)	1.18 (3)	3.28 (10)					
		Anápolis - Brasília	0.73 (1)	0.001 (16)	2.65 (254)	1.55 (155)		2.47 (3)	4.79 (21)		4.36 (2)			

TABLE E.5 - NUMBER OF EQUIVALENT AXLES PER VEHICLE FOR SECTIONS LOCATED IN DISTRITO FEDERAL (CONT' D)

SECTION NUMBER / DATE	ROAD Nº	DIRECTION	AVERAGE NUMBER OF EQUIVALENT AXLES PER VEHICLE (NUMBER OF MEASUREMENTS PER SAMPLE)											
			VEHICLE CLASS											
			2	3	4	5	6	7	8	9	10	11	12	13
010 31/05 - 03/06/76	DF - 8	Brasília - Brazlândia	0.33 (26)	0.000 (142)	0.59 (84)	0.59 (17)		0.36 (3)						
		Brazlândia - Brasília	0.82 (10)	0.000 (92)	0.18 (60)	0.39 (19)		0.28 (2)						
011 21/06 - 25/06/76	BR 070	Brasília - Barr. do Descob.	0.30 (8)	0.000 (120)	0.08 (254)	0.10 (9)		2.92 (2)						
		Barr. do Descob. - Brasília	0.14 (7)	0.001 (65)	2.14 (202)	0.58 (3)								
201 13/07 - 16/07/76	DF-21	Unaí - BR 020		0.000 (7)	0.46 (2)									
		BR 020 - Unaí		0.001 (7)	0.57 (5)									
202 05/07 - 09/07/76	DF-21	Unaí - BR 020		0.001 (11)	0.29 (7)									
		BR 020 - Unaí		0.001 (14)	1.22 (7)	0.01 (1)								
203 11/10 - 15/10/76	DR-12	EPCT - Papuda			0.04 (39)	0.01 (2)								
		Papuda - EPCT			3.06 (55)									

TABLE E.5 - NUMBER OF EQUIVALENT AXLES PER VEHICLE FOR SECTIONS LOCATED IN DISTRITO FEDERAL (CONT'D)

SECTION NUMBER DATE	ROAD Nº	DIRECTION	AVERAGE NUMBER OF EQUIVALENT AXLES PER VEHICLE (NUMBER OF MEASUREMENTS PER SAMPLE)											
			VEHICLE CLASS											
			2	3	4	5	6	7	8	9	10	11	12	13
204 06/12 - 10/12/76	DF-17	DF/GO Border - BR 020			0.66 (21)	2.85 (7)								
		BR 020 - DF/GO Border			1.59 (14)	0.24 (14)		0.28 (1)						

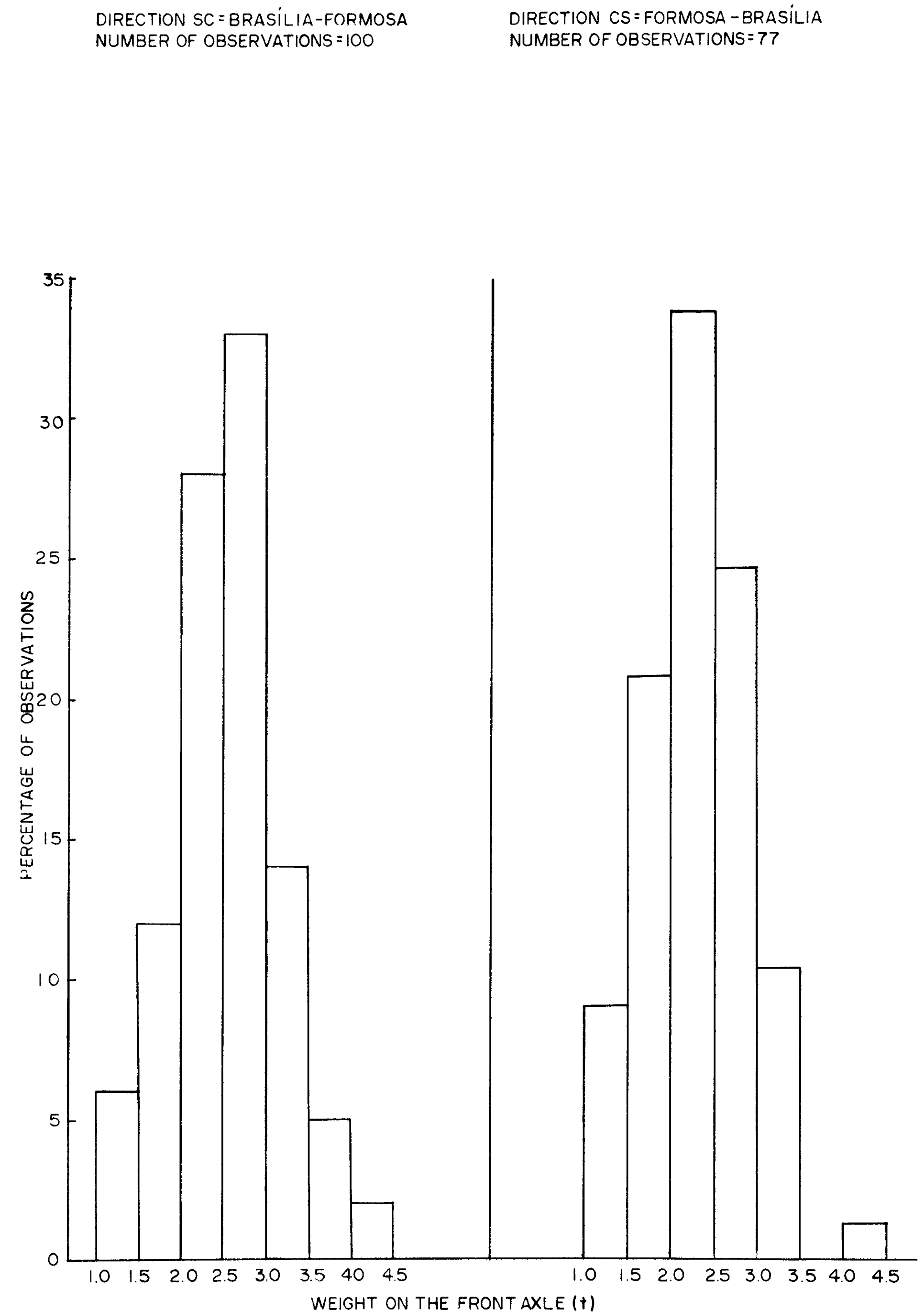


FIG. 48

HISTOGRAM OF FRONT AXLE LOADS - CLASS 4 VEHIC. - SECTION 007

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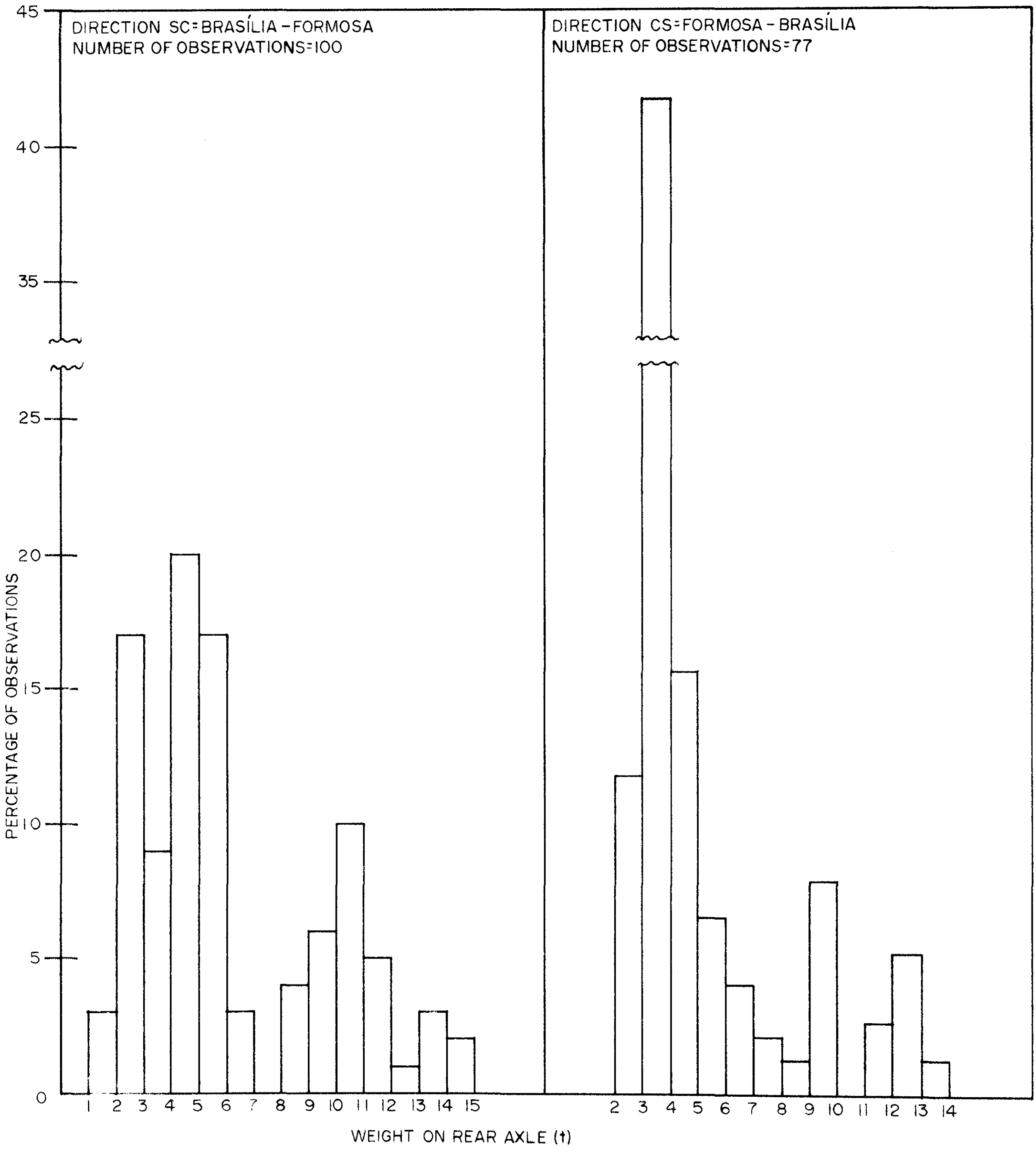

FIG. 49

HISTOGRAM OF REAR AXLE LOADS-CLASS 4 VEHIC.-SECTION 007

(Ref. 11).

To evaluate the results presented in Table E.5 , the equivalent axles per vehicle for each class, for the legal axle loads, have been calculated to use as a reference base. These results are presented in Table E.6.

The results in Table E.6 indicate that for classes 11 and 13, which are vehicles with single axles and trailers with single or tandem axles, the number of equivalent axles per vehicle are considerable in excess of the other vehicle classes. This is despite the fact that for a class 11 vehicle, the gross vehicle weight would be 35 t, whereas for a class 8 vehicle the gross vehicle weight is 40 t. Referring to Table E.5. it can be seen that very few of the class 11 or 13 vehicles exist on the road network, but those that have been measured have a severely damaging effect when laden. In those cases where the number of equivalent axles of about 0.10 has been recorded in Table E.5,it indicates that the vehicle was unladen. This is true for all the classes.

Buses, which are class 2 vehicles, are laden well below the maximum legal load on average, since on all the sections measured the minimum average number of equivalent axles was 0.22, whereas the maximum was 1.08. It was not possible to relate the number of equivalent axles per vehicle to the types of road or region. Generally, the equivalent axles of buses are equal in both directions. If no weight data is available on a particular road, the number of equivalent axles per class 2 vehicles can be estimated at between 0.5 and 1.0. It is suggested that this value be used for planning purposes and in the model, when other data are not available.

The average equivalent-axle results of class 4 vehicles are extremely variable, ranging from a minimum of about 0.1 to a maximum of 4.1, which is considerable in excess of the maximum result permissible with legal axle loads. Some stratification is possible which will permit better evaluation of the results. There are some sections which carry very heavy tip-truck traffic loaded with sand, gravel or ore in one direction, while the trucks return empty in the opposite direction. These sections are 002, 004, 009, 011, 203, 031, 032, 251, 252 and 107. The equivalent axle results on these sections are summarized in Table E.7. Compared with the maximum permissible equivalent axle loads, all sections except 011 show results exceeding the permissible for vehicles laden. In the case where no results are available,

TABLE E.6 - EQUIVALENT AXLES PER VEHICLE FOR THE MAXIMUM LEGAL AXLE LOADS

Vehicle Class	Equivalent Axles per Vehicle
2 and 4	2.48
5	1.75
6	4.83
7	4.10
8	4.02
9	3.38
10	3.30
11	7.19
12	1.67
13	6.47

TABLE E.7 - EQUIVALENT AXLE LOADS PER VEHICLE FOR CLASS 4 VEHICLES (SECTIONS LOCATED BETWEEN GRAVEL OR SAND PITS AND LOCATION OF USE)

Section Number	Number of Equivalent Axle Loads per Vehicle	
	Vehicles Laden	Vehicles Empty
002	2.32 and 2.79	0.58 and 0.24
004	3.53 and 3.65	0.08 and 0.06
009	2.65	0.28
011	2.14	0.08
203	3.06	0.04
031 and 032	4.10	0.54
107	3.50	0.39

estimates for two different cases on these haul routes can be used. The one is for roads where enforcement is strict, where the number of equivalent axles per vehicle for class 4 vehicles laden would range between 2.0 and 2.5, and the other case is for roads with no enforcement where the result would be between 3.0 and 4.0. In the unladen direction, the results would be from about 0.1 to 0.6. One route passes over four different sections, namely sections 004, 009, 031 and 032, and referring to Table E.7 it is interesting to note that all the results are similar.

On routes carrying normal over-the-highway traffic of class 4, the results generally lie between 1.0 and 2.0. These results can thus be used for estimative purposes where no data exist.

The situation for class 5 vehicles is similar to those of class 4 vehicles, except that the overloading is not as severe on the sand or gravel routes, although it does exist. In general, normal traffic exhibits between 0.7 and 1.6 standard axles per vehicle for class 5.

The other vehicle classes generally have very small sample sizes, mainly because of their relative low proportion on the road network. A special effort is being made to obtain measurements on a larger number of these vehicles. On some of the long-haul routes, larger numbers of class 8 vehicles are encountered. These are generally heavily laden to the limit or above. If data are lacking, an estimate of between 3.5 and 6.0 can be used. This figure will of course approach the value of 4.0, which is the maximum permissible, with more effective enforcement.

Thus far we have frequently referred to values which could be used in the absence of any data. It should, however, be borne in mind that for the analysis of pavement performance only actual results will be used.

(3) *Repeatability of Results*

Three of the sections in Table E.5 were repeated in order to verify the variability of measurements over time. Those sections which appeared to have unusual results were selected. Since the distributions are non-normal, standard parametric tests such as the F and t tests are not aplicable. A non-parametric test which considers the proportions of the two distributions above and below their common median was found which, although not a very strong statistical test, could be used as a good indicator (Ref. 12). This method is only meaningful for sample sizes of more than about 20. Analysis of the distributions of the repeated measurements of class 4 on section 002, class 4 on section 004, and classes 4 and 5 on sections 007 and 008 showed that there was no significant difference at the 95-percent level of confidence. In all cases a X^2 of less than 1.00 was found while the limiting X^2 is 3.84 at the 95-percent level of confidence. In trying to relate the distributions on both directions on these roads, large differences in the distributions were found, as would be expected from the average results presented in Table E.4.

This statistical technique was also tried in a attempt relate the distributions on roads carrying similar traffic, but this was not found to be successful.

d *Weigh-In-Motion System*

The system measures vehicle weights while the vehicles are travelling at normal highway speeds. It consists of two transducer units, which are built into the road in each wheelpath of a lane, and induction loops which serve as presence detectors and which also measure vehicle speeds. The supporting electronic hardware consists of a computer, which serves as calculating unit for the system and which also acts as driver for a magnetic tape unit, onto which all the data are recorded, a video screen were the data received are verified before writing onto tape, and a printer unit where the data can be printed. All this equipment is housed in a Caravan trailer, which makes the system completely mobile. Power is obtained from portable generators or from the electrical distribution network if power is close to the site.

The installations are made on tangential sections of road which have a grade of less than 1 percent, good riding quality and very little transverse deformation, to avoid problems as a result of dynamic forces. Up to the present time, two installations have been made. The installation is shown in Figure 50.

To initiate measurements, the transducers are placed into the frame and the wires to the control box are fixed to the transducers, and the computer is connected to the control box. After completion of testing, the transducers are removed and replaced by dummy transducers.

FIG. 50

VEHICLE WEIGHING WITH WEIGH-IN-MOTION SYSTEM

e Comparison of WIM and Portable Scale Results

After installation of the WIM system, a truck with known axle loads is used to calibrate the system. A necessary task is to check the reliability and calibration of the system in comparison with the portable scales. During two half-day periods, the WIM crew printed all the axle-load data of the vehicles passing and also noted the vehicle registration numbers. The portable scales were stationed about 1 km downstream, where they would not interfere with normal highway speeds at the WIM site. Axle loads of most vehicles were measured, again noting vehicle registration numbers. A comparison of the axle weights is shown in Figure 51. On the average, the portable scales weighed an equivalent of 243 kg higher than the WIM, which is on average about a 5-percent difference. This is an acceptable difference for these types of measuring devices. The slope of a regression line passing through the origin was calculated to be 0.435 for 237 points.

Another way of analyzing these results is to calculate the equivalency factors. as discussed above. These calculations for class 2 and 4 vehicles are presented in Table E,8 together with the sample sizes.

A difference of 5 percent in axle weights would result in a difference of 23.5 percent in the equivalency factors because the error in weight is raised to the power 4.32. The WIM results presented in Table E.8 lie within about 22 percent of the results measured with the portable scales, which are as would be expected from the average difference in weight between the two measuring devices.

f WIM Results for the Site on BR-040

Data were collected with the WIM at the site located at KM 1 on BR-040, near Brasilia, and adjacent to section 006. Measurements were limited to the lane carrying traffic from Belo Horizonte and Luziânia to Brasília. Previous measurements with the portable scales showed that this was the lane carrying the heavier traffic. Measurements were taken during the day from July 19 to August 2, 1977. Measurements were taken over a seven-day period from August 3 to 10, for 24 hours per day, in order to obtain comparisons between day and night axle loads.

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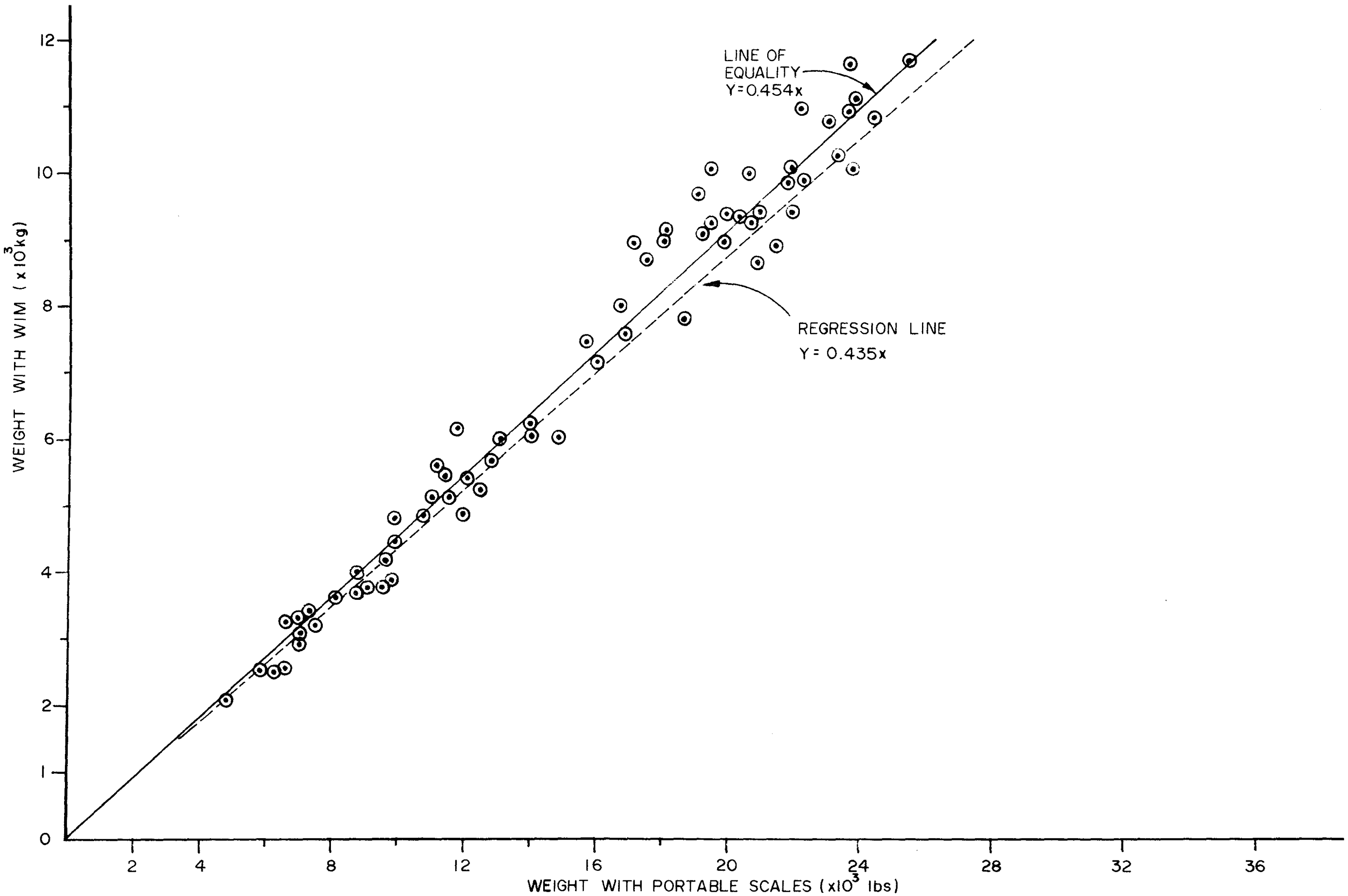

FIG. 51

COMPARISON OF AXLE LOADS MEASURED WITH THE WIM AND PORTABLE SCALES

TABLE E.8 - COMPARISON OF EQUIVALENCY FACTORS CALCULATED FROM DATA OBTAINED WITH THE PORTABLE SCALES AND THE WIM

	Equivalency Factors				Sample Size	
	CLASS 2		CLASS 4		CLASS 2	CLASS 4
	Portable Scales	WIM	Portable Scales	WIM		
2 August 1977	0.82	0.64	2.47	1.96	10	57
3 August 1977	0.92	0.66	2.76	2.15	3	20

(1) *Axle-Load Distribution*

The data collected were analyzed to give a frequency distribution of axle loads. The computer program, which uses the magnetic tape as input, uses either the class of vehicle written onto the tape by the operator, or the axle configuration and spacing to distinguish between the different vehicle classes. The frequency distributions for the two periods, day only, and day and night, are given in Appendix B. To illustrate the severity of overloading, the percentages of axles overladen are given in Table E.9.

There is little difference between the severity of overloading when night traffic is also considered. This point will be discussed further when comparing the equivalent axles per vehicle.

(2) *Equivalent Axles*

The number of equivalent axles per vehicle were calculated as in the case of the portable scales. These results are presented i Table E.10 for each day, together with the times during which measurements were made. When comparing day and night measurements, day has been defined as the hours between 08:00 and 17:00 hours each day, whereas night results were taken between 17:00 and 08:00 hours.

To facilitate the exposition about the number of equivalent axles during the day and at night, histograms (Figures 52 and 53) have been compiled, showing the number of equivalent axles during the day and at night, for the different days of the week for vehicle classes 2, 4 and 5. These classes conist of relatively large samples which make the comparisons meaningful. There is little variation in the equivalent axles per vehicle for the buses, which vary from 0.40 to 0.63 during the day and 0.35 to 0.57 at night. There is also no meaningful difference between the means calculated for day and night, which are respectively 0.48 and 0.43.

