is approximately 9 mph below the general traffic; thus, recreational vehicles may become critical vehicles in the heavy timber haul route; and

4. The speed of government vehicles on forest roads is slightly slower than other vehicles, except recreational vehicles.

ACKNOWLEDGMENT

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Vehicle Operating Costs in the Caribbean

H. HIDE, G. MOROSIUK, AND S.W. ABAYNAYAKA

This paper describes an investigation into factors that affect vehicle operating costs in the Eastern Caribbean. The study was designed to check the validity of the vehicle operating cost relations derived from an earlier study in Kenya and to extend these relations to include the effects of road geometry and poor bituminous surfaces. Data were collected over a two-year period and the effect of various road and vehicle parameters on the components of vehicle operating cost was examined. The results of the analysis are presented and are compared with the results obtained from the Kenya study.

This paper describes a study of the factors that affect vehicle operating costs in the Eastern Caribbean. The study was designed to extend the vehicle operating cost relations derived in the Kenya Road Transport Cost Study (1) to include the effects of road geometry and poor bituminous surfaces. These relations form part of the Transport and Road Research Laboratory (TRRL) road investigation model for developing countries (RTIM2) (2), which is designed to assist investment decisions concerning nonurban roads in developing countries. The vehicle operating cost relations may also be used manually for this purpose if computer facilities are not available. The Kenya study could not isolate the effect of road geometry on the components of vehicle operating cost other than fuel consumption because the rolling or flat terrain of Kenya precluded the possibility of obtaining data on vehicles that operated predominantly on roads that have steep gradients or high degrees of curvature. In order to investigate this effect it was necessary to obtain operating cost data on fleets of vehicles that operate in separate areas with significantly different kinds of terrain. The islands of the Eastern Caribbean are well suited to such a study. In addition, the condition of the road systems in the Eastern Caribbean made it possible to examine the effect of very rough bituminous roads on vehicle operating costs. The study consisted of two parts--an experimental investigation into vehicle speed and fuel consumption and a survey of vehicle operators.

STUDY LOCATION

The experimental study of vehicle speed and fuel consumption was located in St. Lucia, a small island that has a predominantly mountainous terrain and a limited network of paved main roads that connect the principal towns. The road conditions on the island provided the wide range of horizontal and vertical curvature, road surface roughness, and road width required for the study. The low traffic volumes encountered meant that traffic interactions did not affect the free speeds of vehicles. However, only the paved road system could be included in this study because the hilly terrain coupled with the high rainfall made it impractical to locate experimental sections on the unpaved roads.

In order to obtain information for the user survey on vehicles that operate in areas of significantly different road geometry and surface condition, it was necessary to collect data from four different islands. As in the experimental study, the data refer to vehicles that operate on paved roads only. The islands selected and their terrain and road roughness classification are as follows:

Island	Terrain	Road Roughness
Barbados	Flat-rolling	Low
St. Vincent	Mountainous	Medium-high
St. Lucia	Rolling-mountainous	Medium
Dominica	Rolling-mountainous	High

The ranges of geometry and road surface roughness encountered on each of the islands are given in the table below. The values quoted refer to essentially homogeneous sections of road of varying lengths, typical of the lengths of trips made by vehicles in the course of their normal operation.

Island	Curvature (deg/km)	Rise and Fall (m/km)	Roughness (mm/km)
Barbados	90-390	8-60	2600-5600
St. Vincent	520-810	37-78	3200-8000
St. Lucia	160-730	17-82	3300-7600
Dominica	180-1040	19-68	3800-9800

EXPERIMENTAL STUDY

Six main routes were selected and surveyed and the vertical profiles of these routes were plotted and examined. From these profiles sections of road with uniform gradients but of varying lengths were selected as test sections. This procedure enabled an acceptable experimental matrix of test sections that contain the full range of vertical and horizontal curvature combinations to be included. The sections of road selected had gradients that ranged from 0 to 14 percent and average curvatures from 0° to 1600°/km. The road widths studied ranged from 4.3 to 8.5 m and the surface roughness from 1400 mm/km to 14 800 mm/km.

The measurements of the physical characteristics of the sections were made by using rod and level surveys, the TRRL gradometer, the TRRL GAMMS gyroscopic unit, and a towed fifth-wheel bump integrator. Details of these instruments and the measuring techniques will be the subject of a separate TRRL report.