A larger variation in the number of equivalent axles is found for class 4 vehicles, for which the variation during day-time ranges from 1.12 to 1.74, and at night from 0.68 to 1.73. There is also no meaningful difference between the average equivalent axles calculated as 1.45 and 1.53 for day and night traffic, respectively,

TABLE E.9 - COMPARISON OF NUMBER OF EQUIVALENT AXLES CALCULATED FROM WIM AND PORTABLE SCALE DATA

Date	Number of equivalent axles per vehicle					
WIM	Class 2 (Sample size)	Class 4	Class 5	Class 6	Class 7	Class 8
19/7-29/7/77 (Daytime)	0.49 (251)	1.69 (814)	1.31 (322)	1.73 (13)	5.41 (14)	3.82 (22)
1/8-10/8/77 (Daytime)	0.48 (390)	1.45 (1048)	1.35 (579)	2.63 (12)	2.83 (33)	4.06 (51)
3/8-10/8/77 (Night)	0.43 (193)	1.53 (534)	1.28 (295)	2.22 (7)	3.68 (14)	3.21 (25)
Portable Scales						
7/6-11/6/76	0.64 (39)	2.35 (215)	1.25 (157)	1.50 (4)	4.98 (6)	7.45 (29)

TABLE E.10 - NUMBER OF EQUIVALENT AXLES PER VEHICLE FOR DIFFERENT DAYS OBTAINED WITH THE WIM

DATE TIME	ROAD Nº	DIRECTION	AVERAGE NUMBER OF EQUIVALENT AXLES PER VEHICLE (NUMBER OF MEASUREMENTS PER SAMPLE)											
			VEHICLE CLASS											
			2	3	4	5	6	7	8	9	10	11	12	13
19/7/77 13h40-16h30	BR040	Luziânia - Brasília	0.54 (9)		1.65 (49)	1.13 (11)		4.21 (1)						
20/7/77 10h00-16h15			0.45 (33)		1.54 (99)	1.33 (47)	3.77 (1)	4.72 (4)	3.02 (5)					
21/7/77 09h30-17h00			0.50 (44)		1.67 (115)	1.49 (44)	1.32 (3)	3.02 (1)	3.42 (3)					4.08 (1)
22/7/77 10h00-12h45			0.52 (16)		2.06 (43)	1.55 (17)	0.56 (1)	6.79 (1)	5.29 (1)			0.05 (1)		
25/7/77 12h45-17h15			0.47 (18)		1.83 (69)	1.07 (15)	1.76 (2)	8.28 (1)	9.96 (1)					4.20 (1)
26/7/77 10h05-17h10			0.51 (32)		1.50 (109)	1.17 (39)	0.79 (1)	6.69 (1)	3.75 (5)					
27/7/77 10h30-17h00			0.48 (30)		1.66 (94)	1.38 (40)			4.09 (5)					
28/7/77 09h30-16h45			0.47 (41)		2.08 (126)	1.28 (56)	2.77 (3)	4.81 (3)	2.38 (1)					
29/7/77 10h00-16h45			0.51 (28)		1.42 (110)	1.24 (53)	0.81 (2)	6.73 (2)	1.78 (1)			0.10 (1)		
1/8/77 10h30-17h00			0.48 (33)		1.68 (99)	1.24 (31)		2.23 (2)	3.93 (5)					
2/8/77 09h43-16h56			0.63 (31)		1.70 (113)	1.51 (42)	1.14 (1)	5.35 (1)	3.24 (11)			0.07 (1)		
3/8/77 11h59-17h02			0.50 (18)		1.70 (74)	1.67 (33)	1.90 (1)	5.60 (2)	1.22 (2)					
3-4/8/77 17h13-07h56			0.43 (37)		1.83 (97)	1.30 (73)	2.13 (2)	5.59 (1)	3.50 (9)					6.65 (1)
4/8/77 08h01-16h56			0.47 (45)		1.13 (138)	1.47 (88)	1.45 (1)	3.25 (8)	5.58 (4)					3.92 (1)
4-5/8/77 19h12-07h59			0.35 (27)		1.73 (80)	1.28 (42)	2.28 (2)	3.93 (5)	2.95 (3)	0.43 (2)				
5/8/77 07h54-16h50			0.48 (40)		1.26 (130)	1.39 (89)	2.61 (5)	1.71 (6)	5.31 (9)					
5-6/8/77 16h58-07h58			0.57 (19)		1.31 (90)	1.22 (25)	3.57 (1)	4.84 (2)	3.38 (3)					

TABLE E.10 NUMBER OF EQUIVALENT AXLES PER VEHICLE FOR DIFFERENT DATS OBTAINED WITH THE WIM (CONT'D)

DATE TIME	ROAD Nº	DIRECTION	AVERAGE NUMBER OF EQUIVALENT AXLES PER VEHICLE (NUMBER OF MEASUREMENTS PER SAMPLE)											
			VEHICLE CLASS											
			2	3	4	5	6	7	8	9	10	11	12	13
6/8/77 08h05-17h00	BR040	Luziânia - Brasília	0.46 (39)		1.16 (89)	0.94 (52)		0.44 (3)	3.99 (8)			0.04 (1)		
6-7/8/77 17h16-08h00			0.42 (37)		0.68 (24)	1.31 (20)								
7/8/77 08h06-17h58			0.47 (59)		1.26 (66)	1.37 (47)	4.96 (2)	3.21 (3)	4.93 (4)	0.15 (1)		11.38 (1)		
7-8/8/77 22h14-06h42			0.48 (17)		1.58 (45)	1.10 (46)	1.57 (2)	6.56 (1)	3.63 (3)					
8/8/77 08h03-16h51			0.40 (38)		1.49 (101)	1.23 (66)	3.48 (1)	3.95 (3)	1.74 (3)					
8-9/8/77 17h05-07h53			0.42 (31)		1.59 (103)	1.15 (49)		1.37 (2)	2.47 (3)					
9/8/77 08h21-16h59			0.43 (45)		1.49 (136)	1.23 (67)		3.17 (4)	5.24 (2)					4.58 (1)
9-10/8/77 17h13-07h56			0.41 (25)		1.40 (95)	1.62 (40)		2.42 (3)	2.86 (4)					
10/8/77 01h05-11h30			0.52 (21)		1.74 (51)	1.45 (32)	0.62 (1)	0.64 (1)	3.93 (3)					

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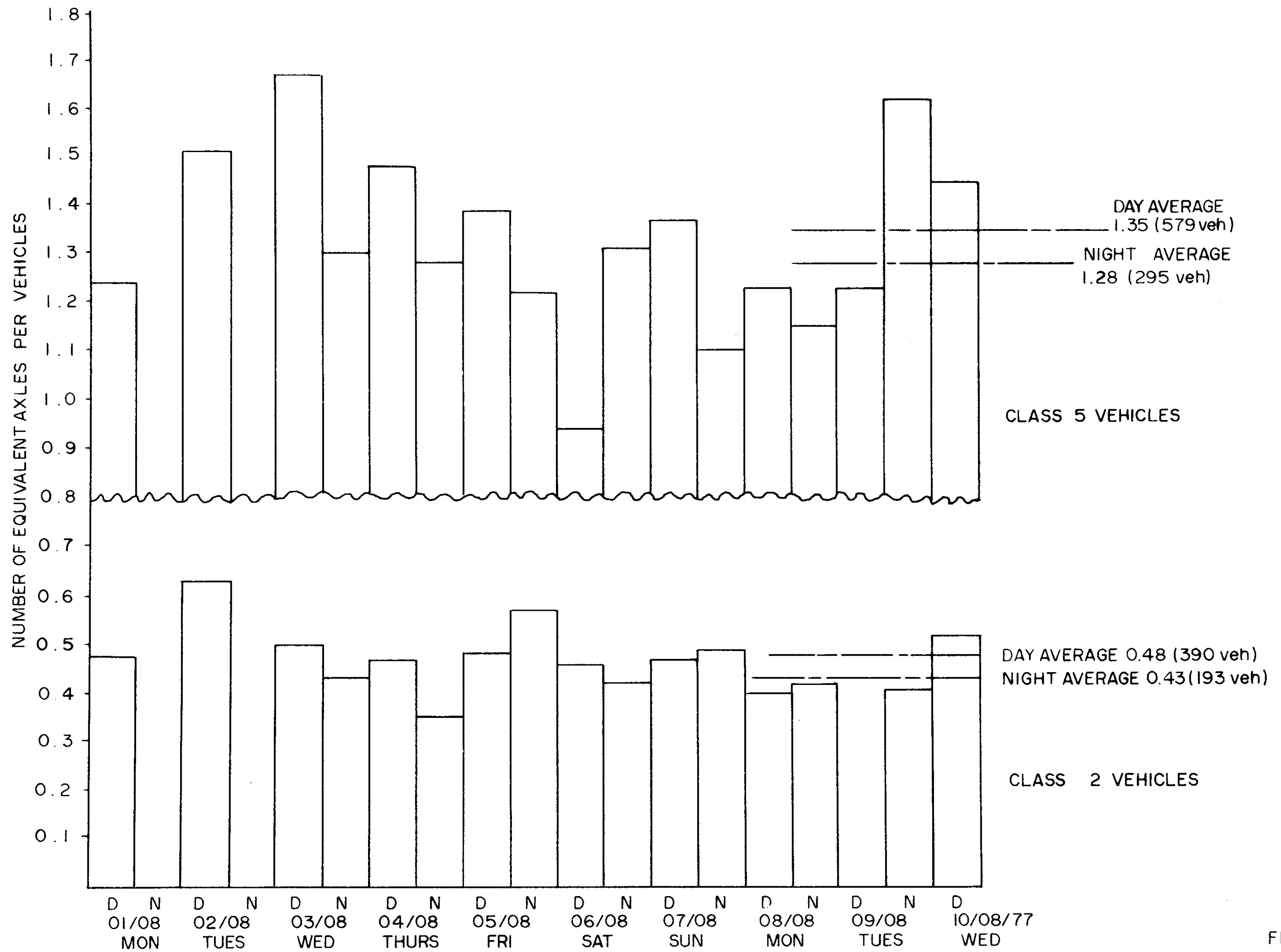

FIG. 52

NUMBER OF EQUIVALENT AXLES- CLASSES 2 AND 5 VEHICLE - DAY AND NIGHT - BR-040

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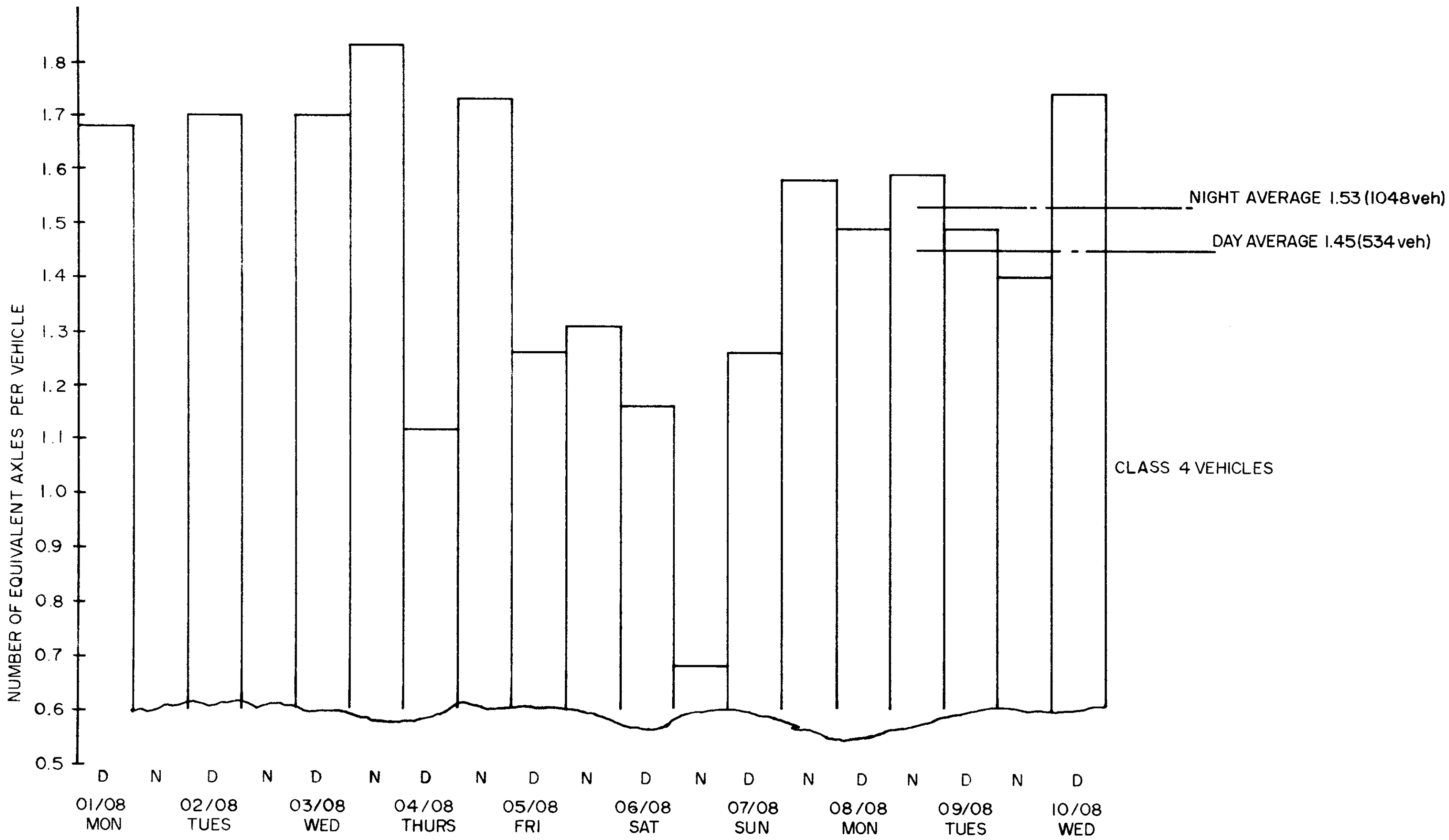

FIG.53

NUMBER OF EQUIVALENT AXLES FOR CLASS 4 VEHICLES FOR DAY AND NIGHT - BR-040

Class 5 vehicles also exhibit a relatively large variation in the number of equivalent axles per vehicle. Daytime averages range from 0.94 to 1.67, whereas night results range from 1.10 to 1.62. Again there is no meaningful difference between the total daytime and nighttime averages of 1,35 and 1,28.

A further comparison was made between average equivalent axe results calculated for two daytime and one nighttime period from WIM data, as well as the results calculated from the portable-scale data for section 006 in the same direction. These results are presented in Table E.11 for vehicle classes 2, 4, 5, 6, 7 and 8, together with tha sample sizes. There are no meaningful differences for the results of class 2, 5, 6 and 7 vehicles, considering the sample sizes. The differences between the WIM and portable scale data of class 4 vehicles could be ascribed to the relatively large proportion of these vehicles, which were carrying gravel and which were weighed with the portable scales. These vehicles appear sporadically since there is no permanent gravel pit located on this route. The difference between WIM and portable scale results for class 8 vehicles are accepted to be normal variations in vehicle weights passing over the road.

9 *WIM Results for the Site on BR-060*

Data were collected with the WIM at another site, located outside the DNER residence near Anápolis on BR-060. The results obtained at this site are not directly comparable with any results obtained with the portable scales, since heavy traffic is generated by the sand pits which are located between the WIM site and the pavement study sections. Measurements, which were limited to the lane carrying traffic from Anápolis to Brasília, were taken over a seven-day period from August 17 to 24 for 24 hours per day, in order to obtain axle load distributions and comparisons between day and night equivalent axles per vehicle.

(1) *Axle-Load Distribution*

The axle-load distribution was calculated as for the first site and is presented in Appendix B. To illustrate the severity of overloading, the percentagens of axles overladen are shown in Table E.12.

TABLE E.11 - COMPARISON OF NUMBER OF EQUIVALENT AXLES CALCULATED FROM WIM AND PORTABLE SCALE DATA

Date	Number of equivalent axles per vehicle					
	Class 2 (Sample size)	Class 4	Class 5	Class 6	Class 7	Class 8
WIM						
19/7-29/7/77 (Daytime)	0.49 (251)	1.69 (814)	1.31 (322)	1.73 (13)	5.41 (14)	3.82 (22)
1/8-10/8/77 (Daytime)	0.48 (390)	1.45 (1048)	1.35 (579)	2.63 (12)	2.83 (33)	4.06 (51)
3/8-10/8/77 (Night)	0.43 (193)	1.53 (534)	1.28 (295)	2.22 (7)	3.68 (14)	3.21 (25)
Portable Scales						
7/6-11/6/76	0.64 (39)	2.35 (215)	1.25 (157)	1.50 (4)	4.98 (6)	7.45 (29)

TABLE E.12 - PROPORTION OF AXLES LADEN ABOVE THE LEGAL LIMITS MEASURED WITH THE WIM ON BR-060

Date	Percentage of Axles Overladen (Sample Size)			
	Front Axles	Single Rear Axles	Tandem Rear Axles	Triple Rear Axles
17/8-24/8/77 (Day and night)	4.1 (2385)	20.2 (1495)	48.9 (948)	44.6 (116)

(2) *Equivalent Axles*

The calculated number of equivalent axles per vehicle are presented in Table E.13 for each day, together with the times during which measurements were made. Day and night are as defined before. Histograms (Figures 54 and 55) have been compiled to facilitate the exposition on the number of equivalent axles during day and night for different days of the week for vehicle classes 2, 4 and 5. There is little variation in the equivalent axles per vehicle for buses, which vary from 0.56 to 1.18 during the day and 0.66 to 0.89 at night. There is also no meaningful difference between the means calculated for day and night, which are respectively 0.90 and 0.81.

Class 4 vehicles again exhibit a large variation in the number of equivalent axles, varying from 0.38 to 2.73 during the day and from 0.68 to 1.69 at night. There is also a fairly large different between the day and nighttime means of 1.89 and 1.28 calculated.

Class 5 vehicles also exhibit some variation, but not as much as class 4 vehicles. Daytime averages range from 1.49 to 2.05, whereas at night results range from 1.58 to 2.09. Again there is no meaningful difference between total daytime and nighttime averages of 1.70 and 1.77.

6 CONCLUSIONS

Axle-load distributions obtained with the portable scales for 34 sites show that 10 to 35 percent of the vehicles are overladen. On those routes located between the gravel or sand pit, or the mine where ore is mined and the destination of these materials, from 40 to 80 percent of the rear axles are overladen.

The data for these sites were also used to calculate the number of equivalent axles per vehicle for the different classes of vehicles. These results will be used together with traffic counts, since the road was opened to traffic to calculate the number of equivalent axles carried by a section during its life. Indications have also been given as to the number of equivalent axles to be used in case of the absence of data for planning purposes. Repeated measurements on the same section but at different time intervals, have shown that the distributions of the equivalent axles are not significantly different at the 95-percent level of confidence. For all the vehicle classes, except

TABLE E.13 - NUMBER OF EQUIVALENT AXLES PER VEHICLE FOR DIFFERENT DAYS OBTAINED WITH THE WIM

DATE TIME	ROAD Nº	DIRECTION	AVERAGE NUMBER OF EQUIVALENT AXLES PER VEHICLE (NUMBER OF MEASUREMENTS PER SAMPLE) VEHICLE CLASS											
			2	3	4	5	6	7	8	9	10	11	12	13
17/8/77 14h58-16h57	BR-060	Anápolis - Brasilia	0.56 (9)		2.18 (14)	2.05 (14)			5.68 (4)					
17-18/8/77 17h03-06h51			0.71 (18)		1.09 (55)	1.79 (54)	0.90 (1)	0.07 (1)	7.14 (10)					
18/8/77 07h59-17h02			0.83 (27)		1.94 (81)	1.78 (74)	0.69 (1)	1.47 (2)	0.97 (7)	3.91 (1)				
18-19/8/77 17h27-07h59			0.77 (24)		0.80 (54)	1.58 (51)		7.20 (1)	3.89 (4)					
19/8/77 08h06-16h55			0.81 (28)		1.76 (83)	1.75 (68)	0.19 (2)	5.34 (2)	3.22 (15)					
19-20/8/77 17h05-07h52			0.85 (41)		1.69 (59)	1.83 (66)	0.19 (1)	1.33 (3)	4.80 (9)	3.81 (1)				
20/8/77 08h02-16h56			0.89 (35)		1.63 (67)	1.75 (61)	0.12 (1)	0.09 (1)	5.91 (15)					
20-21/8/77 17h04-07h56			0.66 (30)		0.68 (38)	2.09 (26)		9.67 (2)	7.93 (4)					10.84 (1)
21/8/77 08h05-16h59			0.86 (33)		0.38 (29)	1.49 (40)		2.33 (5)	13.96 (2)					
21-22/8/77 17h11-07h59			0.89 (44)		1.35 (56)	1.75 (59)		2.28 (5)	6.87 (13)					
22/8/77 08h05-16h58			0.95 (29)		2.25 (74)	1.56 (78)	1.69 (1)	1.83 (3)	2.93 (10)	3.75 (1)				
22-23/8/77 17h07-07h58			0.87 (32)		1.62 (72)	1.88 (112)		2.54 (2)	7.11 (5)	1.73 (1)				
23/8/77 08h02-17h01			0.92 (31)		1.90 (96)	1.91 (62)	0.78 (2)	4.49 (2)	2.97 (9)	3.34 (4)				
23-24/8/77 17h22-07h58			0.78 (25)		1.36 (71)	1.59 (71)		2.77 (5)	7.65 (5)					
24/8/77 08h05-14h36			1.18 (18)		2.73 (46)	1.54 (57)	0.06 (1)	4.96 (4)	3.29 (4)					

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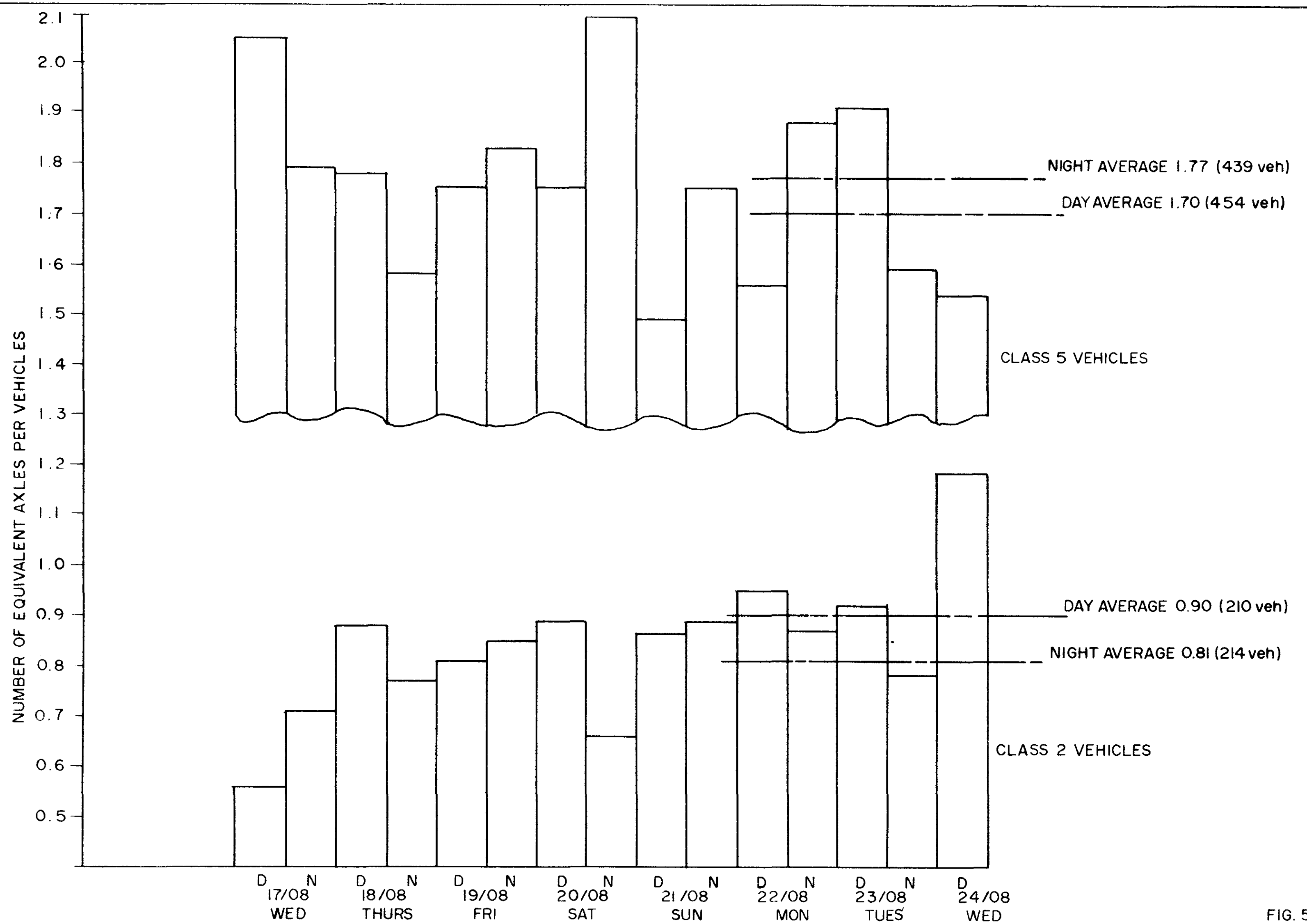

FIG. 54

NUMBER OF EQUIVALENT AXLES FOR CLASSES 5 AND 2 VEHICLES FOR DAY AND NIGHT - BR-060

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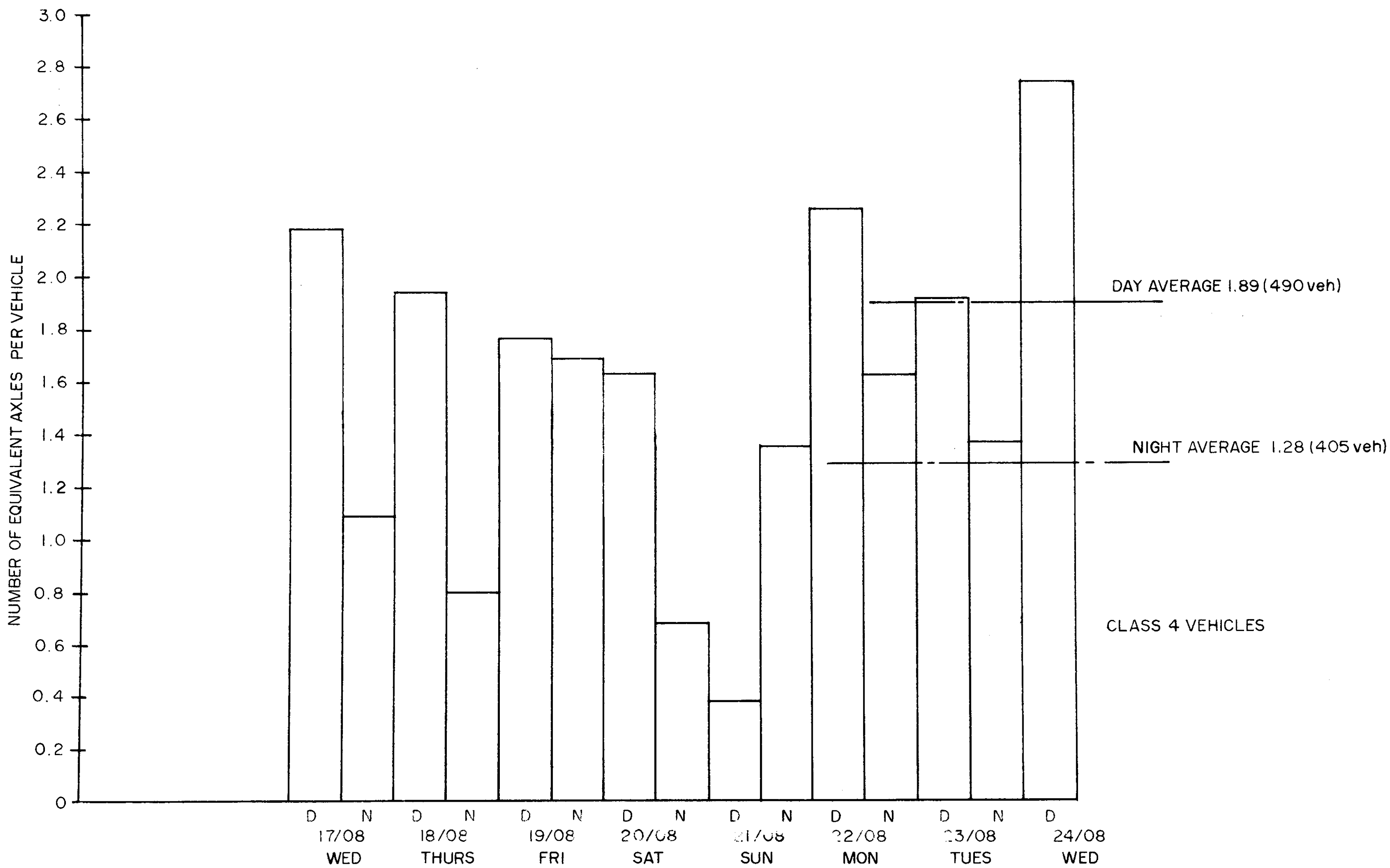

FIG. 55

NUMBER OF EQUIVALENT AXLES FOR CLASS 4 VEHICLES FOR DAY AND NIGHT - BR-060 class 2, there is a meaningful difference between the number of equivalent axles in both directions.

Some very interesting results have been obtained with the WIM system. Axle loads measured are similar to those measured with the portable scales. Meaningful differences in the number of equivalent axles per vehicle for class 4 and 5 vehicles were recorded for different days of the week during the day as well as at night. However, when considering average day and average night results over a week period, there is no meaningfull difference. Therefore, the procedure adopted to measure at one site over a five-day period during daylight hours with the portable scales appears to be valid, and not influenced by daily variations, or day-to-night variations. These conclusions will be verified at future WIM installations, since the equipment is expected to take regular measurements at six sites.

7 SUMMARY

The pavement performance and maintenance studies is program geared to complete a model by November 1978. The experiments are, however, designed and developed to continue under the auspices of highway authorities in Brazil after the term of the project staff has expired.

To complete a model by November 1978 it is essential that the different relationships being developed by our group be available for input into the model by July 1978. This means that data to be used in comparing maintenance alternatives will have a maximum 15 months time base, and many of the sections with maintenance would only be nine months old.

8 WORKPLAN AND SCHEDULE

Figure 56 shows the activities planned for the remainder of the study. All of the principal measurement activities on both the paved and unpaved test sections are shown to the very end of the study period. The assumption made is that this work will be carried forward by State highway authorities following the termination of the activities of this research project.

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WORK PLAN AND SCHEDULE

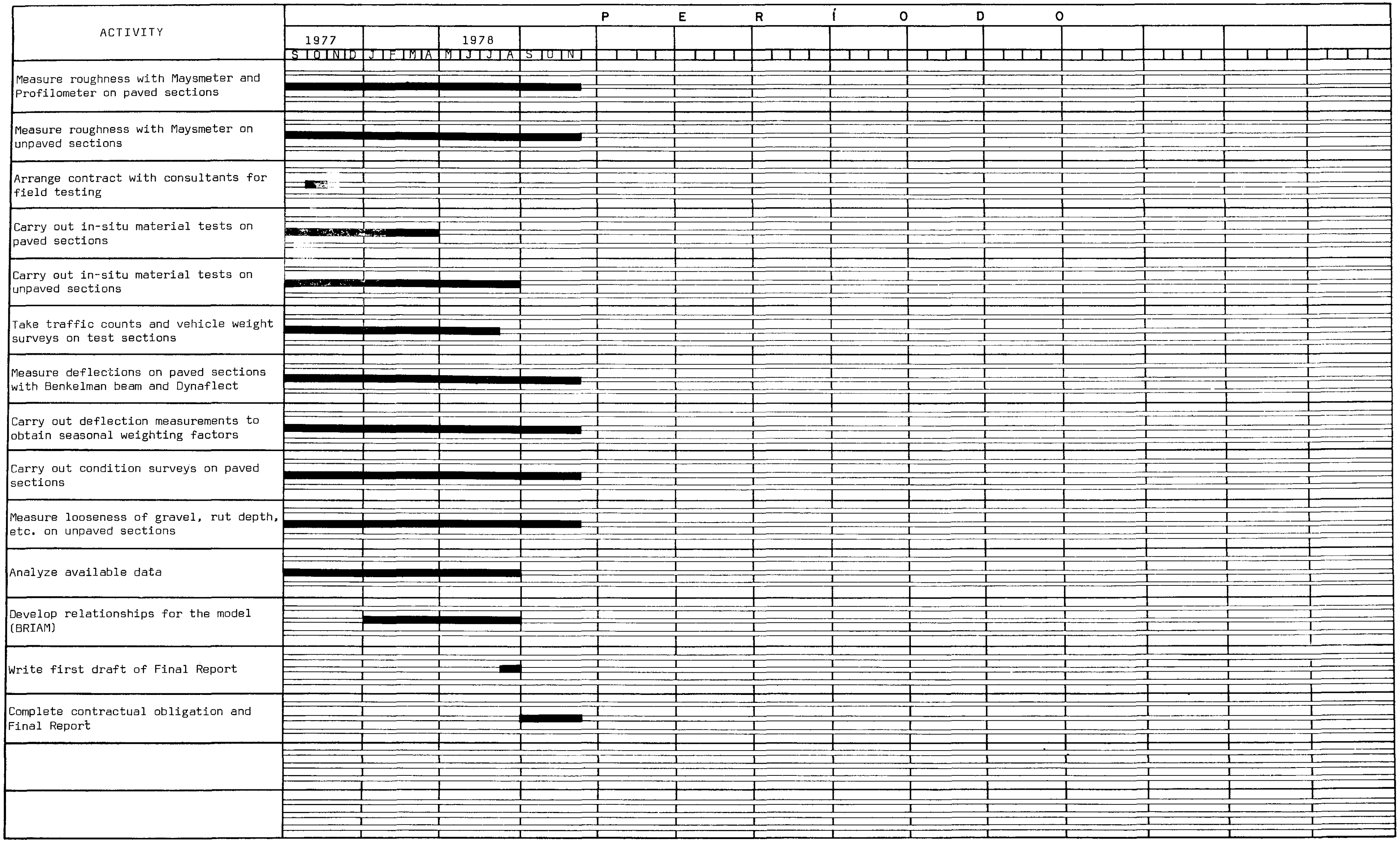

FIG. 56

CHAPTER F

MODEL DEVELOPMENT

7 MODEL DEVELOPMENT

In the Inception Report (Ref. 1), *Test and Adapt TRRL/MIT Highway Cost Models* was identified as one of the major activities of the project. Envisioned was the direct adaptation of relationships developed in the project to the latest version of the Highway Planning Model. In the last half of 1976, the TRRL Model was seriously studied and flow charted by the project staff. Planned was the testing of the construction subroutines using data from recently completed construction projects. These tests were designed to check the suitability of the Kenya construction routines in the Brazil environment.

Work with the Kenya model ceased early in 1977 when the World Bank announced that the TRRL model had been outdated by a new combined TRRL/MIT model entitled the Road Investment Analysis Model. A number of modifications were made to this new model by the Bank before it was made available to the project in mid 1977. With assistance from personnel of the World Bank, our Computer Group attempted to make operational the recent investment model in Brazil. Although the program has been compiled it has not yet been successfully run.

Thus far, we have made very little progress toward actually putting together a Brazil Road Investment Analysis Model (BRIAM). The reason is that we have assigned higher priority to other research activities. Each of the three study groups have marshalled considerable resources to generate information from which interrelationships on highway construction, maintenance and utilization are to be developed for Brazil. Without these relationships, the development of a planning model is meaningless.

However, the Brazilian Government has insisted that the final product of this research project be an operational Highway Investment Model that incorporates the relationships developed during the study period. Also it is mandatory that the model be programmed and documented so that it can be readily modified and updated by users in Brazil after the project is complete and the research team is dismantled. This means that all of the coding must be oriented to a Brazilian interpretation, use FORTRAN variable names that are based on the Portuguese language and have appropriate Portuguese comments to clarify each of the steps in the programming.

Given the need to produce an operational model before the termination of the project in November 1978, it becomes necessary to set forth at this time a work program to achieve this objective.

Before detailing a workplan, the research team reviewed anew the Requirements for a Brazil model and the current efforts of the research team to develop inputs for such a model. There was no commitment to adopt exactly any of the existing investment models, so it was considered within the prerogatives of the project staff to establish the shape and scope of the Investment Model to be developed for Brazil.

The model being developed for Brazil could be directed to any one of a number of planning levels. To illustrate, a subjective scale of sensitivity is shown in Figure 57. At the top end of the scale we show network planning. At this level, the planner wants to establish the character of the links in a state or countrywide analysis. Considered are traffic patterns and benefits resulting when links are added to or improved within the existing network. The number of combinations requiring examination is large, and therefore only the most general evaluation of individual link costs are feasible.

Next we have the selections of alternates, from where it is possible to examine any number of possible paths and roadway standards between two points and select an alternative based on the optimization of a specified value function. In this situation, one expects to evaluate different length routes over different terrain. A moderate level of sophistication is warranted such as predicting earthwork as a function of maximum grades and contour line crossings.

At the project link analysis level, essentially one path is considered. The geometry may be optimized to minimize either construction or total transport costs over the link. One expects a reasonably good description of the terrain, and accuracy sufficient for feasibility estimates of cost.

Finally, a model can be developed to produce essentially final design details suitable for construction plans.

During the conceptualization of this study for the Inception Report, the TRRL Model was examined as a guide. The level of detail varied considerable within that model, but the construction subroutines were far more sophisticated than either the pavement performance maintenance routines or the user costs routines.

The major thrust of the Brazil study is to develop improved relationships on pavement performance and vehicle operation costs.

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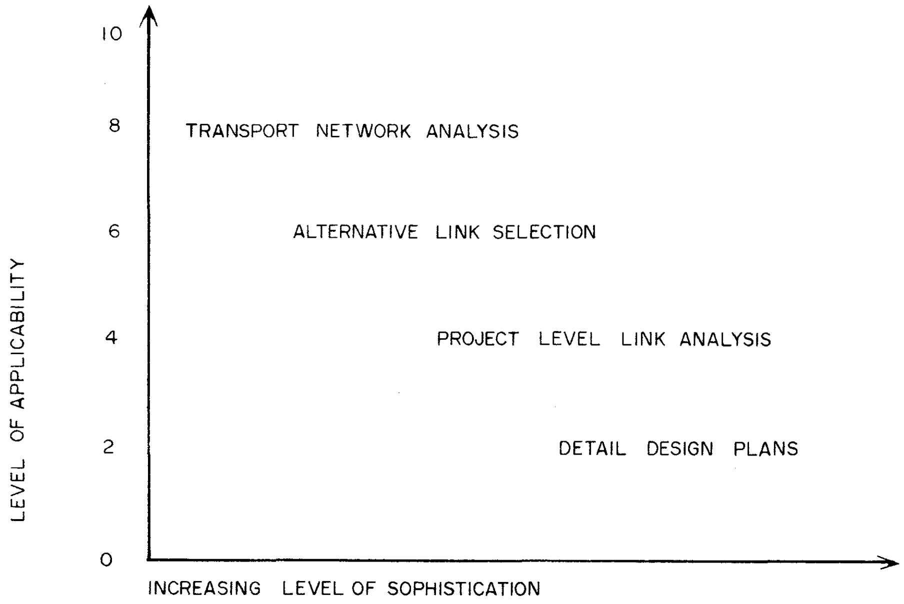

FIG. 57

RELATIONSHIP BETWEEN LEVELS OF APPLICABILITY AND SOPHISTICATION

Further, the study has been formulated so that it will be possible to develop routines with details comparable to those used in the TRRL construction subroutines.

Instead of a generalized rise-and-fall index for vertical geometry, plans were formulated to evaluate the influence of individual grades on vehicle operation cost. The same was true for horizontal curves. The entire inference space on each experiment was made as wide as possible. A detailed program was outlined to monitor the behavior of pavements receiving two extreme maintenance responses. The objective was to have information at hand to develop relationships which would improve on the sophistication of the maintenance and pavement performance subroutines and the vehicle operating cost routines of the TRRL model.

Therefore, it seemed clear that the output of this study would be relationships more detailed and sophisticated than those used in the TRRL pavement and user costs routines, and comparable in detail to the TRRL construction routines. On our planning level scale shown in Figure 57, the TRRL model would be rated at level 4.1. The model being envisioned for Brazil will be more detailed and so might receive a 3.8 rating.

The option to generalize the detailed relationships being developed is always available, and therefore they can be used in a broad level analysis at some future time. However, if the relationships were generalized now, it would not be possible to work back to the detail and sophistication feasible with the data being developed.

Therefore, the model to be developed will be limited to a link analysis where variations in design standard can be studied for a single corridor. The model will be designed to permit construction, maintence and user cost to be evaluated for alternate surface types, maintenance policies and construction and maintenance methods.

a *Approach*

As a result of the work being pursued it is expected that major modifications to some of the relationships used in the existing models will be made. Foremost will be the manner vehicle speeds and fuel consumption are to be handled. Instead of using a single predictor equation for a link or section, we propose to simulate the behavior of a vehicle on the study link and develop a continuous speed profile reflecting the impact of changes in vertical and horizontal alignment by vehicle class for given different levels of volume and various vehicle compositions.

Fuel consumption also will be computed in increments and accumulated for every change in speed or mode of operation defined by the speed profile.

The greater number of different classifications of vehicles over a range of loading being studied is expected to produce relationships covering a wider spectrum of the vehicle stream. Therefore,more classifications of vehicle types will be handled in the model than is currently possible.

A high priority item in this study is the development of information on the utilization rates of vehicles on different roadways. This will have an important impact on determining depreciation rates where almost no information has been developed historically on the influence of the road itself on vehicle utilization.

A completely new set of equations are expected to be developed for vehicle maintenance and repair, tire wear and oil consumption, based on the user cost surveys.

New and improved relationships, permitting the impact ov various maintenance levels on future pavement performance, are expected to be developed from our pavement performance and maintenance studies.

Modifying the existing World Bank Model to incorporate these new relationships being developed during the study was originally considered as an option. This model is made up of 88 different subroutines, and it was thought that three or four new subroutines could be developed to replace or interface with an equal number of the existing routines to make use of this model.

Closer examination showed that many of the input routines would require major modifications.

A construction routine that outputs a description of the roadway link in terms of each grade and horizontal curve is not part of the existing model, yet the project approach to developing vehicle speed and fuel consumption requires this detail. To handle volume and composition effect on traffic congestion, hourly distributions of traffic by vehicle class are required.

Finally, documentation on the Road Investment Analysis Model (RIAM) is currently incomplete, so it does not appear feasible to in corporate within the existing coding stream the new relationships deve loped from this study. Further, before the current model could be ado pted, it would need to be recoded in its entirety to satisfy the documentation requirements neeeded for Brazil. Therefore, we do not believe it is feasible to attempt to directly adopt RIAM within the remaining study frame. Rather, it has been decided that the more practi cal course will be to code a new model from scratch. The conceptual framework already exists from the first MIT study the subsequent TRRL model and the current version of RIAM. We propose to adopt the concepts used by TRRL for their construction subroutine, recode the program in FORTRAN with all variables and coments based on Portuguese.

Further we propose to adopt the input documentation format presently used for RIAM and use the current ouput formats of RIAM as a guideline. We expect to develop completely new modules for pavement and maintenance and user cost, based on the new relationships being developed.

b *Model Workplan and Schedule*

It is proposed that work begin on the development of the Brazil Roadway Investment Analysis Model (BRIAM) in November 1977,at which time the conceptualization phase would commence. The first task of this phase would be to:

- Establish the desired outputs of the final model;
- Establish those paramenters to be generated by the model;
- Define the necessary inputs to satisfay these needs.

Concurrently, the relationships between each of the program modules would be defined. The general structure of the module interfacing shown in Figure 58 would be detailed to establish common areas and transfer variables between modules. Also to be identified will be the required input and output requirements of each module. Defining these input and output requirements for each module provides the analyst with the necessary quidelines to develop each of the modules independently. This will permit a more detailed design of both the modules and BRIAM at an early stage and enable programming efforts to be carried out independent of actual development of useable relationships. Into this last category fit the input/output subroutines. Once the inputs are

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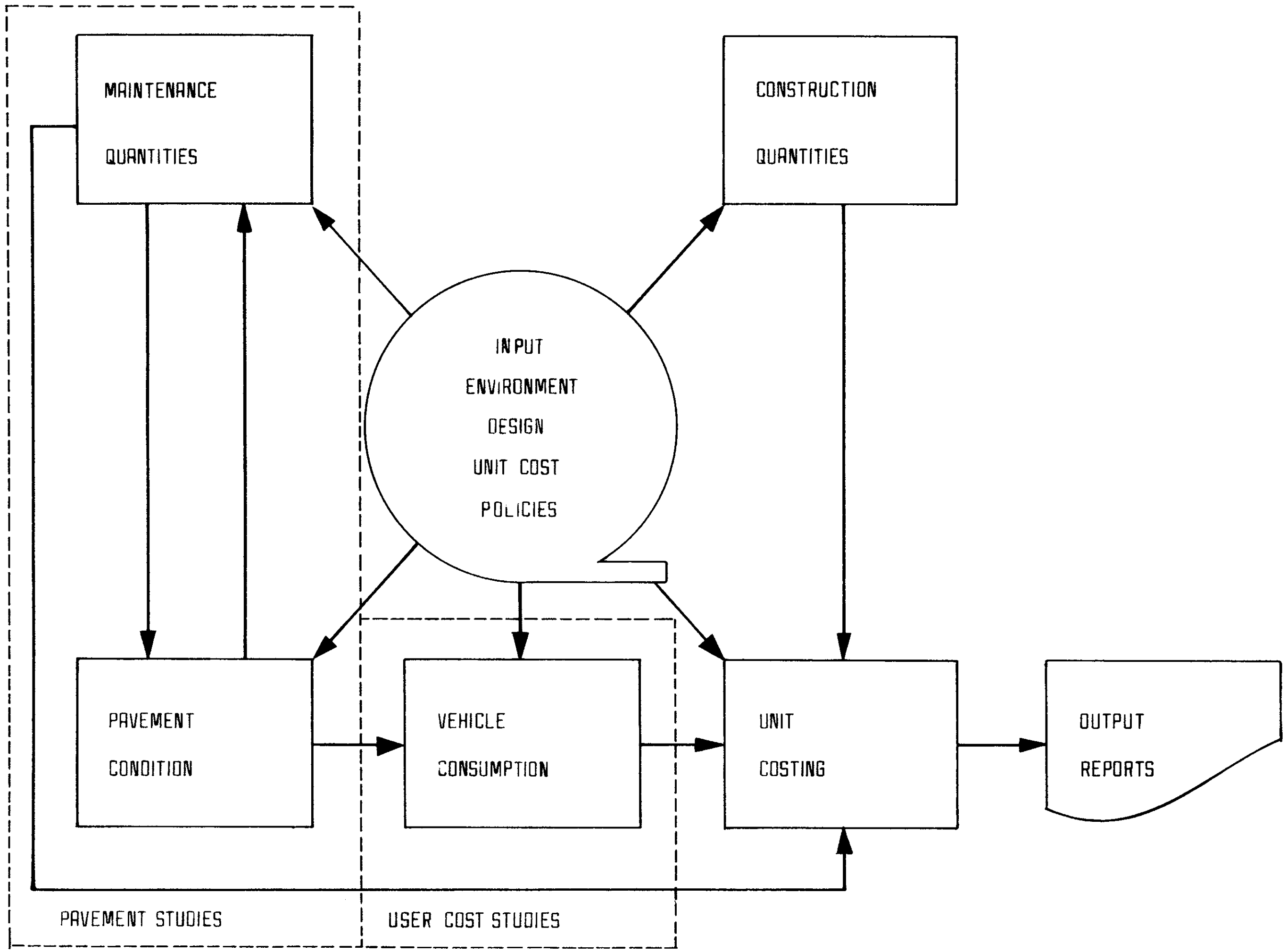

FIG. 58

CONCEPTUAL FRAMEWORK OF BRIAM SHOWING MODULE INTERFACING known, even if specifications must be made for the maximum input possible, appropriate subprograms can then be written to read data, to generate reports on input information, and to generate output reports.

The documentation in these first two phases will involve the writing of specifications on the I/O routines and of documentation of the overall model system.

Work on the construction module will begin as early as possible. The data requirements for the various construction routines, i.e., earthwork, drainage, etc., and for the Time and Fuel Algorithm (TAFA) will establish the inputs for the early phases. Detailed study of the TRRL model construction routines will be reinitiated to permit flow-charting of a modified routine to be used by BRIAM. Once a flow chart is available, programming will proceed as quickly as possible to permit more time for model validation.

Documentation will consist of program specifications, input-card layouts, and flow charts. The effort to be expended in this phase will be a major part of the total.

The vehicle-performance module consists of two major tasks: programming, debugging and testing of TAFA, and development of the routines to calculate user-cost quantities. TAFA is currently in the process of being defined. Before being programmed it will be reviewed and structured to fit the overall model requirements.

Once the maintenance activities to be included in the model are established, much of the programming for this module can start. The key element will be the establishment of workload, an input determined from a definition of maintenance levels interacting with the condition of the pavement in the pavement condition mudule. The establishment of pavement deterioration relationships is a very time-dependent study, and final relationships are not expected to be available until mid 1978.

Analysis work on unpaved roads will start in 1978, so the general structure of parts of this model will start as soon as these relationships are available. The conceptualization relating maintenance to pavement condition can begin earlier and will be developed in conjunction with the maintenance module.

The last phase, model synthesis, should not require extensive time, providing care is taken from the beginning to ensure that all of the modules are compatible. This will leave more time for sensitivity studies and final documentation. Providing each module is documented as it is developed, this final documentation should consist of consolidating existing documents into a user's manual, final model documen tation, and presentation of the results of the sensitivity studies an example applications of the model.

The Workplan with a Time Schedule for development of BRIAM is shown in Figure 59 .