Vehicle Speed Measurements

The purpose of the study was to relate vehicle speeds to the general layout of roads; therefore, the appropriate measure of speed was the average journey speed that corresponds to the average journey time. Measurements of the journey times of samples of vehicles were made on all the speed test sections; the sample size depended on the vehicle flows on each route. Only three classifications of vehicle were used--cars, light vehicles, and trucks. Light vehicles were defined as passenger vehicles other than cars and goods vehicles that had a gross vehicle weight not greater than 3000 kg; trucks included all other types of goods vehicles. Very few three-axled goods vehicles were encountered and the buses were of the minibus category, which are included in the light-vehicle class.

The journey time observations were made by stationing two observers with synchronized stopwatches at each end of a test section. Each observer recorded the vehicle registration number, the vehicle class, the direction of travel, and the time as the vehicle passed the observer's station. The mean speeds of cars and light vehicles and their standard deviations were calculated from the journey times of the vehicles monitored for each section. However, the individual speeds of trucks were calculated for each section because these speeds were analyzed against the individual gross vehicle weight of the vehicle. The gross vehicle weights of the trucks were obtained by conducting an axle-load survey at the same time as the vehicle speed survey. In order to ensure that the speeds of the vehicles being measured were not affected by the axle-load survey, the latter was always located a few kilometers before or after the speed measuring sites. Frequently more than one speed survey site was in operation on the same route at the same time, which enabled a larger sample to be collected for analysis. The total sample of car speeds was more than 20 000 and of light vehicle speeds was more than 13 000. Close to 5000 truck speeds were matched to gross vehicle weights.

Fuel Consumption Measurements

These measurements were made by conducting a series of controlled experiments with three test vehicles that were representative of the three vehicle classes used in the vehicle speed study. The vehicles used were

1. A Ford Cortina estate car with a 1.6-liter, 4-cylinder petrol engine,
2. A Ford Transit van with a 2.0-liter, 6-cylinder petrol engine, and
3. A Ford D1010 truck with a 6.0-liter, 6-cylinder diesel engine.

Detailed specifications of the vehicles are given in Table 1.

The car was operated in one load condition only--with two passengers and the necessary instrumentation. The Transit van was operated in two load conditions--empty and loaded, which gave gross vehicle weights of 1.5 t and 2.6 t, respectively. The Ford D1010 truck was operated in three load conditions--empty, half load, and full load. The respective gross vehicle weights were 4.0, 7.0, and 10.0 t.

The instrumentation of the test vehicles consisted of a Transflo positive displacement type fuel meter with a remote digital read-out working in units of 1/1000 liters.

Six test runs were made in each direction at a series of constant speeds that ranged from 16 km/h

Table 1. Details of test vehicles used for fuel-consumption measurements.

Vehicle and Engine	No. of Cylinders	Cubic Capacity (cc)	Power	Torque	Tire Size	Gross Weight (kg)	Power to Weight Ratio
Cortina estate car, petrol engine	4	1593	48 kW at 4750 rpm	114 Nm at 2800 rpm	165SR13 radial	1115	
Ford Transit van, petrol engine	4	1996	51 kW at 4500 rpm	139.3 Nm at 2500 rpm	185SR14 radial	Empty, 1610	42.9:1
						Full load, 2600	26.5:1
						Empty, 4030	28.5:1
Ford truck D1010, diesel engine	6	6000	86 kW at 2600 rpm	353 Nm at 1600 rpm	825 x 20 radial ply	Half load, 7030	16.4:1
						Full load, 10 030	11.5:1

(10 miles/h) to the maximum speed attainable by each vehicle at increments of 8 km/h (5 miles/h). In practice these discrete speed intervals could not be attained precisely because of the severe terrain over which the vehicles were operating; therefore the actual speed maintained was calculated from the elapsed time over the section measured by using a stopwatch.

User Survey

Data on individual vehicles were collected for a 12-month period from the owners and operators of the vehicles, who were visited approximately every six weeks. Data were obtained from a variety of sources: government, institutional, and private operators, both large and small. The route patterns of the vehicles monitored were also defined, and the physical characteristics of the roads concerned were measured dynamically by using the TRRL vehicle-mounted roughness and road geometry measuring instruments.

Details of the data collected are given below.