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WORK PLAN AND SCHEDULE

ACTIVITY	PERÍODO
	1977 S O N D / 1978 J F M A M J J A S O N
CONCEPTUALIZATION	
Identify program input and output requirements	
Define module structure and interfacing	
Document	
DESIGN INPUT FORMATS & REPORTS	
Read and display model inputs	
Display model information	
Document	
CONSTRUCTION MODULE STRUCTURE CONSTRUCTION MODEL	
Define TAFA requirements and construction costing routines	
Define inputs	
Define and modify TRRL construction routine (flowcharting)	
Program and debug module	
Validate module	
Document	
VEHICLE MODULE	

FIG. 59

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WORK PLAN AND SCHEDULE

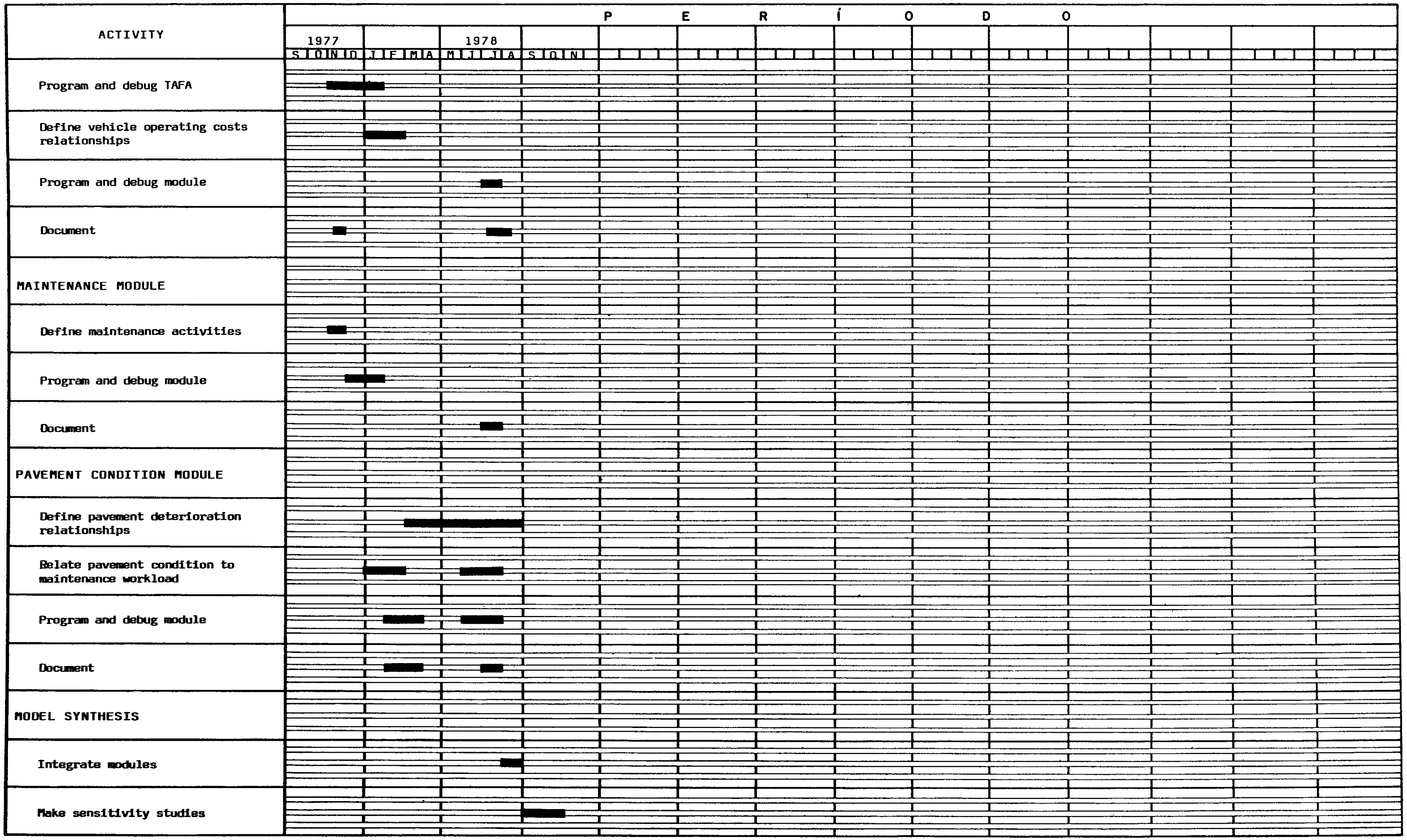

FIG. 59 (CONT.)

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WORK PLAN AND SCHEDULE

ACTIVITY	PERÍODO														
	1977								1978						
	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N
Develop example application of model															
Document															

FIG. 59 (CONT.)

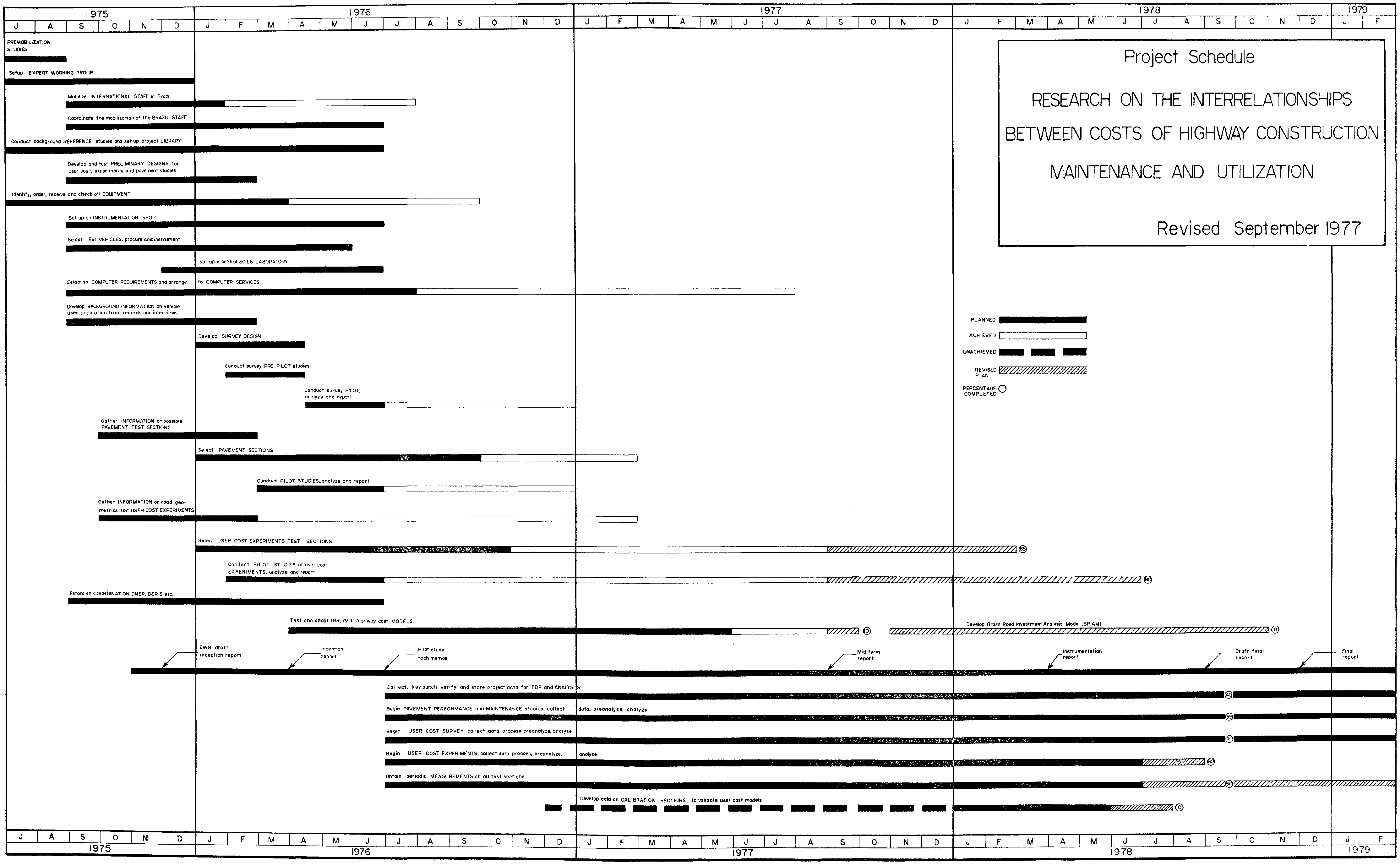
CHAPTER G

GENERAL WORK PLAN

Detailed schedules are included in Chapters C through F for each of the major study phases. This general work plan summarizes these activities for the entire project, and the project schedule shown in Figure 60 is an updated version of the one included in the Inception Report (Ref. 1). Each of the activities that were completed as planned are unaltered. For those that required more time but are now complete, an achieved line is shown. A cross-hatched pettern is used to show present revised plan on all unfinished activities. Also, for each activity that is not complete, a current estimate of the percentage completed is indicated.

Seven of the activities that are now complete were finished later than originally planned. Each activity has been extended using the achieved coding. The following brief explanations are offered for the delays.

- *Mobilize International Staff in Brazil* - The staff was completed as indicated but the Instrumentation engineer arrival in Brazil was delayed, so that more time could be spent checking on equipment in the U.S.A. Also, contract changes in March resulted in modified international staffing requirements. An economist was added for the full length of the study and it was decided to immediately add a modeler to project staff, and he arrived in August 1976.
- *Identify, Order, Receive, and Check all Equipment* - All of the equipment except the Profilometer, which arrived in June, and the A/D and resilient modulus soil testing equipment, which arrived in September, was received as scheduled.
- *Establish Computer Requirements and Arrange for Computer Services* - The establishment of adequate computer facilities for the project has proved a formidable task. The final configuration includes service contracts with CAEEB and EMBRAPA, the latter having been signed in May 1977, and the establishment of a remote terminal connection to DNER, which only became operational in May 1977.
- *Conduct Survey Pilot, Analyze and Report* - The main study effort started as scheduled, but complete refinement of the data-collection documents was not finalized until December. Data collected during the first six months of the main survey needed to be transformed to conform with the final study documentation format.



Project Schedule
RESEARCH ON THE INTERRELATIONSHIPS BETWEEN COSTS OF HIGHWAY CONSTRUCTION MAINTENANCE AND UTILIZATION
Revised September 1977
1975
1976
1977
1978
1979
J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F
PREMOBILIZATION STUDIES
Setup EXPERT WORKING GROUP
Mobilize INTERNATIONAL STAFF in Brazil
Coordinate the mobilization of the BRAZIL STAFF
Conduct background REFERENCE studies and set up project LIBRARY
Develop and test PRELIMINARY DESIGNS for user costs experiments and pavement studies
Identify, order, receive and check all EQUIPMENT
Set up an INSTRUMENTATION SHOP
Select TEST VEHICLES, procure and instrument
Set up a control SOILS LABORATORY
Establish COMPUTER REQUIREMENTS and arrange for COMPUTER SERVICES
Develop BACKGROUND INFORMATION on vehicle user population from records and interviews
Develop SURVEY DESIGN
Conduct survey PRE-PILOT studies
Conduct survey PILOT, analyze and report
Gather INFORMATION on possible PAVEMENT TEST SECTIONS
Select PAVEMENT SECTIONS
Conduct PILOT STUDIES, analyze and report
Gather INFORMATION on road geometrics for USER COST EXPERIMENTS
Select USER COST EXPERIMENTS TEST SECTIONS
Conduct PILOT STUDIES of user cost EXPERIMENTS, analyze and report
Establish COORDINATION DNER, DER'S etc.
Test and adapt TRRL/MIT highway cost MODELS
Develop Brazil Road Investment Analysis Model (BRIAM)
EWG draft inception report
Inception report
Pilot study tech memos
Mid term report
Instrumentation report
Draft final report
Final report
Collect, key punch, verify, and store project data for EDP and ANALYSIS
Begin PAVEMENT PERFORMANCE and MAINTENANCE studies, collect data, preanalyze, analyze
Begin USER COST SURVEY collect data, process, preanalyze, analyze
Begin USER COST EXPERIMENTS, collect data, process, preanalyze, analyze
Obtain periodic MEASUREMENTS on all test sections
Develop data on CALIBRATION SECTIONS to validate user cost models
PLANNED
ACHIEVED
UNACHIEVED
REVISED PLAN
PERCENTAGE COMPLETED

- *Select Pavement Test Sections* - After an exhaustive search extending beyond the originally planned study area, it was not possible to locate test sections for all of the pavement study factorial cells. Therefore, the analysis will be based on a reduced factorial design.
- *Conduct Pavement Pilot Studies, Analyze and Report* - Locating the test sections required far more time than anticipated. Finalizing the measurement system to be used to document information being monitored on the test sections was also delayed, with the last being the condition survey procedures which were finalized in December 1976.
- *Gather Information on Road Geometrics for User Costs Experiments* - In searching for experimental sections, the first step was establishing suitable geometric characteristics, and this process continued as the search for rough paved sections was pursued.

A revised schedule has been established for all remaining project activities that were not originally projected to continue to the very end of the study period. The activities that were changed and the reason for the required extension in their schedule follow:

- *Select User Cost Experiments Test Sections* - This activity was expected to be completed early in the study, but it has proved impossible to locate some of the desired test sections. Rough paved sections meeting the study factorial requirements could not be found close to the operations base in Brasilia. Suitable sections were eventually found in Goiás and Minas Gerais after extensive searching. The specifications for test sections require uniform grades 1.5 to 2-km long over a range of roughness and with reasonable traffic volumes for the speed studies. A current search has been initiated of the user surveys route inventory file. If the critical section cannot be found, the constraints will be relaxed so that all feasible sections are in hand by March 78. About half of the remaining 35% which need to be located are associated with experiments not yet initiated and will only require identification.
- *Conduct Pilot Studies of User Cost Experiments, Analyze and Report* - Four of the 13 main experiments have not been pilot tested. These are all relatively short experiments but have not yet started because priority has been

given to the completion of ongoing major experiments. Not included in this revised plan is the pilot testing of two of the nine satellite studies not programmed in the current schedule.

- *Test and Adapt TRRL/MIT Highway Cost Models* - The TRRL model is operational and has been studied. However, limited work was done with the existing combined model, because the latest version has not been made operational. There is a need to have a final model oriented to the Portuguese language and completely operational by the end of the study. Adopting the existing model does not appear feasible within the remaining time because current documentation is incomplete and this makes modification impractical. Therefore, proposed is a newly structured and coded model to be developed during the remaining study period.
- *Begin User Cost Experiments, Collect Data, Process, Pre-Analyze, Analyze* - This activity has been extended two months to permit maximum time to collect and analyze data to include in the model. Refinements to the various relationships being developed can be made right up until they are presented in the final draft report.
- *Obtain Periodic Measurements on all Test Sections* - The establishment of specially trained teams to develop measures of performance on both paved and unpaved road sections, together with the acquisition and modification or fabrication of suitable measure equipment took many months. The pavement studies are expected to be carried forward into the future, Retaining the continuity of the measurements by keeping the teams in the field will help this transition.
- *Develop Data on Calibration Sections to Validate User Cost Model* - This activity has not started although the necessary tachographs and fuel meters have been checked out. The new schedule shows this activity starting in January 1978, when the necessary vehicles can be diverted for this purpose.

CHAPTER H

SUMMARY AND RECOMMENDATIONS

Although all project studies are progressing well, under the programs developed by the main study groups, the November 1978 termina tion date has brought into focus areas where inadequate time has placed some serious constraints on the scope of the project. It seems clear, then, that substantial benefits would be realized if the project could be extended. Such an extension is warranted by the many delays and unforessen events that have effectively shortened the actual study period.

1 *STATUS OF THE STUDIES*

All three main study groups have refined their field procedures, and a comprehensive data-collection program is well underway.

a *Road User Costs Survey*

The User Costs Surveys Group has developed procedures that are generating vehicle operating-cost data from a wide variety of survey participants who are becoming increasingly cooperative. An average of over 6,000 vehicle/months of data, covering different items of user costs, are in hand and ready to be processed. Detailed inventory information, covering roadway characteristics on over 12,000 km of user survey routes, has been developed by two survey vehicles that have been operating continuously since the beginning of 1977.

All of the inventory data are validated on computer files, but only 20 percent of operating-cost data have passed preliminary processing, and even less have been completely validated for analysis. Inadequate computer support, together with delay in consolidating summaries of the data have seriously hampered the processing operation. Modified procedures directed toward collecting monthly summaries of user data are presently being implemented. These procedures will permit better validation-screening in the field and will reduce the volume of information to be processed.

High priority has been placed on processing all existing data and on establishing the exact disposition of participants in a new, quantified version of the user surveys design factorial. In the future, highest priority will be given to filling identified gaps in this factorial, and efforts will concentrate on developing information on those items that have the most impact on user costs.

b *Road User Costs and Traffic Experiments*

This Group has identified 13 necessary and nine desired experiments that they plan to conduct in developing a deterministic model to predict speeds and fuel consumption. This includes nine required speed studies with a nine-man crew, which are 44% complete, and four required fuel studies with a 19-man crew, which are 74% complete. Preliminary equations developed from the fuel data are presented in this report, and final relationships will be established in the near future, as each of the experiments is completed.

It was necessary to expand the driver-behavior experiments following the implemantation by the government of a policy of strict enforcement of speed limits, in November 1976. This had a major impact on driver speeds, and therefore complicated our data analysis requirements. Lack of programming support has slowed the data flow and delayed the analysis effort. Missing was programming to generate summary reports which would permit field data screening to locate discrepancies and errors.

A conceptual framework has been developed for a deterministic model to predict time and fuel consumption, while different traffic-simulation programs are being examined for use in explaining traffic-composition effects on speed.

A tight schedule has been established to finish the required traffic experiments. The fuel crews expected to complete their studies early in 1978 will then be diverted to help with the traffic-behavior experiments. However, within this time frame it will not be possible to complete the proposed satellite studies that are estimated to require three months.

c *Pavement and Maintenance Studies*

This Group has established 86 paved sections, having completed at least one cycle of roughness, deflection and condition survey measures on every section. The measurement program is running smoothly. Material characterization on 21 sections is complete, and a material consultant is currently conducting test on another 30 sections. Another contract has been signed for 20 more sections, and the consultant is presently starting the work.

Axle-loading data have been collected on over a third of the sections, and this program will continue. Traffic-classification information has been developed for a limited number of test sections. However, considerable assistance is expected in the future from DNER/ DER agencies, so no problems are expected in this area.

The methodology for the unpaved roads was refined on six sections, while the more time-dependent paved sections were being established. The major work program on unpaved roads has been started and a number of sections have now been established.

Because of the large volume of laboratory work, the pavement studies will have to rely on the pledged cooperation from DER-DF to handle this work.

A work schedule has been developed and the necessary resources have been established to complete the objectives of the pavement studies before November 1978. Nevertheless, there is considerable concern that, for the paved sections, the period of observation will be too short to produce meaningful results, particularly for the maintenance studies, whose monitoring period will last only about nine months.

2 *RECOMMENDATIONS*

The period of the project, relating specifically to work in Brazil, was originally conceived to last 42 months. Two to three months were spent on recruiting the international staff, and nearly half a year was dedicated to getting the Brazilian technical staff together. Additional time was consumed by the pilot tests, calibration of the equipment and establishment of computer facilities. It is estimated, therefore, that a study of the scope originally envisioned will require 12 additional months.

Well trained field teams in all areas of the research are now productively generating information. It has required from 12 to 24 month to realize this level of implementation, so every month added to the field efforts at this point is extremely cost effective.

A work program has been designed to keep the entire team together through November 1978, which is the end of the current budget period for the international staff. Current plans call for the Brazilian staff to carry the project forward to February 1979.

It is recommended that the project be extended for a year, in terms of participation by the international staff, and for nine months, in terms of the Brazilian staff, with the last six months being reserved for the analysis and final report.

Such an extension would also add to the data-collection phase and reduce overlap between producing final relationships and incorporating them into a computer model. The extension of the data-collection period would especially benefit the user surveys area, where recently-identified participants are critical in filling the survey factorial. The pavement studies area would also benefit from the extension of the observation period for alt-rnative levels of maintenance response. In addition, it would also permit the completion of all the user cost and traffic experiment satellite studies.

Regardless of what happens related to recommended project extensions, the research team will need continued access to suitable computer facilities to finish the project.

APPENDIX A

AXLE LOAD DISTRIBUTION BY TEST SECTION (40 TABLES)

SECTION 001 ON EPCT
Direction SC - BR-020/Barragem
Direction CS - Barragem BR-020

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	13	68.4	10	76.9
2000 - 3000	4	21.1	3	23.1
3000 - 4000	2	10.5	0	0.0
4000 - 5000	0	0.0	0	0.0
5000 - 6000	0	0.0	0	0.0
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	19		13	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	8	42.1	3	23.1
2000 - 3000	4	21.1	6	46.2
3000 - 4000	1	5.3	2	15.4
4000 - 5000	0	0.0	2	15.4
5000 - 6000	0	0.0	0	0.0
6000 - 7000	0	0.0	0	0.0
7000 - 8000	0	0.0	0	0.0
8000 - 9000	0	0.0	0	0.0
9000 - 10000	3	15.8	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	2	10.5	0	0.0
12000 - 13000	1	5.3	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	19		13	

TRIPLE REAR AXLES

TANDEM REAR AXLES

SECTION 002 ON BR-251
Direction SC - Unaí/Brasília
Direction CS - Brasília/Unaí

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	3	4.4	0	0.0
2000 - 3000	56	82.4	39	65.0
3000 - 4000	8	11.8	17	28.3
4000 - 5000	1	1.5	4	6.7
5000 - 6000	0	0.0	0	0.0
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	68		60	

TRIPLE REAR AXLES

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	1	1.6	0	0.0
2000 - 3000	42	68.9	3	5.5
3000 - 4000	10	16.4	1	1.8
4000 - 5000	2	3.3	0	0.0
5000 - 6000	0	0.0	1	1.8
6000 - 7000	0	0.0	2	3.6
7000 - 8000	2	3.3	2	3.6
8000 - 9000	0	0.0	3	5.5
9000 - 10000	1	1.6	11	20.0
10000 - 11000	2	3.3	18	32.7
11000 - 12000	1	1.6	11	20.0
12000 - 13000	0	0.0	3	5.5
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	61		55	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	0	0.0
4000 - 5000	2	28.6	0	0.0
5000 - 6000	3	42.9	0	0.0
6000 - 7000	0	0.0	0	0.0
7000 - 8000	0	0.0	0	0.0
8000 - 9000	0	0.0	0	0.0
9000 - 10000	1	14.3	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	1	14.3	0	0.0
15000 - 16000	0	0.0	1	20.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	4	80.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	0	0.0
TOTAL	7		5	

SECTION 002 ON BR-251
Direction SC - Unaí/Brasília
Direction CS - Brasília/Unaí

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	16	11.6	11	12.1
2000 - 3000	55	39.9	51	56.0
3000 - 4000	54	39.1	19	20.9
4000 - 5000	9	6.5	8	8.8
5000 - 6000	4	2.9	2	2.2
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	138		91	

TRIPLE REAR AXLES

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	9	7.1	10	12.3
2000 - 3000	17	13.4	36	44.4
3000 - 4000	12	9.4	10	12.3
4000 - 5000	2	1.6	0	0.0
5000 - 6000	5	3.9	6	7.4
6000 - 7000	7	5.5	5	6.2
7000 - 8000	4	3.1	0	0.0
8000 - 9000	7	5.5	5	6.2
9000 - 10000	10	7.9	3	3.7
10000 - 11000	27	21.3	3	3.7
11000 - 12000	20	15.7	3	3.7
12000 - 13000	7	5.5	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	127		81	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	0	0.0
4000 - 5000	2	18.2	1	10.0
5000 - 6000	3	27.3	3	30.0
6000 - 7000	0	0.0	1	10.0
7000 - 8000	0	0.0	0	0.0
8000 - 9000	0	0.0	0	0.0
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	1	9.1	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	1	9.1	2	20.0
16000 - 17000	1	9.1	0	0.0
17000 - 18000	1	9.1	1	10.0
18000 - 19000	1	9.1	0	0.0
19000 - 20000	1	9.1	2	20.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	0	0.0
TOTAL	11		10	

SECTION 003 ON BR-020
Direction SC - Formosa/Sobradinho
Direction CS - Sobradinho/Formosa

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	64	32.8	74	31.1
2000 - 3000	62	31.8	51	21.4
3000 - 4000	26	13.3	74	31.1
4000 - 5000	41	21.0	37	15.5
5000 - 6000	2	1.0	2	0.8
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	195		238	

TRIPLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 8000 KG	0	0.0	0	0.0
8000 - 9000	0	0.0	0	0.0
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
24000 - 25000	0	0.0	0	0.0
25000 - 26000	0	0.0	0	0.0
26000 - 27000	0	0.0	0	0.0
27000 - 28000	0	0.0	0	0.0
28000 - 29000	0	0.0	0	0.0
29000 - 30000	1	50.0	0	0.0
30000 - 31000	0	0.0	0	0.0
31000 - 32000	0	0.0	0	0.0
32000 - 33000	1	50.0	0	0.0
33000 - 34000	0	0.0	0	0.0
34000 - 35000	0	0.0	0	0.0
> 35000	0	0.0	0	0.0
TOTAL	2		0	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	44	25.1	52	24.6
2000 - 3000	39	22.3	15	7.1
3000 - 4000	13	7.4	17	8.1
4000 - 5000	22	12.5	24	11.4
5000 - 6000	22	12.6	36	17.1
6000 - 7000	17	9.7	21	10.0
7000 - 8000	5	2.9	15	7.1
8000 - 9000	2	1.1	4	1.9
9000 - 10000	4	2.3	10	4.7
10000 - 11000	1	0.6	6	2.8
11000 - 12000	2	1.1	5	2.4
12000 - 13000	1	0.6	3	1.4
13000 - 14000	2	1.1	3	1.4
14000 - 15000	0	0.0	0	0.0
15000 - 16000	1	0.6	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	175		211	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	1	4.5	0	0.0
4000 - 5000	10	45.5	4	8.2
5000 - 6000	0	0.0	0	0.0
6000 - 7000	1	4.5	22	44.9
7000 - 9000	1	4.5	0	0.0
8000 - 9000	0	0.0	4	8.2
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	4	8.2
12000 - 13000	0	0.0	2	4.1
13000 - 14000	0	0.0	2	4.1
14000 - 15000	1	4.5	2	4.1
15000 - 16000	1	4.5	3	6.1
16000 - 17000	2	9.1	1	2.0
17000 - 18000	1	4.5	2	4.1
18000 - 19000	1	4.5	2	4.1
19000 - 20000	1	4.5	1	2.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	2	9.1	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	0	0.0
TOTAL	22		49	

SECTION 004 ON DF-20
Direction SC - BR-060/Gama
Direction CS - Gama/BR-060

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	3	12.0	4	13.3
2000 - 3000	13	52.0	20	66.7
3000 - 4000	9	36.0	4	13.3
4000 - 5000	0	0.0	2	6.7
5000 - 6000	0	0.0	0	0.0
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	25		30	

TRIPLE REAR AXLES

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	1	4.2	2	7.7
2000 - 3000	3	12.5	20	76.9
3000 - 4000	1	4.2	0	0.0
4000 - 5000	0	0.0	2	7.7
5000 - 6000	0	0.0	1	3.8
6000 - 7000	0	0.0	0	0.0
7000 - 8000	0	0.0	1	3.8
8000 - 9000	0	0.0	0	0.0
9000 - 10000	1	4.2	0	0.0
10000 - 11000	6	25.0	0	0.0
11000 - 12000	6	25.0	0	0.0
12000 - 13000	4	16.7	0	0.0
13000 - 14000	2	8.3	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	24		26	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	0	0.0
4000 - 5000	0	0.0	1	25.0
5000 - 6000	0	0.0	0	0.0
6000 - 7000	0	0.0	0	0.0
7000 - 8000	0	0.0	2	50.0
8000 - 9000	0	0.0	0	0.0
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	1	100.0	1	25.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	0	0.0
TOTAL	1		4	

SECTION 004 ON DF-20
Direction SC - BR-060/Gama
Direction CS - Gama/BR-060

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	14	15.6	12	15.6
2000 - 3000	32	35.6	52	67.5
3000 - 4000	42	46.7	11	14.3
4000 - 5000	0	0.0	2	2.6
5000 - 6000	2	2.2	0	0.0
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	90		77	

TRIPLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 8000 KG	0	0.0	1	100.0
8000 - 9000	0	0.0	0	0.0
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
24000 - 25000	0	0.0	0	0.0
25000 - 26000	0	0.0	0	0.0
26000 - 27000	0	0.0	0	0.0
27000 - 28000	0	0.0	0	0.0
28000 - 29000	0	0.0	0	0.0
29000 - 30000	0	0.0	0	0.0
30000 - 31000	0	0.0	0	0.0
31000 - 32000	0	0.0	0	0.0
32000 - 33000	0	0.0	0	0.0
33000 - 34000	0	0.0	0	0.0
34000 - 35000	0	0.0	0	0.0
> 35000	0	0.0	0	0.0
TOTAL	0		1	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT
< 2000 KG	10	12.5	9	14.3
2000 - 3000	4	5.0	37	58.7
3000 - 4000	3	3.7	4	6.3
4000 - 5000	3	3.7	8	12.7
5000 - 6000	1	1.2	2	3.2
6000 - 7000	0	0.0	0	0.0
7000 - 8000	0	0.0	1	1.6
8000 - 9000	1	1.2	2	3.2
9000 - 10000	5	6.3	0	0.0
10000 - 11000	18	22.5	0	0.0
11000 - 12000	20	25.0	0	0.0
12000 - 13000	12	15.0	0	0.0
13000 - 14000	3	3.7	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	80		63	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	0	0.0
4000 - 5000	0	0.0	8	44.4
5000 - 6000	0	0.0	2	11.1
6000 - 7000	0	0.0	0	0.0
7000 - 8000	0	0.0	3	16.7
8000 - 9000	0	0.0	1	5.6
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	2	20.0	0	0.0
12000 - 13000	1	10.0	1	5.6
13000 - 14000	0	0.0	1	5.6
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	1	5.6
16000 - 17000	0	0.0	0	0.0
17000 - 18000	2	20.0	1	5.6
18000 - 19000	1	10.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	1	10.0	0	0.0
21000 - 22000	2	20.0	0	0.0
22000 - 23000	1	10.0	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	0	0.0
TOTAL	10		18	

SECTION 006 ON BR-040
Direction SC - Brasília/Luziânia
Direction CS - Luziânia/Brasília

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	45	11.7	68	14.2
2000 - 3000	199	51.8	210	43.8
3000 - 4000	98	25.5	143	29.9
4000 - 5000	39	10.2	52	10.9
5000 - 6000	3	0.8	6	1.3
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	384		479	

TRIPLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 8000 KG	3	11.1	0	0.0
8000 - 9000	4	14.8	0	0.0
9000 - 10000	2	7.4	0	0.0
10000 - 11000	2	7.4	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	1	3.7	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	2	7.4	1	3.4
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	1	3.4
22000 - 23000	1	3.7	1	3.4
23000 - 24000	1	3.7	1	3.4
24000 - 25000	1	3.7	2	6.9
25000 - 26000	0	0.0	1	3.4
26000 - 27000	0	0.0	1	3.4
27000 - 28000	2	7.4	6	20.7
28000 - 29000	2	7.4	0	0.0
29000 - 30000	2	7.4	7	24.1
30000 - 31000	1	3.7	2	6.9
31000 - 32000	2	7.4	2	6.9
32000 - 33000	0	0.0	1	3.4
33000 - 34000	0	0.0	1	3.4
34000 - 35000	1	3.7	1	3.4
> 35000	0	0.0	1	3.4
TOTAL	27		29	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	28	9.8	37	11.1
2000 - 3000	77	26.8	28	8.4
3000 - 4000	53	18.5	22	6.6
4000 - 5000	32	11.1	21	6.3
5000 - 6000	21	7.3	18	5.4
6000 - 7000	16	5.6	25	7.5
7000 - 8000	9	3.1	27	8.1
8000 - 9000	10	3.5	19	5.7
9000 - 10000	13	4.5	18	5.4
10000 - 11000	8	2.8	25	7.5
11000 - 12000	14	4.9	41	12.3
12000 - 13000	4	1.4	36	10.8
13000 - 14000	1	0.3	14	4.2
14000 - 15000	1	0.3	1	0.3
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	287		332	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	2	2.2	2	2.4
4000 - 5000	3	3.2	9	10.8
5000 - 6000	21	22.6	19	22.9
6000 - 7000	17	18.3	3	3.6
7000 - 8000	3	3.2	3	3.6
8000 - 9000	4	4.3	0	0.0
9000 - 10000	2	2.2	2	2.4
10000 - 11000	1	1.1	6	7.2
11000 - 12000	0	0.0	13	15.7
12000 - 13000	3	3.2	2	2.4
13000 - 14000	7	7.5	1	1.2
14000 - 15000	2	2.2	3	3.6
15000 - 16000	7	7.5	1	1.2
16000 - 17000	1	1.1	2	2.4
17000 - 18000	8	8.6	2	2.4
18000 - 19000	7	7.5	8	9.6
19000 - 20000	2	2.2	3	3.6
20000 - 21000	1	1.1	3	3.6
21000 - 22000	1	1.1	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	1	1.1	1	1.2
TOTAL	93		83	

SECTION 007 ON BR-020
Direction SC - Sobradinho/Formosa
Direction CS - Formosa/Sobradinho

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	142	32.9	121	33.2
2000 - 3000	152	35.2	133	36.4
3000 - 4000	105	24.3	77	21.1
4000 - 5000	29	6.7	33	9.0
5000 - 6000	4	0.9	1	0.3
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	432		365	

TRIPLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 8000 KG	0	0.0	0	0.0
8000 - 9000	0	0.0	0	0.0
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
24000 - 25000	0	0.0	0	0.0
25000 - 26000	1	100.0	0	0.0
26000 - 27000	0	0.0	0	0.0
27000 - 28000	0	0.0	0	0.0
28000 - 29000	0	0.0	0	0.0
29000 - 30000	0	0.0	0	0.0
30000 - 31000	0	0.0	1	100.0
31000 - 32000	0	0.0	0	0.0
32000 - 33000	0	0.0	0	0.0
33000 - 34000	0	0.0	0	0.0
34000 - 35000	0	0.0	0	0.0
> 35000	0	0.0	0	0.0
TOTAL	1		1	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	112	31.8	94	31.5
2000 - 3000	31	8.8	59	19.8
3000 - 4000	26	7.4	24	8.1
4000 - 5000	28	8.0	18	6.0
5000 - 6000	59	16.8	25	8.4
6000 - 7000	24	6.8	28	9.4
7000 - 8000	6	1.7	12	4.0
8000 - 9000	9	2.6	13	4.4
9000 - 10000	15	4.3	4	1.3
10000 - 11000	22	6.3	7	2.3
11000 - 12000	9	2.6	9	3.0
12000 - 13000	4	1.1	4	1.3
13000 - 14000	3	0.9	1	0.3
14000 - 15000	4	1.1	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	352		298	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	1	0.8	2	2.0
4000 - 5000	22	16.7	18	18.0
5000 - 6000	59	44.7	26	26.0
6000 - 7000	3	2.3	4	4.0
7000 - 8000	9	6.8	1	1.0
8000 - 9000	6	4.5	2	2.0
9000 - 10000	1	0.8	2	2.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	2	1.5	0	0.0
12000 - 13000	3	2.3	2	2.0
13000 - 14000	1	0.8	5	5.0
14000 - 15000	2	1.5	9	9.0
15000 - 16000	5	3.8	9	9.0
16000 - 17000	8	6.1	8	8.0
17000 - 18000	4	3.0	6	6.0
18000 - 19000	1	0.8	2	2.0
19000 - 20000	0	0.0	1	1.0
20000 - 21000	2	1.5	3	3.0
21000 - 22000	2	1.5	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	1	0.8	0	0.0
TOTAL	132		100	

SECTION 007 ON BR-020
Direction SC - Sobradinho/Formosa
Direction CS - Formosa/Sobradinho

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	17	11.9	12	9.4
2000 - 3000	57	39.9	62	48.4
3000 - 4000	54	37.8	33	25.8
4000 - 5000	14	9.8	20	15.6
5000 - 6000	1	0.7	1	0.8
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	143		128	

TRIPLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 8000 KG	0	0.0	0	0.0
8000 - 9000	0	0.0	0	0.0
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
24000 - 25000	0	0.0	0	0.0
25000 - 26000	1	100.0	0	0.0
26000 - 27000	0	0.0	0	0.0
27000 - 28000	0	0.0	0	0.0
28000 - 29000	0	0.0	0	0.0
29000 - 30000	0	0.0	0	0.0
30000 - 31000	0	0.0	1	100.0
31000 - 32000	0	0.0	0	0.0
32000 - 33000	0	0.0	0	0.0
33000 - 34000	0	0.0	0	0.0
34000 - 35000	0	0.0	0	0.0
> 35000	0	0.0	0	0.0
TOTAL	1		1	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	4	3.7	2	2.2
2000 - 3000	13	11.9	25	28.1
3000 - 4000	16	14.7	11	12.4
4000 - 5000	7	6.4	9	10.1
5000 - 6000	20	18.3	14	15.7
6000 - 7000	10	9.2	13	14.6
7000 - 8000	5	4.6	8	9.0
8000 - 9000	5	4.6	4	4.5
9000 - 10000	9	8.3	1	1.1
10000 - 11000	11	10.1	0	0.0
11000 - 12000	4	3.7	0	0.0
12000 - 13000	3	2.8	1	1.1
13000 - 14000	0	0.0	1	1.1
14000 - 15000	2	1.8	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	109		89	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	1	1.9
4000 - 5000	9	17.6	11	21.2
5000 - 6000	20	39.2	15	28.8
6000 - 7000	1	2.0	1	1.9
7000 - 8000	4	7.8	0	0.0
8000 - 9000	3	5.9	0	0.0
9000 - 10000	0	0.0	1	1.9
10000 - 11000	0	0.0	0	0.0
11000 - 12000	1	2.0	0	0.0
12000 - 13000	1	2.0	1	1.9
13000 - 14000	0	0.0	2	3.8
14000 - 15000	0	0.0	4	7.7
15000 - 16000	1	2.0	3	5.8
16000 - 17000	3	5.9	4	7.7
17000 - 18000	2	3.9	5	9.6
18000 - 19000	1	2.0	1	1.9
19000 - 20000	0	0.0	1	1.9
20000 - 21000	2	3.9	2	3.8
21000 - 22000	2	3.9	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	1	2.0	0	0.0
TOTAL	51		52	

SECTION 008 ON BR-020
Direction SC - Sobradinho/Formosa
Direction CS - Formosa/Sobradinho

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	17	11.9	12	9.4
2000 - 3000	57	39.9	62	48.4
3000 - 4000	54	37.8	33	25.8
4000 - 5000	14	9.8	20	15.6
5000 - 6000	1	0.7	1	0.8
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	143		128	

TRIPLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 8000 KG	0	0.0	0	0.0
8000 - 9000	0	0.0	0	0.0
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
24000 - 25000	0	0.0	0	0.0
25000 - 26000	1	100.0	0	0.0
26000 - 27000	0	0.0	0	0.0
27000 - 28000	0	0.0	0	0.0
28000 - 29000	0	0.0	0	0.0
29000 - 30000	0	0.0	0	0.0
30000 - 31000	0	0.0	1	100.0
31000 - 32000	0	0.0	0	0.0
32000 - 33000	0	0.0	0	0.0
33000 - 34000	0	0.0	0	0.0
34000 - 35000	0	0.0	0	0.0
> 35000	0	0.0	0	0.0
TOTAL	1		1	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	4	3.7	2	2.2
2000 - 3000	13	11.9	25	28.1
3000 - 4000	16	14.7	11	12.4
4000 - 5000	7	6.4	9	10.1
5000 - 6000	20	18.3	14	15.7
6000 - 7000	10	9.2	13	14.6
7000 - 8000	5	4.6	8	9.0
8000 - 9000	5	4.6	4	4.5
9000 - 10000	9	8.3	1	1.1
10000 - 11000	11	10.1	0	0.0
11000 - 12000	4	3.7	0	0.0
12000 - 13000	3	2.8	1	1.1
13000 - 14000	0	0.0	1	1.1
14000 - 15000	2	1.8	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	109		89	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	1	1.9
4000 - 5000	9	17.6	11	21.2
5000 - 6000	20	39.2	15	28.8
6000 - 7000	1	2.0	1	1.9
7000 - 8000	4	7.8	0	0.0
8000 - 9000	3	5.9	0	0.0
9000 - 10000	0	0.0	1	1.9
10000 - 11000	0	0.0	0	0.0
11000 - 12000	1	2.0	0	0.0
12000 - 13000	1	2.0	1	1.9
13000 - 14000	0	0.0	2	3.8
14000 - 15000	0	0.0	4	7.7
15000 - 16000	1	2.0	3	5.8
16000 - 17000	3	5.9	4	7.7
17000 - 18000	2	3.9	5	9.6
18000 - 19000	1	2.0	1	1.9
19000 - 20000	0	0.0	1	1.9
20000 - 21000	2	3.9	2	3.8
21000 - 22000	2	3.9	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	1	2.0	0	0.0
TOTAL	51		52	

SECTION 008 ON BR-020
Direction SC - Sobradinho/Formosa
Direction CS - Formosa/Sobradinho

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	142	32.9	121	33.2
2000 - 3000	152	35.2	133	36.4
3000 - 4000	105	24.3	77	21.1
4000 - 5000	29	6.7	33	9.0
5000 - 6000	4	0.9	1	0.3
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	432		365	

TRIPLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 8000 KG	0	0.0	0	0.0
8000 - 9000	0	0.0	0	0.0
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
24000 - 25000	0	0.0	0	0.0
25000 - 26000	1	100.0	0	0.0
26000 - 27000	0	0.0	0	0.0
27000 - 28000	0	0.0	0	0.0
28000 - 29000	0	0.0	0	0.0
29000 - 30000	0	0.0	0	0.0
30000 - 31000	0	0.0	1	100.0
31000 - 32000	0	0.0	0	0.0
32000 - 33000	0	0.0	0	0.0
33000 - 34000	0	0.0	0	0.0
34000 - 35000	0	0.0	0	0.0
> 35000	0	0.0	0	0.0
TOTAL	1		1	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	112	31.8	94	31.5
2000 - 3000	31	8.8	59	19.8
3000 - 4000	26	7.4	24	8.1
4000 - 5000	28	8.0	18	6.0
5000 - 6000	59	16.8	25	8.4
6000 - 7000	24	6.8	28	9.4
7000 - 8000	6	1.7	12	4.0
8000 - 9000	9	2.6	13	4.4
9000 - 10000	15	4.3	4	1.3
10000 - 11000	22	6.3	7	2.3
11000 - 12000	9	2.6	9	3.0
12000 - 13000	4	1.1	4	1.3
13000 - 14000	3	0.9	1	0.3
14000 - 15000	4	1.1	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	352		298	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	1	0.8	2	2.0
4000 - 5000	22	16.7	18	18.0
5000 - 6000	59	44.7	26	26.0
6000 - 7000	3	2.3	4	4.0
7000 - 8000	9	6.8	1	1.0
8000 - 9000	6	4.5	2	2.0
9000 - 10000	1	0.8	2	2.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	2	1.5	0	0.0
12000 - 13000	3	2.3	2	2.0
13000 - 14000	1	0.8	5	5.0
14000 - 15000	2	1.5	9	9.0
15000 - 16000	5	3.8	9	9.0
16000 - 17000	8	6.1	8	8.0
17000 - 18000	4	3.0	6	6.0
18000 - 19000	1	0.8	2	2.0
19000 - 20000	0	0.0	1	1.0
20000 - 21000	2	1.5	3	3.0
21000 - 22000	2	1.5	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	1	0.8	0	0.0
TOTAL	132		100	

SECTION 009 ON BR-060
Direction SC - Brasília/Anápolis
Direction CS - Anápolis/Brasília

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	62	16.3	53	11.6
2000 - 3000	251	65.9	170	37.9
3000 - 4000	49	12.9	182	40.6
4000 - 5000	17	4.5	36	8.0
5000 - 6000	2	0.5	7	1.6
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	381		448	

TRIPLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 8000 KG	3	30.0	2	8.7
8000 - 9000	0	0.0	2	8.7
9000 - 10000	0	0.0	1	4.3
10000 - 11000	0	0.0	0	0.0
11000 - 12000	1	10.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	1	10.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	1	10.0	1	4.3
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	2	8.7
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	1	4.3
24000 - 25000	0	0.0	1	4.3
25000 - 26000	0	0.0	2	8.7
26000 - 27000	1	10.0	2	8.7
27000 - 28000	1	10.0	1	4.3
28000 - 29000	0	0.0	4	17.4
29000 - 30000	1	10.0	3	13.0
30000 - 31000	1	10.0	0	0.0
31000 - 32000	0	0.0	0	0.0
32000 - 33000	0	0.0	0	0.0
33000 - 34000	0	0.0	0	0.0
34000 - 35000	0	0.0	1	4.3
> 35000	0	0.0	0	0.0
TOTAL	10		23	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	34	14.2	21	7.1
2000 - 3000	103	43.1	15	5.1
3000 - 4000	35	14.6	13	4.4
4000 - 5000	16	6.7	16	5.4
5000 - 6000	6	2.5	7	2.4
6000 - 7000	11	4.6	9	3.1
7000 - 8000	9	3.8	13	4.4
8000 - 9000	4	1.7	12	4.1
9000 - 10000	8	3.3	35	11.9
10000 - 11000	7	2.9	73	24.8
11000 - 12000	4	1.7	48	16.3
12000 - 13000	2	0.8	27	9.2
13000 - 14000	0	0.0	3	1.0
14000 - 15000	0	0.0	2	0.7
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	239		294	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	12	12.2	1	0.8
4000 - 5000	14	14.3	5	3.9
5000 - 6000	7	7.1	4	3.1
6000 - 7000	9	9.2	10	7.8
7000 - 8000	6	6.1	2	1.6
8000 - 9000	3	3.1	5	3.9
9000 - 10000	4	4.1	2	1.6
10000 - 11000	0	0.0	3	2.3
11000 - 12000	13	13.3	7	5.5
12000 - 13000	1	1.0	0	0.0
13000 - 14000	1	1.0	4	3.1
14000 - 15000	3	3.1	9	7.0
15000 - 16000	5	5.1	19	14.8
16000 - 17000	7	7.1	14	10.9
17000 - 18000	7	7.1	1	0.8
18000 - 19000	6	6.1	17	13.3
19000 - 20000	0	0.0	11	8.6
20000 - 21000	0	0.0	9	7.0
21000 - 22000	0	0.0	2	1.6
22000 - 23000	0	0.0	2	1.6
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	1	0.8
TOTAL	98		128	

SECTION 010 ON DF-08
Direction SC - Taguatinga/Brazlândia
Direction CS - Brazlândia/Taguatinga

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	181	66.5	124	68.1
2000 - 3000	46	16.9	33	18.1
3000 - 4000	21	7.7	17	9.3
4000 - 5000	18	6.6	4	2.2
5000 - 6000	1	0.4	4	2.2
6000 - 7000	5	1.8	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	272		182	

TRIPLE REAR AXLES

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	152	59.6	96	58.5
2000 - 3000	25	9.8	21	12.8
3000 - 4000	17	6.7	12	7.3
4000 - 5000	13	5.1	11	6.7
5000 - 6000	16	6.3	11	6.7
6000 - 7000	9	3.5	3	1.8
7000 - 8000	7	2.7	3	1.8
8000 - 9000	6	2.4	3	1.8
9000 - 10000	2	0.8	3	1.8
10000 - 11000	5	2.0	1	0.6
11000 - 12000	2	0.8	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	1	0.4	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	255		164	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	1	3.3
4000 - 5000	14	35.9	12	40.0
5000 - 6000	1	2.6	4	13.3
6000 - 7000	1	2.6	4	13.3
7000 - 8000	8	20.5	3	10.0
8000 - 9000	0	0.0	1	3.3
9000 - 10000	0	0.0	0	0.0
10000 - 11000	6	15.4	0	0.0
11000 - 12000	0	0.0	1	3.3
12000 - 13000	3	7.7	0	0.0
13000 - 14000	1	2.6	0	0.0
14000 - 15000	3	7.7	0	0.0
15000 - 16000	1	2.6	1	3.3
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	3	10.0
18000 - 19000	1	2.6	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	0	0.0
TOTAL	39		30	

SECTION 011 ON BR-070

Direction SC - Taguatinga/B. Descoberto

Direction CS - B. Descoberto/Taguatinga

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	177	45.2	105	38.3
2000 - 3000	181	46.2	76	27.7
3000 - 4000	26	6.6	87	31.8
4000 - 5000	8	2.0	6	2.2
5000 - 6000	0	0.0	0	0.0
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	392		274	

TRIPLE REAR AXLES

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	134	35.0	67	24.7
2000 - 3000	164	42.8	16	5.9
3000 - 4000	45	11.7	9	3.3
4000 - 5000	11	2.9	14	5.2
5000 - 6000	12	3.1	10	3.7
6000 - 7000	7	1.8	1	0.4
7000 - 8000	4	1.0	3	1.1
8000 - 9000	1	0.3	29	10.7
9000 - 10000	3	0.8	38	14.0
10000 - 11000	1	0.3	44	16.2
11000 - 12000	1	0.3	33	12.2
12000 - 13000	0	0.0	6	2.2
13000 - 14000	0	0.0	1	0.4
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	383		271	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	1	5.3	0	0.0
4000 - 5000	3	15.8	0	0.0
5000 - 6000	13	68.4	1	33.3
6000 - 7000	1	5.3	0	0.0
7000 - 8000	0	0.0	1	33.3
8000 - 9000	0	0.0	0	0.0
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	1	5.3	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	1	33.3
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	0	0.0
TOTAL	19		3	

SECTION 201 ON DF-21
Direction SC - DF-10/BR-020
Direction CS - BR-020/DF-10

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	8	88.9	12	100.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	1	11.1	0	0.0
4000 - 5000	0	0.0	0	0.0
5000 - 6000	0	0.0	0	0.0
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	9		12	

TRIPLE REAR AXLES

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	7	77.8	8	66.7
2000 - 3000	0	0.0	1	8.3
3000 - 4000	1	11.1	0	0.0
4000 - 5000	0	0.0	1	8.3
5000 - 6000	0	0.0	0	0.0
6000 - 7000	0	0.0	0	0.0
7000 - 8000	1	11.1	0	0.0
8000 - 9000	0	0.0	1	8.3
9000 - 10000	0	0.0	1	8.3
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	9		12	

TANDEM REAR AXLES

SECTION 202 ON DF-21
Direction SC - Unaí/BR-020
Direction CS - BR-020/Unaí

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	12	66.7	19	86.4
2000 - 3000	3	16.7	1	4.5
3000 - 4000	3	16.7	2	9.1
4000 - 5000	0	0.0	0	0.0
5000 - 6000	0	0.0	0	0.0
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	18		22	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	11	61.1	13	61.9
2000 - 3000	1	5.6	4	19.0
3000 - 4000	1	5.6	0	0.0
4000 - 5000	3	16.7	2	9.5
5000 - 6000	0	0.0	0	0.0
6000 - 7000	0	0.0	0	0.0
7000 - 8000	1	5.6	0	0.0
8000 - 9000	1	5.6	1	4.8
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	1	4.8
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	18		21	

TRIPLE REAR AXLES

TANDEM REAR AXLES

SECTION 203 ON DF-12
Direction SC - EPCT/Papuda
Direction CS - Papuda/EPCT

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	5	12.2	11	20.0
2000 - 3000	36	87.8	29	52.7
3000 - 4000	0	0.0	15	27.3
4000 - 5000	0	0.0	0	0.0
5000 - 6000	0	0.0	0	0.0
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	41		55	

TRIPLE REAR AXLES

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	36	92.3	2	3.6
3000 - 4000	2	5.1	2	3.6
4000 - 5000	0	0.0	4	7.3
5000 - 6000	0	0.0	1	1.8
6000 - 7000	0	0.0	2	3.6
7000 - 8000	0	0.0	0	0.0
8000 - 9000	1	2.6	3	5.5
9000 - 10000	0	0.0	9	16.4
10000 - 11000	0	0.0	13	23.6
11000 - 12000	0	0.0	10	18.2
12000 - 13000	0	0.0	5	9.1
13000 - 14000	0	0.0	4	7.3
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	39		55	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	0	0.0
4000 - 5000	2	100.0	0	0.0
5000 - 6000	0	0.0	0	0.0
6000 - 7000	0	0.0	0	0.0
7000 - 8000	0	0.0	0	0.0
8000 - 9000	0	0.0	0	0.0
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	0	0.0
TOTAL	2		0	

SECTION 204 ON DF-17
Direction SC - Border DF-GO/BR-020
Direction CS - BR-020/Border DF-GO

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	2	7.1	1	3.4
2000 - 3000	17	60.7	10	34.5
3000 - 4000	4	14.3	14	48.3
4000 - 5000	5	17.9	4	13.8
5000 - 6000	0	0.0	0	0.0
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	28		29	

TRIPLE REAR AXLES

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	6	28.6	1	6.7
3000 - 4000	6	28.6	0	0.0
4000 - 5000	1	4.8	0	0.0
5000 - 6000	2	9.5	1	6.7
6000 - 7000	1	4.8	1	6.7
7000 - 8000	0	0.0	0	0.0
8000 - 9000	1	4.8	4	26.7
9000 - 10000	2	9.5	7	46.7
10000 - 11000	1	4.8	1	6.7
11000 - 12000	1	4.8	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	21		15	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	1	6.3
4000 - 5000	0	0.0	4	25.0
5000 - 6000	0	0.0	5	31.3
6000 - 7000	0	0.0	2	12.5
7000 - 8000	0	0.0	0	0.0
8000 - 9000	0	0.0	0	0.0
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	1	14.3	1	6.3
12000 - 13000	0	0.0	1	6.3
13000 - 14000	0	0.0	1	6.3
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	1	6.3
17000 - 18000	1	14.3	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	2	28.6	0	0.0
20000 - 21000	2	28.6	0	0.0
21000 - 22000	1	14.3	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	0	0.0
TOTAL	7		16	

SECTION 021 ON BR-050
Direction SC - Cristalina/Campo Alegre
Direction CS - Campo Alegre/Cristalina

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	6	9.2	5	5.7
2000 - 3000	32	49.2	31	35.6
3000 - 4000	17	26.2	27	31.0
4000 - 5000	7	10.8	17	19.5
5000 - 6000	3	4.6	7	8.0
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	65		87	

TRIPLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 8000 KG	0	0.0	1	8.3
8000 - 9000	1	50.0	3	25.0
9000 - 10000	1	50.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
24000 - 25000	0	0.0	0	0.0
25000 - 26000	0	0.0	0	0.0
26000 - 27000	0	0.0	0	0.0
27000 - 28000	0	0.0	1	8.3
28000 - 29000	0	0.0	2	16.7
29000 - 30000	0	0.0	1	8.3
30000 - 31000	0	0.0	1	8.3
31000 - 32000	0	0.0	1	8.3
32000 - 33000	0	0.0	0	0.0
33000 - 34000	0	0.0	1	8.3
34000 - 35000	0	0.0	1	8.3
> 35000	0	0.0	0	0.0
TOTAL	2		12	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	1	2.5	1	1.9
2000 - 3000	10	25.0	6	11.5
3000 - 4000	9	22.5	9	17.3
4000 - 5000	1	2.5	6	11.5
5000 - 6000	8	20.0	2	3.8
6000 - 7000	3	7.5	3	5.8
7000 - 8000	3	7.5	0	0.0
8000 - 9000	1	2.5	4	7.7
9000 - 10000	1	2.5	4	7.7
10000 - 11000	2	5.0	9	17.3
11000 - 12000	1	2.5	4	7.7
12000 - 13000	0	0.0	1	1.9
13000 - 14000	0	0.0	3	5.8
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	40		52	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	0	0.0
4000 - 5000	2	8.3	3	8.6
5000 - 6000	2	8.3	2	5.7
6000 - 7000	3	12.5	0	0.0
7000 - 8000	1	4.2	2	5.7
8000 - 9000	1	4.2	1	2.9
9000 - 10000	1	4.2	2	5.7
10000 - 11000	0	0.0	1	2.9
11000 - 12000	1	4.2	1	2.9
12000 - 13000	4	16.7	2	5.7
13000 - 14000	2	8.3	2	5.7
14000 - 15000	1	4.2	4	11.4
15000 - 16000	0	0.0	2	5.7
16000 - 17000	1	4.2	6	17.1
17000 - 18000	1	4.2	5	14.3
18000 - 19000	3	12.5	1	2.9
19000 - 20000	1	4.2	1	2.9
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	0	0.0
TOTAL	24		35	

SECTION 022 ON BR-050
Direction SC - Cristalina/Catalão
Direction CS - Catalão/Cristalina

FRONT AXLES

WEIGHT	Direction SC Nº OF OBS.	Direction SC PERCENT.	Direction CS Nº OF OBS.	Direction CS PERCENT.
< 2000 KG	6	9.2	5	5.7
2000 - 3000	32	49.2	31	35.6
3000 - 4000	17	26.2	27	31.0
4000 - 5000	7	10.8	17	19.5
5000 - 6000	3	4.6	7	8.0
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	65		87	

TRIPLE REAR AXLES

WEIGHT	Direction SC Nº OF OBS.	Direction SC PERCENT.	Direction CS Nº OF OBS.	Direction CS PERCENT.
< 8000 KG	0	0.0	1	8.3
8000 - 9000	1	50.0	3	25.0
9000 - 10000	1	50.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
24000 - 25000	0	0.0	0	0.0
25000 - 26000	0	0.0	0	0.0
26000 - 27000	0	0.0	0	0.0
27000 - 28000	0	0.0	1	8.3
28000 - 29000	0	0.0	2	16.7
29000 - 30000	0	0.0	1	8.3
30000 - 31000	0	0.0	1	8.3
31000 - 32000	0	0.0	1	8.3
32000 - 33000	0	0.0	0	0.0
33000 - 34000	0	0.0	1	8.3
34000 - 35000	0	0.0	1	8.3
> 35000	0	0.0	0	0.0
TOTAL	2		12	

SINGLE REAR AXLES

WEIGHT	Direction SC Nº OF OBS.	Direction SC PERCENT.	Direction CS Nº OF OBS.	Direction CS PERCENT.
< 2000 KG	1	2.5	1	1.9
2000 - 3000	10	25.0	6	11.5
3000 - 4000	9	22.5	9	17.3
4000 - 5000	1	2.5	6	11.5
5000 - 6000	8	20.0	2	3.8
6000 - 7000	3	7.5	3	5.8
7000 - 8000	3	7.5	0	0.0
8000 - 9000	1	2.5	4	7.7
9000 - 10000	1	2.5	4	7.7
10000 - 11000	2	5.0	9	17.3
11000 - 12000	1	2.5	4	7.7
12000 - 13000	0	0.0	1	1.9
13000 - 14000	0	0.0	3	5.8
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	40		52	

TANDEM REAR AXLES

WEIGHT	Direction SC Nº OF OBS.	Direction SC PERCENT.	Direction CS Nº OF OBS.	Direction CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	0	0.0
4000 - 5000	2	8.3	3	8.6
5000 - 6000	2	8.3	2	5.7
6000 - 7000	3	12.5	0	0.0
7000 - 8000	1	4.2	2	5.7
8000 - 9000	1	4.2	1	2.9
9000 - 10000	1	4.2	2	5.7
10000 - 11000	0	0.0	1	2.9
11000 - 12000	1	4.2	1	2.9
12000 - 13000	4	16.7	2	5.7
13000 - 14000	2	8.3	2	5.7
14000 - 15000	1	4.2	4	11.4
15000 - 16000	0	0.0	2	5.7
16000 - 17000	1	4.2	6	17.1
17000 - 18000	1	4.2	5	14.3
18000 - 19000	3	12.5	1	2.9
19000 - 20000	1	4.2	1	2.9
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	0	0.0
TOTAL	24		35	

SECTION 024 ON BR-060
Direction SC - Rio Verde/Goiânia
Direction CS - Goiânia/Rio Verde

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	17	10.8	14	8.2
2000 - 3000	80	51.0	68	40.0
3000 - 4000	32	20.4	61	35.9
4000 - 5000	24	15.3	22	12.9
5000 - 6000	4	2.5	4	2.4
6000 - 7000	0	0.0	1	0.6
> 7000	0	0.0	0	0.0
TOTAL	157		170	

TRIPLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 8000 KG	0	0.0	2	22.2
8000 - 9000	1	8.3	3	33.3
9000 - 10000	1	8.3	1	11.1
10000 - 11000	2	16.7	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
24000 - 25000	1	8.3	0	0.0
25000 - 26000	0	0.0	0	0.0
26000 - 27000	2	16.7	0	0.0
27000 - 28000	0	0.0	0	0.0
28000 - 29000	2	16.7	1	11.1
29000 - 30000	1	8.3	2	22.2
30000 - 31000	1	8.3	0	0.0
31000 - 32000	1	8.3	0	0.0
32000 - 33000	0	0.0	0	0.0
33000 - 34000	0	0.0	0	0.0
34000 - 35000	0	0.0	0	0.0
> 35000	0	0.0	0	0.0
TOTAL	12		9	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	3	2.8	0	0.0
2000 - 3000	23	21.5	9	7.7
3000 - 4000	26	24.3	12	10.3
4000 - 5000	11	10.3	16	13.7
5000 - 6000	1	0.9	5	4.3
6000 - 7000	7	6.5	3	2.6
7000 - 8000	10	9.3	7	6.0
8000 - 9000	3	2.8	8	6.8
9000 - 10000	5	4.7	15	12.8
10000 - 11000	8	7.5	19	16.2
11000 - 12000	7	6.5	9	7.7
12000 - 13000	3	2.8	9	7.7
13000 - 14000	0	0.0	5	4.3
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	107		117	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	1	1.9
4000 - 5000	6	12.0	13	24.1
5000 - 6000	12	24.0	3	5.6
6000 - 7000	6	12.0	3	5.6
7000 - 8000	4	8.0	0	0.0
8000 - 9000	2	4.0	0	0.0
9000 - 10000	0	0.0	0	0.0
10000 - 11000	1	2.0	1	1.9
11000 - 12000	2	4.0	0	0.0
12000 - 13000	3	6.0	3	5.6
13000 - 14000	1	2.0	4	7.4
14000 - 15000	3	6.0	2	3.7
15000 - 16000	5	10.0	0	0.0
16000 - 17000	3	6.0	4	7.4
17000 - 18000	1	2.0	4	7.4
18000 - 19000	1	2.0	7	13.0
19000 - 20000	0	0.0	2	3.7
20000 - 21000	0	0.0	2	3.7
21000 - 22000	0	0.0	4	7.4
22000 - 23000	0	0.0	1	1.9
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	0	0.0
TOTAL	50		54	

SECTION 025 ON GO-070
Direction SC - Inhumas/Goiânia
Direction CS - Goiânia/Inhumas

FRONT AXLES		DIRECTION SC		DIRECTION CS	
	WEIGHT	Nº OF OBS.	PERCENT.	Nº OF OBS.	PERCENT.
	< 2000 KG	38	10.3	49	12.7
	2000 - 3000	152	41.2	175	45.5
	3000 - 4000	131	35.5	105	27.3
	4000 - 5000	44	11.9	52	13.5
	5000 - 6000	4	1.1	4	1.0
	6000 - 7000	0	0.0	0	0.0
	> 7000	0	0.0	0	0.0
	TOTAL	369		385	

TRIPLE REAR AXLES		DIRECTION SC		DIRECTION CS	
	WEIGHT	Nº OF OBS.	PERCENT.	Nº OF OBS.	PERCENT.
	< 6000 KG	0	0.0	1	20.0
	8000 - 9000	1	50.0	0	0.0
	9000 - 10000	0	0.0	0	0.0
	10000 - 11000	0	0.0	0	0.0
	11000 - 12000	0	0.0	0	0.0
	12000 - 13000	0	0.0	0	0.0
	13000 - 14000	0	0.0	0	0.0
	14000 - 15000	0	0.0	0	0.0
	15000 - 16000	0	0.0	0	0.0
	16000 - 17000	0	0.0	0	0.0
	17000 - 18000	0	0.0	0	0.0
	18000 - 19000	0	0.0	0	0.0
	19000 - 20000	0	0.0	0	0.0
	20000 - 21000	0	0.0	1	20.0
	21000 - 22000	0	0.0	0	0.0
	22000 - 23000	0	0.0	1	20.0
	23000 - 24000	1	50.0	0	0.0
	24000 - 25000	0	0.0	0	0.0
	25000 - 26000	0	0.0	0	0.0
	26000 - 27000	0	0.0	0	0.0
	27000 - 28000	0	0.0	0	0.0
	28000 - 29000	0	0.0	0	0.0
	29000 - 30000	0	0.0	0	0.0
	30000 - 31000	0	0.0	1	20.0
	31000 - 32000	0	0.0	0	0.0
	32000 - 33000	0	0.0	0	0.0
	33000 - 34000	0	0.0	1	20.0
	34000 - 35000	0	0.0	0	0.0
	> 35000	0	0.0	0	0.0
	TOTAL	2		5	

SINGLE REAR AXLES		DIRECTION SC		DIRECTION CS	
	WEIGHT	Nº OF OBS.	PERCENT.	Nº OF OBS.	PERCENT.
	< 2000 KG	5	1.7	6	1.9
	2000 - 3000	47	15.9	85	26.3
	3000 - 4000	29	9.8	55	17.0
	4000 - 5000	25	8.5	31	9.6
	5000 - 6000	59	20.0	63	19.5
	6000 - 7000	24	8.1	29	9.0
	7000 - 8000	9	3.1	12	3.7
	8000 - 9000	9	3.1	3	0.9
	9000 - 10000	33	11.2	6	1.9
	10000 - 11000	32	10.8	13	4.0
	11000 - 12000	14	4.7	10	3.1
	12000 - 13000	7	2.4	8	2.5
	13000 - 14000	2	0.7	2	0.6
	14000 - 15000	0	0.0	0	0.0
	15000 - 16000	0	0.0	0	0.0
	> 16000	0	0.0	0	0.0
	TOTAL	295		323	

TANDEM REAR AXLES		DIRECTION SC		DIRECTION CS	
	WEIGHT	Nº OF OBS.	PERCENT.	Nº OF OBS.	PERCENT.
	< 2000 KG	0	0.0	0	0.0
	2000 - 3000	0	0.0	0	0.0
	3000 - 4000	0	0.0	0	0.0
	4000 - 5000	13	9.3	15	16.7
	5000 - 6000	60	42.9	3	3.3
	6000 - 7000	25	17.9	30	33.3
	7000 - 8000	16	11.4	0	0.0
	8000 - 9000	0	0.0	4	4.4
	9000 - 10000	1	0.7	0	0.0
	10000 - 11000	1	0.7	1	1.1
	11000 - 12000	1	0.7	0	0.0
	12000 - 13000	8	5.7	2	2.2
	13000 - 14000	3	2.1	2	2.2
	14000 - 15000	1	0.7	2	2.2
	15000 - 16000	1	0.7	17	18.9
	16000 - 17000	1	0.7	5	5.6
	17000 - 18000	3	2.1	2	2.2
	18000 - 19000	5	3.6	5	5.6
	19000 - 20000	1	0.7	0	0.0
	20000 - 21000	0	0.0	2	2.2
	21000 - 22000	0	0.0	0	0.0
	22000 - 23000	0	0.0	0	0.0
	23000 - 24000	0	0.0	0	0.0
	> 24000	0	0.0	0	0.0
	TOTAL	140		90	

SECTION 026 ON BR-153
Direction SC - Uruaçu/Ceres
Direction CS - Ceres /Uruaçu

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	13	6.0	17	6.1
2000 - 3000	63	29.0	105	37.5
3000 - 4000	90	41.5	119	42.5
4000 - 5000	44	20.3	30	10.7
5000 - 6000	6	2.8	9	3.2
6000 - 7000	1	0.5	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	217		280	

TRIPLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 8000 KG	0	0.0	1	11.1
8000 - 9000	0	0.0	0	0.0
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	1	11.1
18000 - 19000	0	0.0	0	0.0
19000 - 20000	1	12.5	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
24000 - 25000	0	0.0	0	0.0
25000 - 26000	0	0.0	0	0.0
26000 - 27000	1	12.5	0	0.0
27000 - 28000	0	0.0	1	11.1
28000 - 29000	1	12.5	0	0.0
29000 - 30000	0	0.0	0	0.0
30000 - 31000	3	37.5	1	11.1
31000 - 32000	1	12.5	0	0.0
32000 - 33000	0	0.0	2	22.2
33000 - 34000	0	0.0	0	0.0
34000 - 35000	1	12.5	1	11.1
> 35000	0	0.0	2	22.2
TOTAL	8		9	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	7	5.9	9	6.3
3000 - 4000	17	14.3	10	6.9
4000 - 5000	14	11.8	14	9.7
5000 - 6000	10	8.4	9	6.3
6000 - 7000	10	8.4	5	3.5
7000 - 8000	5	4.2	10	6.9
8000 - 9000	12	10.1	10	6.9
9000 - 10000	12	10.1	11	7.6
10000 - 11000	8	6.7	30	20.8
11000 - 12000	15	12.6	22	15.3
12000 - 13000	6	5.0	9	6.3
13000 - 14000	1	0.8	4	2.8
14000 - 15000	2	1.7	0	0.0
15000 - 16000	0	0.0	1	0.7
> 16000	0	0.0	0	0.0
TOTAL	119		144	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	0	0.0
4000 - 5000	4	3.8	7	5.9
5000 - 6000	5	4.8	7	5.9
6000 - 7000	10	9.5	6	5.1
7000 - 8000	2	1.9	3	2.5
8000 - 9000	13	12.4	11	9.3
9000 - 10000	13	12.4	4	3.4
10000 - 11000	5	4.8	4	3.4
11000 - 12000	9	8.6	3	2.5
12000 - 13000	3	2.9	5	4.2
13000 - 14000	3	2.9	5	4.2
14000 - 15000	2	1.9	6	5.1
15000 - 16000	9	8.6	12	10.2
16000 - 17000	16	15.2	23	19.5
17000 - 18000	1	1.0	1	0.8
18000 - 19000	1	1.0	1	0.8
19000 - 20000	1	1.0	16	13.6
20000 - 21000	1	1.0	2	1.7
21000 - 22000	6	5.7	0	0.0
22000 - 23000	1	1.0	2	1.7
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	0	0.0
TOTAL	105		118	

SECTION 029 ON GO-080
Direction SC - BR-153/Goianésia
Direction CS - Goianésia/BR-153

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	11	9.6	7	6.7
2000 - 3000	65	57.0	41	39.4
3000 - 4000	34	29.8	33	31.7
4000 - 5000	4	3.5	21	20.2
5000 - 6000	0	0.0	2	1.9
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	114		104	

TRIPLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 8000 KG	0	0.0	0	0.0
8000 - 9000	3	100.0	0	0.0
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
24000 - 25000	0	0.0	0	0.0
25000 - 26000	0	0.0	0	0.0
26000 - 27000	0	0.0	1	100.0
27000 - 28000	0	0.0	0	0.0
28000 - 29000	0	0.0	0	0.0
29000 - 30000	0	0.0	0	0.0
30000 - 31000	0	0.0	0	0.0
31000 - 32000	0	0.0	0	0.0
32000 - 33000	0	0.0	0	0.0
33000 - 34000	0	0.0	0	0.0
34000 - 35000	0	0.0	0	0.0
> 35000	0	0.0	0	0.0
TOTAL	3		1	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	13	18.6	7	9.2
3000 - 4000	6	8.6	11	14.5
4000 - 5000	11	15.7	9	11.8
5000 - 6000	8	11.4	12	15.8
6000 - 7000	11	15.7	6	7.9
7000 - 8000	2	2.9	1	1.3
8000 - 9000	1	1.4	0	0.0
9000 - 10000	6	8.6	3	3.9
10000 - 11000	5	7.1	16	21.1
11000 - 12000	7	10.0	9	11.8
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	2	2.6
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	70		76	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	4	9.1	0	0.0
4000 - 5000	25	56.8	2	7.1
5000 - 6000	5	11.4	2	7.1
6000 - 7000	1	2.3	2	7.1
7000 - 8000	0	0.0	1	3.6
8000 - 9000	1	2.3	2	7.1
9000 - 10000	0	0.0	1	3.6
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	1	3.6
12000 - 13000	2	4.5	0	0.0
13000 - 14000	2	4.5	1	3.6
14000 - 15000	0	0.0	4	14.3
15000 - 16000	2	4.5	3	10.7
16000 - 17000	1	2.3	3	10.7
17000 - 18000	1	2.3	3	10.7
18000 - 19000	0	0.0	2	7.1
19000 - 20000	0	0.0	1	3.6
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	0	0.0
TOTAL	44		28	

SECTION 030 ON BR-050
Direction SC - Border MG/GO/Catalão
Direction CS - Catalão/Border MG/GO/Catalão

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	11	2.9	7	4.1
2000 - 3000	156	40.5	75	44.4
3000 - 4000	110	28.6	52	30.8
4000 - 5000	92	23.9	31	18.3
5000 - 6000	16	4.2	3	1.8
6000 - 7000	0	0.0	1	0.6
> 7000	0	0.0	0	0.0
TOTAL	385		169	

TRIPLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 8000 KG	0	0.0	2	14.3
8000 - 9000	0	0.0	2	14.3
9000 - 10000	0	0.0	3	21.4
10000 - 11000	2	5.6	2	14.3
11000 - 12000	1	2.8	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	1	2.8	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	1	2.8	0	0.0
21000 - 22000	2	5.6	0	0.0
22000 - 23000	1	2.8	0	0.0
23000 - 24000	0	0.0	1	7.1
24000 - 25000	3	8.3	0	0.0
25000 - 26000	2	5.6	0	0.0
26000 - 27000	3	8.3	2	14.3
27000 - 28000	3	8.3	1	7.1
28000 - 29000	5	13.9	1	7.1
29000 - 30000	3	8.3	0	0.0
30000 - 31000	4	11.1	0	0.0
31000 - 32000	2	5.6	0	0.0
32000 - 33000	2	5.6	0	0.0
33000 - 34000	1	2.8	0	0.0
34000 - 35000	0	0.0	0	0.0
> 35000	0	0.0	0	0.0
TOTAL	36		14	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	1	1.0
2000 - 3000	6	3.0	24	23.8
3000 - 4000	15	7.5	17	16.8
4000 - 5000	18	9.0	20	19.8
5000 - 6000	17	8.5	10	9.9
6000 - 7000	13	6.5	5	5.0
7000 - 8000	15	7.5	6	5.9
8000 - 9000	31	15.6	10	9.9
9000 - 10000	32	16.1	1	1.0
10000 - 11000	24	12.1	4	4.0
11000 - 12000	11	5.5	3	3.0
12000 - 13000	10	5.0	0	0.0
13000 - 14000	5	2.5	0	0.0
14000 - 15000	2	1.0	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	199		101	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	2	3.8
4000 - 5000	6	5.5	3	5.8
5000 - 6000	6	5.5	9	17.3
6000 - 7000	14	12.8	5	9.6
7000 - 8000	3	2.8	7	13.5
8000 - 9000	2	1.8	2	3.8
9000 - 10000	5	4.6	0	0.0
10000 - 11000	9	8.3	2	3.8
11000 - 12000	10	9.2	1	1.9
12000 - 13000	9	8.3	0	0.0
13000 - 14000	6	5.5	0	0.0
14000 - 15000	6	5.5	6	11.5
15000 - 16000	1	0.9	1	1.9
16000 - 17000	1	0.9	5	9.6
17000 - 18000	15	13.8	2	3.8
18000 - 19000	8	7.3	3	5.8
19000 - 20000	4	3.7	3	5.8
20000 - 21000	1	0.9	0	0.0
21000 - 22000	1	0.9	0	0.0
22000 - 23000	2	1.8	1	1.9
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	0	0.0
TOTAL	109		52	

SECTION 031 ON BR-060
Direction SC - Anápolis/Brasília
Direction CS - Brasília/Anápolis

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	3	2.5	7	3.7
2000 - 3000	19	15.6	113	59.5
3000 - 4000	66	54.1	45	23.7
4000 - 5000	26	21.3	20	10.5
5000 - 6000	7	5.7	4	2.1
6000 - 7000	1	0.8	0	0.0
> 7000	0	0.0	1	0.5
TOTAL	122		190	

TRIPLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 8000 KG	0	0.0	1	10.0
8000 - 9000	0	0.0	5	50.0
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	1	10.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
24000 - 25000	0	0.0	0	0.0
25000 - 26000	1	33.3	0	0.0
26000 - 27000	0	0.0	0	0.0
27000 - 28000	0	0.0	0	0.0
28000 - 29000	0	0.0	0	0.0
29000 - 30000	0	0.0	0	0.0
30000 - 31000	0	0.0	0	0.0
31000 - 32000	0	0.0	1	10.0
32000 - 33000	2	66.7	1	10.0
33000 - 34000	0	0.0	0	0.0
34000 - 35000	0	0.0	1	10.0
> 35000	0	0.0	0	0.0
TOTAL	3		10	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	1	1.2	3	2.5
2000 - 3000	1	1.2	30	25.4
3000 - 4000	4	4.7	44	37.3
4000 - 5000	7	8.1	10	8.5
5000 - 6000	2	2.3	4	3.4
6000 - 7000	7	8.1	5	4.2
7000 - 8000	6	7.0	1	0.8
8000 - 9000	4	4.7	7	5.9
9000 - 10000	4	4.7	1	0.8
10000 - 11000	5	5.8	0	0.0
11000 - 12000	16	18.6	7	5.9
12000 - 13000	21	24.4	2	1.7
13000 - 14000	6	7.0	3	2.5
14000 - 15000	2	2.3	1	0.8
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	86		118	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	1	2.3
4000 - 5000	1	2.9	8	18.6
5000 - 6000	0	0.0	11	25.6
6000 - 7000	1	2.9	4	9.3
7000 - 8000	1	2.9	2	4.7
8000 - 9000	0	0.0	0	0.0
9000 - 10000	0	0.0	1	2.3
10000 - 11000	0	0.0	2	4.7
11000 - 12000	0	0.0	2	4.7
12000 - 13000	1	2.9	3	7.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	1	2.9	2	4.7
15000 - 16000	5	14.7	1	2.3
16000 - 17000	3	8.8	1	2.3
17000 - 18000	6	17.6	1	2.3
18000 - 19000	7	20.6	2	4.7
19000 - 20000	1	2.9	2	4.7
20000 - 21000	3	8.8	0	0.0
21000 - 22000	1	2.9	0	0.0
22000 - 23000	2	5.9	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	1	2.9	0	0.0
TOTAL	34		43	

SECTION 032 ON BR-060
Direction SC - Brasília/Anápolis
Direction CS - Anápolis/Brasília

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	3	2.5	7	3.7
2000 - 3000	19	15.6	113	59.5
3000 - 4000	66	54.1	45	23.7
4000 - 5000	26	21.3	20	10.5
5000 - 6000	7	5.7	4	2.1
6000 - 7000	1	0.8	0	0.0
> 7000	0	0.0	1	0.5
TOTAL	122		190	

TRIPLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 8000 KG	0	0.0	1	10.0
8000 - 9000	0	0.0	5	50.0
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	1	10.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
24000 - 25000	0	0.0	0	0.0
25000 - 26000	1	33.3	0	0.0
26000 - 27000	0	0.0	0	0.0
27000 - 28000	0	0.0	0	0.0
28000 - 29000	0	0.0	0	0.0
29000 - 30000	0	0.0	0	0.0
30000 - 31000	0	0.0	0	0.0
31000 - 32000	0	0.0	1	10.0
32000 - 33000	2	66.7	1	10.0
33000 - 34000	0	0.0	0	0.0
34000 - 35000	0	0.0	1	10.0
> 35000	0	0.0	0	0.0
TOTAL	3		10	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	1	1.2	3	2.5
2000 - 3000	1	1.2	30	25.4
3000 - 4000	4	4.7	44	37.3
4000 - 5000	7	8.1	10	8.5
5000 - 6000	2	2.3	4	3.4
6000 - 7000	7	8.1	5	4.2
7000 - 8000	6	7.0	1	0.8
8000 - 9000	4	4.7	7	5.9
9000 - 10000	4	4.7	1	0.8
10000 - 11000	5	5.8	0	0.0
11000 - 12000	16	18.6	7	5.9
12000 - 13000	21	24.4	2	1.7
13000 - 14000	6	7.0	3	2.5
14000 - 15000	2	2.3	1	0.8
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	86		118	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	1	2.3
4000 - 5000	1	2.9	8	18.6
5000 - 6000	0	0.0	11	25.6
6000 - 7000	1	2.9	4	9.3
7000 - 8000	1	2.9	2	4.7
8000 - 9000	0	0.0	0	0.0
9000 - 10000	0	0.0	1	2.3
10000 - 11000	0	0.0	2	4.7
11000 - 12000	0	0.0	2	4.7
12000 - 13000	1	2.9	3	7.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	1	2.9	2	4.7
15000 - 16000	5	14.7	1	2.3
16000 - 17000	3	8.8	1	2.3
17000 - 18000	6	17.6	1	2.3
18000 - 19000	7	20.6	2	4.7
19000 - 20000	1	2.9	2	4.7
20000 - 21000	3	8.8	0	0.0
21000 - 22000	1	2.9	0	0.0
22000 - 23000	2	5.9	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	1	2.9	0	0.0
TOTAL	34		43	

SECTION 033 ON GO-070
Direction SC - Goianira/Inhumas
Direction CS - Inhumas/Goianira

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	38	10.3	49	12.7
2000 - 3000	152	41.2	175	45.5
3000 - 4000	131	35.5	105	27.3
4000 - 5000	44	11.9	52	13.5
5000 - 6000	4	1.1	4	1.0
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	369		385	

TRIPLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 8000 KG	0	0.0	1	20.0
8000 - 9000	1	50.0	0	0.0
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	1	20.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	1	20.0
23000 - 24000	1	50.0	0	0.0
24000 - 25000	0	0.0	0	0.0
25000 - 26000	0	0.0	0	0.0
26000 - 27000	0	0.0	0	0.0
27000 - 28000	0	0.0	0	0.0
28000 - 29000	0	0.0	0	0.0
29000 - 30000	0	0.0	0	0.0
30000 - 31000	0	0.0	1	20.0
31000 - 32000	0	0.0	0	0.0
32000 - 33000	0	0.0	0	0.0
33000 - 34000	0	0.0	1	20.0
34000 - 35000	0	0.0	0	0.0
> 35000	0	0.0	0	0.0
TOTAL	2		5	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	5	1.7	6	1.9
2000 - 3000	47	15.9	85	26.3
3000 - 4000	29	9.8	55	17.0
4000 - 5000	25	8.5	31	9.6
5000 - 6000	59	20.0	63	19.5
6000 - 7000	24	8.1	29	9.0
7000 - 8000	9	3.1	12	3.7
8000 - 9000	9	3.1	3	0.9
9000 - 10000	33	11.2	6	1.9
10000 - 11000	32	10.8	13	4.0
11000 - 12000	14	4.7	10	3.1
12000 - 13000	7	2.4	8	2.5
13000 - 14000	2	0.7	2	0.6
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	295		323	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	0	0.0
4000 - 5000	13	9.3	15	16.7
5000 - 6000	60	42.9	3	3.3
6000 - 7000	25	17.9	30	33.3
7000 - 8000	16	11.4	0	0.0
8000 - 9000	0	0.0	4	4.4
9000 - 10000	1	0.7	0	0.0
10000 - 11000	1	0.7	1	1.1
11000 - 12000	1	0.7	0	0.0
12000 - 13000	8	5.7	2	2.2
13000 - 14000	3	2.1	2	2.2
14000 - 15000	1	0.7	2	2.2
15000 - 16000	1	0.7	17	18.9
16000 - 17000	1	0.7	5	5.6
17000 - 18000	3	2.1	2	2.2
18000 - 19000	5	3.6	5	5.6
19000 - 20000	1	0.7	0	0.0
20000 - 21000	0	0.0	2	2.2
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	0	0.0
TOTAL	140		90	

SECTION 034 ON GO-206
Direction SC - BR-452/C. Dourada
Direction CS - C. Dourada/BR-452

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	13	13.5	16	17.6
2000 - 3000	50	52.1	42	46.2
3000 - 4000	11	11.5	20	22.0
4000 - 5000	21	21.9	13	14.3
5000 - 6000	1	1.0	0	0.0
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	96		91	

TRIPLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 8000 KG	0	0.0	0	0.0
8000 - 9000	0	0.0	0	0.0
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
24000 - 25000	1	100.0	0	0.0
25000 - 26000	0	0.0	0	0.0
26000 - 27000	0	0.0	0	0.0
27000 - 28000	0	0.0	0	0.0
28000 - 29000	0	0.0	0	0.0
29000 - 30000	0	0.0	0	0.0
30000 - 31000	0	0.0	0	0.0
31000 - 32000	0	0.0	0	0.0
32000 - 33000	0	0.0	0	0.0
33000 - 34000	0	0.0	0	0.0
34000 - 35000	0	0.0	0	0.0
> 35000	0	0.0	0	0.0
TOTAL	1		0	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	4	5.9
2000 - 3000	22	29.3	10	14.7
3000 - 4000	6	8.0	7	10.3
4000 - 5000	3	4.0	9	13.2
5000 - 6000	18	24.0	9	13.2
6000 - 7000	7	9.3	16	23.5
7000 - 8000	4	5.3	2	2.9
8000 - 9000	2	2.7	1	1.5
9000 - 10000	4	5.3	2	2.9
10000 - 11000	2	2.7	8	11.8
11000 - 12000	5	6.7	0	0.0
12000 - 13000	1	1.3	0	0.0
13000 - 14000	1	1.3	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	75		68	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	3	13.0
4000 - 5000	7	33.3	9	39.1
5000 - 6000	2	9.5	2	8.7
6000 - 7000	1	4.8	0	0.0
7000 - 8000	0	0.0	0	0.0
8000 - 9000	1	4.8	0	0.0
9000 - 10000	1	4.8	0	0.0
10000 - 11000	1	4.8	2	8.7
11000 - 12000	1	4.8	2	8.7
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	2	8.7
14000 - 15000	0	0.0	1	4.3
15000 - 16000	4	19.0	0	0.0
16000 - 17000	1	4.8	1	4.3
17000 - 18000	1	4.8	0	0.0
18000 - 19000	0	0.0	1	4.3
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	1	4.8	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	0	0.0
TOTAL	21		23	

SECTION 035 ON GO-206
Direction SC - BR-452/C. Dourado
Direction CS - C. Dourada/BR-452

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	13	13.5	16	17.6
2000 - 3000	50	52.1	42	46.2
3000 - 4000	11	11.5	20	22.0
4000 - 5000	21	21.9	13	14.3
5000 - 6000	1	1.0	0	0.0
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	96		91	

TRIPLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 8000 KG	0	0.0	0	0.0
8000 - 9000	0	0.0	0	0.0
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
24000 - 25000	1	100.0	0	0.0
25000 - 26000	0	0.0	0	0.0
26000 - 27000	0	0.0	0	0.0
27000 - 28000	0	0.0	0	0.0
28000 - 29000	0	0.0	0	0.0
29000 - 30000	0	0.0	0	0.0
30000 - 31000	0	0.0	0	0.0
31000 - 32000	0	0.0	0	0.0
32000 - 33000	0	0.0	0	0.0
33000 - 34000	0	0.0	0	0.0
34000 - 35000	0	0.0	0	0.0
> 35000	0	0.0	0	0.0
TOTAL	1		0	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	4	5.9
2000 - 3000	22	29.3	10	14.7
3000 - 4000	6	8.0	7	10.3
4000 - 5000	3	4.0	9	13.2
5000 - 6000	18	24.0	9	13.2
6000 - 7000	7	9.3	16	23.5
7000 - 8000	4	5.3	2	2.9
8000 - 9000	2	2.7	1	1.5
9000 - 10000	4	5.3	2	2.9
10000 - 11000	2	2.7	8	11.8
11000 - 12000	5	6.7	0	0.0
12000 - 13000	1	1.3	0	0.0
13000 - 14000	1	1.3	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	75		68	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	3	13.0
4000 - 5000	7	33.3	9	39.1
5000 - 6000	2	9.5	2	8.7
6000 - 7000	1	4.8	0	0.0
7000 - 8000	0	0.0	0	0.0
8000 - 9000	1	4.8	0	0.0
9000 - 10000	1	4.8	0	0.0
10000 - 11000	1	4.8	2	8.7
11000 - 12000	1	4.8	2	8.7
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	2	8.7
14000 - 15000	0	0.0	1	4.3
15000 - 16000	4	19.0	0	0.0
16000 - 17000	1	4.8	1	4.3
17000 - 18000	1	4.8	0	0.0
18000 - 19000	0	0.0	1	4.3
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	1	4.8	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	0	0.0
TOTAL	21		23	

SECTION 251 ON BR-414
Direction SC - Anápolis/Corumbá
Direction CS - Corumbá/Anápolis

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	22	21.6	16	22.5
2000 - 3000	38	37.3	26	36.6
3000 - 4000	26	25.5	19	26.8
4000 - 5000	14	13.7	9	12.7
5000 - 6000	2	2.0	1	1.4
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	102		71	

TRIPLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 8000 KG	0	0.0	0	0.0
8000 - 9000	0	0.0	0	0.0
9000 - 10000	1	25.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
24000 - 25000	0	0.0	0	0.0
25000 - 26000	0	0.0	0	0.0
26000 - 27000	1	25.0	0	0.0
27000 - 28000	0	0.0	0	0.0
28000 - 29000	0	0.0	0	0.0
29000 - 30000	1	25.0	0	0.0
30000 - 31000	0	0.0	0	0.0
31000 - 32000	0	0.0	0	0.0
32000 - 33000	0	0.0	0	0.0
33000 - 34000	0	0.0	3	100.0
34000 - 35000	0	0.0	0	0.0
> 35000	1	25.0	0	0.0
TOTAL	4		3	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	13	18.1	5	10.0
2000 - 3000	24	33.3	4	8.0
3000 - 4000	8	11.1	14	28.0
4000 - 5000	2	2.8	4	8.0
5000 - 6000	3	4.2	3	6.0
6000 - 7000	7	9.7	3	6.0
7000 - 8000	2	2.8	1	2.0
8000 - 9000	1	1.4	0	0.0
9000 - 10000	2	2.8	1	2.0
10000 - 11000	0	0.0	3	6.0
11000 - 12000	4	5.6	5	10.0
12000 - 13000	4	5.6	6	12.0
13000 - 14000	2	2.8	1	2.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	72		50	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	0	0.0
4000 - 5000	8	25.8	0	0.0
5000 - 6000	5	16.1	3	14.3
6000 - 7000	0	0.0	1	4.8
7000 - 8000	0	0.0	1	4.8
8000 - 9000	0	0.0	0	0.0
9000 - 10000	0	0.0	1	4.8
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	1	3.2	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	2	6.5	0	0.0
17000 - 18000	5	16.1	0	0.0
18000 - 19000	7	22.6	3	14.3
19000 - 20000	3	9.7	4	19.0
20000 - 21000	0	0.0	2	9.5
21000 - 22000	0	0.0	4	19.0
22000 - 23000	0	0.0	2	9.5
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	0	0.0
TOTAL	31		21	

SECTION 252 ON BR-414
Direction SC - Anápolis/Corumbá
Direction CS - Corumbá/Anápolis

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	22	21.6	16	22.5
2000 - 3000	38	37.3	26	36.6
3000 - 4000	26	25.5	19	26.8
4000 - 5000	14	13.7	9	12.7
5000 - 6000	2	2.0	1	1.4
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	102		71	

TRIPLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 8000 KG	0	0.0	0	0.0
8000 - 9000	0	0.0	0	0.0
9000 - 10000	1	25.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
24000 - 25000	0	0.0	0	0.0
25000 - 26000	0	0.0	0	0.0
26000 - 27000	1	25.0	0	0.0
27000 - 28000	0	0.0	0	0.0
28000 - 29000	0	0.0	0	0.0
29000 - 30000	1	25.0	0	0.0
30000 - 31000	0	0.0	0	0.0
31000 - 32000	0	0.0	0	0.0
32000 - 33000	0	0.0	0	0.0
33000 - 34000	0	0.0	3	100.0
34000 - 35000	0	0.0	0	0.0
> 35000	1	25.0	0	0.0
TOTAL	4		3	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	13	18.1	5	10.0
2000 - 3000	24	33.3	4	8.0
3000 - 4000	8	11.1	14	28.0
4000 - 5000	2	2.8	4	8.0
5000 - 6000	3	4.2	3	6.0
6000 - 7000	7	9.7	3	6.0
7000 - 8000	2	2.8	1	2.0
8000 - 9000	1	1.4	0	0.0
9000 - 10000	2	2.8	1	2.0
10000 - 11000	0	0.0	3	6.0
11000 - 12000	4	5.6	5	10.0
12000 - 13000	4	5.6	6	12.0
13000 - 14000	2	2.8	1	2.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	72		50	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	0	0.0
4000 - 5000	8	25.8	0	0.0
5000 - 6000	5	16.1	3	14.3
6000 - 7000	0	0.0	1	4.8
7000 - 8000	0	0.0	1	4.8
8000 - 9000	0	0.0	0	0.0
9000 - 10000	0	0.0	1	4.8
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	1	3.2	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	2	6.5	0	0.0
17000 - 18000	5	16.1	0	0.0
18000 - 19000	7	22.6	3	14.3
19000 - 20000	3	9.7	4	19.0
20000 - 21000	0	0.0	2	9.5
21000 - 22000	0	0.0	4	19.0
22000 - 23000	0	0.0	2	9.5
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	0	0.0
TOTAL	31		21	

SECTION 101 ON MG-188
Direction SC - Paracatu/Unaí
Direction CS - Unaí/Paracatu

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	13	13.8	11	10.3
2000 - 3000	65	69.1	62	57.9
3000 - 4000	7	7.4	24	22.4
4000 - 5000	9	9.6	10	9.3
5000 - 6000	0	0.0	0	0.0
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	94		107	

TRIPLE REAR AXLES

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	2	2.7	1	1.3
2000 - 3000	42	57.5	5	6.3
3000 - 4000	8	11.0	4	5.1
4000 - 5000	3	4.1	8	10.1
5000 - 6000	8	11.0	12	15.2
6000 - 7000	3	4.1	3	3.8
7000 - 8000	3	4.1	2	2.5
8000 - 9000	0	0.0	8	10.1
9000 - 10000	1	1.4	23	29.1
10000 - 11000	2	2.7	10	12.7
11000 - 12000	1	1.4	2	2.5
12000 - 13000	0	0.0	1	1.3
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	73		79	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	2	9.5	0	0.0
4000 - 5000	7	33.3	5	17.9
5000 - 6000	1	4.8	0	0.0
6000 - 7000	4	19.0	3	10.7
7000 - 8000	1	4.8	0	0.0
8000 - 9000	3	14.3	0	0.0
9000 - 10000	1	4.8	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	3	10.7
13000 - 14000	0	0.0	1	3.6
14000 - 15000	0	0.0	3	10.7
15000 - 16000	2	9.5	7	25.0
16000 - 17000	0	0.0	2	7.1
17000 - 18000	0	0.0	3	10.7
18000 - 19000	0	0.0	1	3.6
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	0	0.0
TOTAL	21		28	

SECTION 104 ON BR-050
Direction SC - Araguari/Border MG/GO
Direction CS - Border MG/GO/Araguari

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	11	2.9	7	4.1
2000 - 3000	156	40.5	75	44.4
3000 - 4000	110	28.6	52	30.8
4000 - 5000	92	23.9	31	18.3
5000 - 6000	16	4.2	3	1.8
6000 - 7000	0	0.0	1	0.6
> 7000	0	0.0	0	0.0
TOTAL	385		169	

TRIPLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 8000 KG	0	0.0	2	14.3
8000 - 9000	0	0.0	2	14.3
9000 - 10000	0	0.0	3	21.4
10000 - 11000	2	5.6	2	14.3
11000 - 12000	1	2.8	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	1	2.8	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	1	2.8	0	0.0
21000 - 22000	2	5.6	0	0.0
22000 - 23000	1	2.8	0	0.0
23000 - 24000	0	0.0	1	7.1
24000 - 25000	3	8.3	0	0.0
25000 - 26000	2	5.6	0	0.0
26000 - 27000	3	8.3	2	14.3
27000 - 28000	3	8.3	1	7.1
28000 - 29000	5	13.9	1	7.1
29000 - 30000	3	8.3	0	0.0
30000 - 31000	4	11.1	0	0.0
31000 - 32000	2	5.6	0	0.0
32000 - 33000	2	5.6	0	0.0
33000 - 34000	1	2.8	0	0.0
34000 - 35000	0	0.0	0	0.0
> 35000	0	0.0	0	0.0
TOTAL	36		14	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	1	1.0
2000 - 3000	6	3.0	24	23.8
3000 - 4000	15	7.5	17	16.8
4000 - 5000	18	9.0	20	19.8
5000 - 6000	17	8.5	10	9.9
6000 - 7000	13	6.5	5	5.0
7000 - 8000	15	7.5	6	5.9
8000 - 9000	31	15.6	10	9.9
9000 - 10000	32	16.1	1	1.0
10000 - 11000	24	12.1	4	4.0
11000 - 12000	11	5.5	3	3.0
12000 - 13000	10	5.0	0	0.0
13000 - 14000	5	2.5	0	0.0
14000 - 15000	2	1.0	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	199		101	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	2	3.8
4000 - 5000	6	5.5	3	5.8
5000 - 6000	6	5.5	9	17.3
6000 - 7000	14	12.8	5	9.6
7000 - 8000	3	2.8	7	13.5
8000 - 9000	2	1.8	2	3.8
9000 - 10000	5	4.6	0	0.0
10000 - 11000	9	8.3	2	3.8
11000 - 12000	10	9.2	1	1.9
12000 - 13000	9	8.3	0	0.0
13000 - 14000	6	5.5	0	0.0
14000 - 15000	6	5.5	6	11.5
15000 - 16000	1	0.9	1	1.9
16000 - 17000	1	0.9	5	9.6
17000 - 18000	15	13.8	2	3.8
18000 - 19000	8	7.3	3	5.8
19000 - 20000	4	3.7	3	5.8
20000 - 21000	1	0.9	0	0.0
21000 - 22000	1	0.9	0	0.0
22000 - 23000	2	1.8	1	1.9
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	0	0.0
TOTAL	109		52	

SECTION 105 ON BR-365
Direction SC - Uberlândia/Patrocínio
Direction CS - Patrocínio/Uberlândia

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	18	6.5	19	6.7
2000 - 3000	170	61.6	173	61.3
3000 - 4000	68	24.6	66	23.4
4000 - 5000	17	6.2	23	8.2
5000 - 6000	3	1.1	1	0.4
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	276		282	

TRIPLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 8000 KG	0	0.0	0	0.0
8000 - 9000	0	0.0	1	100.0
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
24000 - 25000	0	0.0	0	0.0
25000 - 26000	0	0.0	0	0.0
26000 - 27000	2	66.7	0	0.0
27000 - 28000	1	33.3	0	0.0
28000 - 29000	0	0.0	0	0.0
29000 - 30000	0	0.0	0	0.0
30000 - 31000	0	0.0	0	0.0
31000 - 32000	0	0.0	0	0.0
32000 - 33000	0	0.0	0	0.0
33000 - 34000	0	0.0	0	0.0
34000 - 35000	0	0.0	0	0.0
> 35000	0	0.0	0	0.0
TOTAL	3		1	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	1	0.5	5	2.5
2000 - 3000	78	42.2	28	13.8
3000 - 4000	23	12.4	19	9.4
4000 - 5000	10	5.4	11	5.4
5000 - 6000	12	6.5	9	4.4
6000 - 7000	5	2.7	3	1.5
7000 - 8000	9	4.9	10	4.9
8000 - 9000	6	3.2	27	13.3
9000 - 10000	19	10.3	43	21.2
10000 - 11000	15	8.1	30	14.8
11000 - 12000	5	2.7	7	3.4
12000 - 13000	2	1.1	10	4.9
13000 - 14000	0	0.0	1	0.5
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	185		203	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	4	4.4	2	2.6
4000 - 5000	25	27.5	11	14.5
5000 - 6000	13	14.3	7	9.2
6000 - 7000	6	6.6	12	15.8
7000 - 8000	2	2.2	8	10.5
8000 - 9000	0	0.0	2	2.6
9000 - 10000	4	4.4	1	1.3
10000 - 11000	1	1.1	1	1.3
11000 - 12000	0	0.0	1	1.3
12000 - 13000	0	0.0	0	0.0
13000 - 14000	4	4.4	3	3.9
14000 - 15000	8	8.8	4	5.3
15000 - 16000	1	1.1	6	7.9
16000 - 17000	12	13.2	4	5.3
17000 - 18000	10	11.0	8	10.5
18000 - 19000	1	1.1	4	5.3
19000 - 20000	0	0.0	1	1.3
20000 - 21000	0	0.0	1	1.3
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	0	0.0
TOTAL	91		76	

SECTION 106 ON BR-365
Direction SC - Patrocínio/Guimarânia
Direction CS - Guimarânia/Patrocínio

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	17	13.9	13	15.9
2000 - 3000	50	41.0	52	63.4
3000 - 4000	44	36.1	11	13.4
4000 - 5000	8	6.6	5	6.1
5000 - 6000	3	2.5	1	1.2
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	122		82	

TRIPLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 8000 KG	1	25.0	0	0.0
8000 - 9000	0	0.0	1	50.0
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	1	25.0	0	0.0
24000 - 25000	0	0.0	0	0.0
25000 - 26000	2	50.0	0	0.0
26000 - 27000	0	0.0	0	0.0
27000 - 28000	0	0.0	0	0.0
28000 - 29000	0	0.0	0	0.0
29000 - 30000	0	0.0	1	50.0
30000 - 31000	0	0.0	0	0.0
31000 - 32000	0	0.0	0	0.0
32000 - 33000	0	0.0	0	0.0
33000 - 34000	0	0.0	0	0.0
34000 - 35000	0	0.0	0	0.0
> 35000	0	0.0	0	0.0
TOTAL	4		2	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	2	2.0	1	1.8
2000 - 3000	14	14.3	21	36.8
3000 - 4000	7	7.1	11	19.3
4000 - 5000	5	5.1	4	7.0
5000 - 6000	7	7.1	3	5.3
6000 - 7000	15	15.3	4	7.0
7000 - 8000	7	7.1	2	3.5
8000 - 9000	6	6.1	2	3.5
9000 - 10000	4	4.1	1	1.8
10000 - 11000	18	18.4	1	1.8
11000 - 12000	11	11.2	2	3.5
12000 - 13000	2	2.0	4	7.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	1	1.8
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	98		57	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	2	8.0
4000 - 5000	5	15.2	11	44.0
5000 - 6000	8	24.2	6	24.0
6000 - 7000	1	3.0	0	0.0
7000 - 8000	3	9.1	0	0.0
8000 - 9000	1	3.0	0	0.0
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	1	4.0
11000 - 12000	1	3.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	1	3.0	0	0.0
14000 - 15000	1	3.0	0	0.0
15000 - 16000	3	9.1	2	8.0
16000 - 17000	6	18.2	1	4.0
17000 - 18000	2	6.1	1	4.0
18000 - 19000	1	3.0	0	0.0
19000 - 20000	0	0.0	1	4.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	0	0.0
TOTAL	33		25	

SECTION 107 ON MG-428
Direction SC - Araxá/Border MG/SP
Direction CS - Border MG/SP/Araxá

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	7	9.2	8	8.5
2000 - 3000	33	43.4	58	61.7
3000 - 4000	28	36.8	24	25.5
4000 - 5000	7	9.2	4	4.3
5000 - 6000	1	1.3	0	0.0
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	76		94	

TRIPLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 8000 KG	0	0.0	6	54.5
8000 - 9000	0	0.0	4	36.4
9000 - 10000	0	0.0	1	9.1
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	1	33.3	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
24000 - 25000	0	0.0	0	0.0
25000 - 26000	0	0.0	0	0.0
26000 - 27000	0	0.0	0	0.0
27000 - 28000	0	0.0	0	0.0
28000 - 29000	0	0.0	0	0.0
29000 - 30000	1	33.3	0	0.0
30000 - 31000	0	0.0	0	0.0
31000 - 32000	1	33.3	0	0.0
32000 - 33000	0	0.0	0	0.0
33000 - 34000	0	0.0	0	0.0
34000 - 35000	0	0.0	0	0.0
> 35000	0	0.0	0	0.0
TOTAL	3		11	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	1	1.2
2000 - 3000	8	12.7	30	36.6
3000 - 4000	4	6.3	18	22.0
4000 - 5000	3	4.8	13	15.9
5000 - 6000	7	11.1	10	12.2
6000 - 7000	2	3.2	1	1.2
7000 - 8000	2	3.2	0	0.0
8000 - 9000	1	1.6	4	4.9
9000 - 10000	7	11.1	1	1.2
10000 - 11000	4	6.3	2	2.4
11000 - 12000	8	12.7	1	1.2
12000 - 13000	10	15.9	1	1.2
13000 - 14000	6	9.5	0	0.0
14000 - 15000	1	1.6	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	63		82	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	1	5.6
4000 - 5000	2	13.3	6	33.3
5000 - 6000	3	20.0	0	0.0
6000 - 7000	3	20.0	2	11.1
7000 - 8000	1	6.7	1	5.6
8000 - 9000	1	6.7	5	27.8
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	1	6.7	0	0.0
12000 - 13000	0	0.0	1	5.6
13000 - 14000	1	6.7	1	5.6
14000 - 15000	2	13.3	1	5.6
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	1	6.7	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	0	0.0
TOTAL	15		18	

SECTION 109 ON BR-040
Direction SC - Junct. BR-365/BR-040/J. Pinheiro
Direction CS - J. Pinheiro/Junct.BR-365/BR-040

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	10	5.5	11	4.8
2000 - 3000	59	32.6	100	44.1
3000 - 4000	69	38.1	70	30.8
4000 - 5000	38	21.0	39	17.2
5000 - 6000	5	2.8	7	3.1
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	181		227	

TRIPLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 8000 KG	1	5.3	0	0.0
8000 - 9000	3	15.8	0	0.0
9000 - 10000	2	10.5	1	6.7
10000 - 11000	1	5.3	0	0.0
11000 - 12000	3	15.8	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	2	10.5	0	0.0
24000 - 25000	0	0.0	0	0.0
25000 - 26000	1	5.3	1	6.7
26000 - 27000	0	0.0	1	6.7
27000 - 28000	0	0.0	1	6.7
28000 - 29000	2	10.5	1	6.7
29000 - 30000	0	0.0	2	13.3
30000 - 31000	1	5.3	4	26.7
31000 - 32000	1	5.3	1	6.7
32000 - 33000	0	0.0	1	6.7
33000 - 34000	1	5.3	2	13.3
34000 - 35000	1	5.3	0	0.0
> 35000	0	0.0	0	0.0
TOTAL	19		15	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	4	4.0	0	0.0
2000 - 3000	7	7.1	9	8.3
3000 - 4000	14	14.1	8	7.3
4000 - 5000	16	16.2	18	16.5
5000 - 6000	5	5.1	15	13.8
6000 - 7000	6	6.1	12	11.0
7000 - 8000	9	9.1	8	7.3
8000 - 9000	7	7.1	7	6.4
9000 - 10000	6	6.1	7	6.4
10000 - 11000	8	8.1	8	7.3
11000 - 12000	6	6.1	8	7.3
12000 - 13000	8	8.1	3	2.8
13000 - 14000	3	3.0	5	4.6
14000 - 15000	0	0.0	1	0.9
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	99		109	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	0	0.0
4000 - 5000	7	10.1	20	18.5
5000 - 6000	2	2.9	16	14.8
6000 - 7000	7	10.1	0	0.0
7000 - 8000	1	1.4	1	0.9
8000 - 9000	0	0.0	3	2.8
9000 - 10000	3	4.3	6	5.6
10000 - 11000	0	0.0	6	5.6
11000 - 12000	0	0.0	2	1.9
12000 - 13000	6	8.7	1	0.9
13000 - 14000	3	4.3	2	1.9
14000 - 15000	1	1.4	5	4.6
15000 - 16000	1	1.4	13	12.0
16000 - 17000	15	21.7	1	0.9
17000 - 18000	1	1.4	1	0.9
18000 - 19000	5	7.2	18	16.7
19000 - 20000	11	15.9	4	3.7
20000 - 21000	5	7.2	3	2.8
21000 - 22000	1	1.4	4	3.7
22000 - 23000	0	0.0	1	0.9
23000 - 24000	0	0.0	1	0.9
> 24000	0	0.0	0	0.0
TOTAL	69		108	

SECTION 110 ON BR-040
Direction SC - Paracatu/Border MG/GO
Direction CS - Border MG/GO/Paracatu

FRONT AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	5	6.4	4	4.3
2000 - 3000	33	42.3	39	42.4
3000 - 4000	23	29.5	30	32.6
4000 - 5000	13	16.7	17	18.5
5000 - 6000	4	5.1	2	2.2
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	78		92	

TRIPLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 8000 KG	0	0.0	1	7.7
8000 - 9000	0	0.0	2	15.4
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	2	15.4
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	0	0.0	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
24000 - 25000	0	0.0	0	0.0
25000 - 26000	1	33.3	0	0.0
26000 - 27000	0	0.0	0	0.0
27000 - 28000	0	0.0	1	7.7
28000 - 29000	1	33.3	0	0.0
29000 - 30000	0	0.0	2	15.4
30000 - 31000	0	0.0	2	15.4
31000 - 32000	0	0.0	0	0.0
32000 - 33000	0	0.0	2	15.4
33000 - 34000	0	0.0	0	0.0
34000 - 35000	1	33.3	0	0.0
> 35000	0	0.0	1	7.7
TOTAL	3		13	

SINGLE REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	1	3.2	0	0.0
2000 - 3000	5	16.1	3	7.7
3000 - 4000	5	16.1	6	15.4
4000 - 5000	2	6.5	6	15.4
5000 - 6000	1	3.2	6	15.4
6000 - 7000	1	3.2	1	2.6
7000 - 8000	3	9.7	2	5.1
8000 - 9000	2	6.5	1	2.6
9000 - 10000	3	9.7	2	5.1
10000 - 11000	3	9.7	3	7.7
11000 - 12000	4	12.9	4	10.3
12000 - 13000	0	0.0	2	5.1
13000 - 14000	1	3.2	1	2.6
14000 - 15000	0	0.0	2	5.1
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	31		39	

TANDEM REAR AXLES

WEIGHT	DIRECTION SC Nº OF OBS.	DIRECTION SC PERCENT.	DIRECTION CS Nº OF OBS.	DIRECTION CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	0	0.0
4000 - 5000	4	9.3	4	8.7
5000 - 6000	3	7.0	11	23.9
6000 - 7000	1	2.3	0	0.0
7000 - 8000	0	0.0	0	0.0
8000 - 9000	1	2.3	1	2.2
9000 - 10000	1	2.3	1	2.2
10000 - 11000	1	2.3	0	0.0
11000 - 12000	4	9.3	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	1	2.2
14000 - 15000	5	11.6	1	2.2
15000 - 16000	3	7.0	6	13.0
16000 - 17000	2	4.7	3	6.5
17000 - 18000	10	23.3	7	15.2
18000 - 19000	1	2.3	5	10.9
19000 - 20000	1	2.3	3	6.5
20000 - 21000	0	0.0	2	4.3
21000 - 22000	4	9.3	0	0.0
22000 - 23000	2	4.7	0	0.0
23000 - 24000	0	0.0	1	2.2
> 24000	0	0.0	0	0.0
TOTAL	43		46	

SECTION 118 ON MG-154
Direction SC - Capinópolis/C. Dourada
Direction CS - C. Dourada/Capinópolis

FRONT AXLES

WEIGHT	Direction SC Nº OF OBS.	Direction SC PERCENT.	Direction CS Nº OF OBS.	Direction CS PERCENT.
< 2000 KG	12	24.0	8	22.9
2000 - 3000	13	26.0	10	28.6
3000 - 4000	24	48.0	17	48.6
4000 - 5000	0	0.0	0	0.0
5000 - 6000	1	2.0	0	0.0
6000 - 7000	0	0.0	0	0.0
> 7000	0	0.0	0	0.0
TOTAL	50		35	

TRIPLE REAR AXLES

SINGLE REAR AXLES

WEIGHT	Direction SC Nº OF OBS.	Direction SC PERCENT.	Direction CS Nº OF OBS.	Direction CS PERCENT.
< 2000 KG	1	2.3	1	3.0
2000 - 3000	11	25.6	11	33.3
3000 - 4000	3	7.0	0	0.0
4000 - 5000	7	16.3	12	36.4
5000 - 6000	18	41.9	9	27.3
6000 - 7000	0	0.0	0	0.0
7000 - 8000	0	0.0	0	0.0
8000 - 9000	0	0.0	0	0.0
9000 - 10000	2	4.7	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	1	2.3	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
> 16000	0	0.0	0	0.0
TOTAL	43		33	

TANDEM REAR AXLES

WEIGHT	Direction SC Nº OF OBS.	Direction SC PERCENT.	Direction CS Nº OF OBS.	Direction CS PERCENT.
< 2000 KG	0	0.0	0	0.0
2000 - 3000	0	0.0	0	0.0
3000 - 4000	0	0.0	0	0.0
4000 - 5000	0	0.0	0	0.0
5000 - 6000	1	12.5	2	100.0
6000 - 7000	0	0.0	0	0.0
7000 - 8000	0	0.0	0	0.0
8000 - 9000	6	75.0	0	0.0
9000 - 10000	0	0.0	0	0.0
10000 - 11000	0	0.0	0	0.0
11000 - 12000	0	0.0	0	0.0
12000 - 13000	0	0.0	0	0.0
13000 - 14000	0	0.0	0	0.0
14000 - 15000	0	0.0	0	0.0
15000 - 16000	0	0.0	0	0.0
16000 - 17000	0	0.0	0	0.0
17000 - 18000	0	0.0	0	0.0
18000 - 19000	0	0.0	0	0.0
19000 - 20000	1	12.5	0	0.0
20000 - 21000	0	0.0	0	0.0
21000 - 22000	0	0.0	0	0.0
22000 - 23000	0	0.0	0	0.0
23000 - 24000	0	0.0	0	0.0
> 24000	0	0.0	0	0.0
TOTAL	8		2	

APPENDIX B

AXLE WEIGHT DISTRIBUTION AT WIM SITES (3 TABLES)

AXLE WEIGHT DISTRIBUTION AT THE WIM SITE FOR DAYTIME DURING PERIOD 07/19/77 TO 08/02/77 AT KM 1 DF. BR-040
Direction - Belo Horizonte/Brasília

FRONT AXLES

WEIGHT	Nº OF OBS.	PERCENT.
< 2000 KG	32	0.11
2000 - 3000	176	0.61
3000 - 4000	68	0.23
4000 - 5000	13	0.04
5000 - 6000	1	0.00
6000 - 7000	0	0.00
> 7000	0	0.00
TOTAL	290	

SINGLE REAR AXLES

WEIGHT	Nº OF OBS.	PERCENT.
< 2000 KG	8	0.04
2000 - 3000	28	0.13
3000 - 4000	12	0.06
4000 - 5000	13	0.06
5000 - 6000	17	0.08
6000 - 7000	21	0.10
7000 - 8000	24	0.11
8000 - 9000	24	0.11
9000 - 10000	28	0.13
10000 - 11000	34	0.16
11000 - 12000	7	0.03
12000 - 13000	1	0.00
13000 - 14000	0	0.00
14000 - 15000	0	0.00
15000 - 16000	0	0.00
> 16000	0	0.00
TOTAL	217	

TRIPLE REAR AXLES

WEIGHT	Nº OF OBS.	PERCENT.
< 8000 KG	0	0.00
8000 - 9000	0	0.00
9000 - 10000	0	0.00
10000 - 11000	0	0.00
11000 - 12000	0	0.00
12000 - 13000	0	0.00
13000 - 14000	0	0.00
14000 - 15000	0	0.00
15000 - 16000	0	0.00
16000 - 17000	0	0.00
17000 - 18000	0	0.00
18000 - 19000	1	0.33
19000 - 20000	0	0.00
20000 - 21000	0	0.00
21000 - 22000	0	0.00
22000 - 23000	1	0.33
23000 - 24000	0	0.00
24000 - 25000	0	0.00
25000 - 26000	1	0.33
26000 - 27000	0	0.00
27000 - 28000	0	0.00
28000 - 29000	0	0.00
29000 - 30000	0	0.00
30000 - 31000	0	0.00
31000 - 32000	0	0.00
32000 - 33000	0	0.00
33000 - 34000	0	0.00
34000 - 35000	0	0.00
> 35000	0	0.00
TOTAL	3	

TANDEM REAR AXLES

WEIGHT	Nº OF OBS.	PERCENT.
< 2000 KG	0	0.00
2000 - 3000	0	0.00
3000 - 4000	0	0.00
4000 - 5000	9	0.13
5000 - 6000	2	0.03
6000 - 7000	2	0.03
7000 - 8000	3	0.04
8000 - 9000	3	0.04
9000 - 10000	1	0.01
10000 - 11000	2	0.03
11000 - 12000	3	0.04
12000 - 13000	2	0.03
13000 - 14000	7	0.10
14000 - 15000	4	0.06
15000 - 16000	9	0.13
16000 - 17000	7	0.10
17000 - 18000	6	0.09
18000 - 19000	4	0.06
19000 - 20000	1	0.01
20000 - 21000	2	0.03
21000 - 22000	2	0.03
22000 - 23000	1	0.01
23000 - 24000	0	0.00
> 24000	0	0.00
TOTAL	70	

AXLE WEIGHT DISTRIBUTION AT THE WIM SITE FOR DAY AND NIGHT DURING PERIOD 08/03/77 TO 08/10/77 AT KM 1 DF. BR-040
Direction - Belo Horizonte/Brasília

FRONT AXLES

WEIGHT	Nº OF OBS.	PERCENT.
< 2000 KG	261	8.4
2000 - 3000	1592	51.5
3000 - 4000	944	30.5
4000 - 5000	275	8.9
5000 - 6000	22	0.7
6000 - 7000	0	0.0
> 7000	0	0.0
TOTAL	3094	

TRIPLE REAR AXLES

WEIGHT	Nº OF OBS.	PERCENT.
< 8000 KG	3	3.9
8000 - 9000	0	0.0
9000 - 10000	0	0.0
10000 - 11000	0	0.0
11000 - 12000	0	0.0
12000 - 13000	0	0.0
13000 - 14000	3	3.9
14000 - 15000	1	1.3
15000 - 16000	0	0.0
16000 - 17000	5	6.6
17000 - 18000	2	2.6
18000 - 19000	1	1.3
19000 - 20000	3	3.9
20000 - 21000	1	1.3
21000 - 22000	6	7.9
22000 - 23000	6	7.9
23000 - 24000	9	11.8
24000 - 25000	7	9.2
25000 - 26000	7	9.2
26000 - 27000	4	5.3
27000 - 28000	4	5.3
28000 - 29000	6	7.9
29000 - 30000	4	5.3
30000 - 31000	4	5.3
31000 - 32000	0	0.0
32000 - 33000	0	0.0
33000 - 34000	0	0.0
34000 - 35000	0	0.0
> 35000	0	0.0
TOTAL	76	

SINGLE REAR AXLES

WEIGHT	Nº OF OBS.	PERCENT.
< 2000 KG	48	2.1
2000 - 3000	227	10.0
3000 - 4000	152	6.7
4000 - 5000	130	6.1
5000 - 6000	214	9.4
6000 - 7000	252	11.1
7000 - 8000	260	11.4
8000 - 9000	205	9.0
9000 - 10000	346	15.2
10000 - 11000	266	11.7
11000 - 12000	129	5.7
12000 - 13000	31	1.4
13000 - 14000	6	0.3
14000 - 15000	0	0.0
15000 - 16000	0	0.0
> 16000	0	0.0
TOTAL	2275	

TANDEM REAR AXLES

WEIGHT	Nº OF OBS.	PERCENT.
< 2000 KG	0	0.0
2000 - 3000	0	0.0
3000 - 4000	5	0.6
4000 - 5000	41	4.6
5000 - 6000	30	3.3
6000 - 7000	39	4.3
7000 - 8000	25	2.8
8000 - 9000	18	2.0
9000 - 10000	21	2.3
10000 - 11000	31	3.4
11000 - 12000	44	4.9
12000 - 13000	38	4.2
13000 - 14000	41	4.6
14000 - 15000	53	5.9
15000 - 16000	91	10.1
16000 - 17000	129	14.3
17000 - 18000	106	11.8
18000 - 19000	83	9.2
19000 - 20000	50	5.6
20000 - 21000	29	3.2
21000 - 22000	18	2.0
22000 - 23000	5	0.6
23000 - 24000	3	0.3
> 24000	0	0.0
TOTAL	900	

AXLE WEIGHT DISTRIBUTION AT THE WIM SITE FOR DAY AND NIGHT DURING PERIOD 08/17/77 TO 08/24/77
AT DNER RESIDENCE IN ANÁPOLIS
Direction - Anápolis/Brasília

FRONT AXLES

WEIGHT	Nº OF OBS.	PERCENT.
< 2000 KG	272	11.4
2000 - 3000	762	31.9
3000 - 4000	784	32.9
4000 - 5000	469	19.7
5000 - 6000	95	4.0
6000 - 7000	2	0.1
> 7000	1	0.0
TOTAL	2395	

TRIPLE REAR AXLES

WEIGHT	Nº OF OBS.	PERCENT.
< 8000 KG	25	21.6
8000 - 9000	1	0.9
9000 - 10000	1	0.9
10000 - 11000	1	0.9
11000 - 12000	0	0.0
12000 - 13000	1	0.9
13000 - 14000	1	0.9
14000 - 15000	0	0.0
15000 - 16000	1	0.9
16000 - 17000	1	0.9
17000 - 18000	3	2.6
18000 - 19000	7	6.0
19000 - 20000	8	6.9
20000 - 21000	4	3.4
21000 - 22000	1	0.9
22000 - 23000	0	0.0
23000 - 24000	2	1.7
24000 - 25000	2	1.7
25000 - 26000	5	4.3
26000 - 27000	4	3.4
27000 - 28000	10	8.6
28000 - 29000	8	6.9
29000 - 30000	4	3.4
30000 - 31000	7	6.0
31000 - 32000	4	3.4
32000 - 33000	5	4.3
33000 - 34000	5	4.3
34000 - 35000	3	2.6
> 35000	2	1.7
TOTAL	116	

SINGLE REAR AXLES

WEIGHT	Nº OF OBS.	PERCENT.
< 2000 KG	77	5.2
2000 - 3000	181	12.1
3000 - 4000	187	12.5
4000 - 5000	111	7.4
5000 - 6000	113	7.6
6000 - 7000	127	8.5
7000 - 8000	128	8.6
8000 - 9000	173	11.6
9000 - 10000	95	6.4
10000 - 11000	65	4.3
11000 - 12000	93	6.2
12000 - 13000	82	5.5
13000 - 14000	53	3.5
14000 - 15000	10	0.7
15000 - 16000	0	0.0
> 16000	0	0.0
TOTAL	1495	

TANDEM REAR AXLES

WEIGHT	Nº OF OBS.	PERCENT.
< 2000 KG	0	0.0
2000 - 3000	1	0.1
3000 - 4000	27	2.8
4000 - 5000	73	7.7
5000 - 6000	24	2.5
6000 - 7000	21	2.2
7000 - 8000	28	3.0
8000 - 9000	18	1.9
9000 - 10000	13	1.4
10000 - 11000	16	1.7
11000 - 12000	19	2.0
12000 - 13000	31	3.3
13000 - 14000	32	3.4
14000 - 15000	45	4.7
15000 - 16000	50	5.3
16000 - 17000	86	9.1
17000 - 18000	125	13.2
18000 - 19000	131	13.8
19000 - 20000	118	12.4
20000 - 21000	30	3.2
21000 - 22000	26	2.7
22000 - 23000	9	0.9
23000 - 24000	10	1.1
> 24000	15	1.6
TOTAL	948	

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LIST OF ABBREVIATIONS

AASHO	-	American Association of State Highway Officials
AASHTO	-	American Association of State Highway and Transportation Officials
A/D	-	Analog/Digital
ADT	-	Average Daily Traffic
BR	-	Prefix Denoting a Federal Highway (as in Br-116)
BRIAM	-	Brazilian Roadway Investment Analysis Model
CAEEB	-	*Companhia Auxiliar das Empresas Elétricas Brasileiras*
CBR	-	California Bearing Ratio
DER	-	*Departamento de Estradas de Rodagem*
DF	-	*Distrito Federal* (Federal District)
DMI	-	Distance Measuring Instrument
DNER	-	*Departamento Nacional de Estradas de Rodagem*
EMBRAPA	-	*Empresa Brasileira de Pesquisa Agropecuária*
EPCT	-	*Estrada Parque Contorno*
GEIPOT	-	*Empresa Brasileira de Planejamento de Transportes*
GO	-	*Goiás* (Brazilian State)
IBRD	-	International Bank for Reconstruction and Development
IPEA	-	*Instituto de Planejamento Econômico e Social*
IPR	-	*Instituto de Pesquisas Rodoviárias*
MIT	-	Massachusetts Institute of Technology
MG	-	*Minas Gerais* (Brazilian State)
QI	-	Quarter-car Simulator Index (a measure of roughness generated by the Quarter-car Simulator in the GM Profilometer)
SAS	-	Statistical Analysis System
SN	-	Structural Number
SOFOT	-	Simulation of Flow of Traffic
SUBIN	-	*Secretaria de Cooperação Econômica e Técnica Internacional*
TAFA	-	Time and Fuel Algorithm
TRDF	-	Texas Research and Development Foundation
TRRL	-	Transport and Road Research Laboratory
UNDP	-	United Nations Development Program
WIM	-	Weigh-in-Motion

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