Data collected on individual vehicles included the make and model, engine size and horsepower, age in years, kilometers run to date, number and size of wheels, and number of passenger seats or laden and unladen weights. Monthly vehicle operating details included kilometers run, fuel consumed, oil consumed, cost of spare parts, cost of maintenance labor, number and condition of tires fitted, and routes operated. Cost details included the current market value of the vehicle and the cost of an equivalent new vehicle. Road characteristics included surface roughness, horizontal geometry (i.e., the degree of curvature of the road), and vertical geometry (i.e., the gradient of the road). The number of vehicles registered by vehicle type, age distribution of the vehicles, and numbers of new vehicles registered each year were also tabulated.

All the data collected on operating details were converted into physical quantities so that the relations developed would hold for as long as the present vehicle technologies remained substantially unchanged. To obtain the actual cost of any vehicle operating cost component at a particular time and place it is thus necessary only to apply the appropriate unit cost.

Vehicle Categories

Although data were collected for as many types of vehicle as possible, the analyses were performed on the broad categories defined below.

Vehicle Category	Description
Car	Passenger vehicle that seats not more than nine persons
Light vehicle	Passenger and goods vehicle that has gross vehicle weight (GVW) not > 3000 kg and is not included in previous category
Truck	All goods vehicles with GVW > 3000 kg, including dual-purpose goods and passenger carriers
Bus (limited sample from one company on one island only)	Purpose-built buses, all of which carry > 40 passengers in this instance

DATA ANALYSIS

The form of analysis used was dictated by the basic requirement to produce a simple and easily usable set of relations for estimating vehicle operating costs by using data collected from a survey of vehicle operators. Data of this type are geared best to analysis by multiple regression techniques and this method was therefore used.

In addition to the overriding requirement that the necessary information must be easy to measure or obtain it was also decided that the number of variables eventually included in the final relations should be kept as small as possible, commensurate with an acceptable level of statistical significance.

STUDY RESULTS

The results obtained are listed below. In the relations the following terms are used:

V = vehicle speed (km/h),
FL = fuel consumption (ml/km),
PC = parts cost per kilometer,
VP = cost of an equivalent new vehicle,
K = total kilometers run to date,
R = surface roughness (mm/km),
C = curvature (degrees/km),
RS = rise (m/km),
F = fall (m/km),
RF = rise and fall (m/km),
G = average weight of the vehicles (t),
W = road width (m),
PW = power-to-weight ratio of the vehicle (brake horsepower/t), and
GVW = gross vehicle weight (t).

Vehicle Speed and Fuel Consumption

The speed-estimating relationships are as follows.

For cars,

$$V = 67.6 - 0.078RS - 0.067F - 0.024C - 0.000\,87R \quad (1)$$

For roads < 5.0 m wide, $\Delta V = -8.1\ (5.0 - W)$ and $r^2 = 0.09$.

For light vehicles,

$$V = 62.6 - 0.085RS - 0.067F - 0.022C - 0.000\,66R \quad (2)$$

For roads < 5.0 m wide, $\Delta V = -7.0\ (5.0 - W)$ and $r^2 = 0.91$.

For trucks,

$$V = 51.9 - 0.222RS - 0.122F - 0.017C - 0.001\,06R + 0.559PW \quad (3)$$

For roads < 5.0 m wide, $\Delta V = -6.2\ (5.0 - W)$ and $r^2 = 0.49$.

In these equations ΔV is the reduction in speed (km/h) when the road is less than 5.0 m wide.

Because the field experiments were conducted at controlled speeds, the equations derived from the analyses relate to estimates of vehicle fuel consumption at a steady speed. In practice vehicles do not travel at steady uninterrupted speeds and are subject to speed-change cycles that result from interaction with other vehicles. On low-volume rural roads, however, vehicles interact infrequently and therefore fuel consumption is not expected to be affected greatly. The limited information obtained suggested that the increase in fuel consumption with speed-change cycles broadly confirms the Kenya findings of increases of 8 percent for cars and light vehicles and 13 percent for trucks, and these values are therefore retained.

The equations for the three vehicle classes are given below with the factors of 1.08 and 1.13 included to give fuel-consumption estimates for normal operating conditions.

For cars,

$$FL = [24 + (969/V) + 0.0076V^2 + 1.33RS - 0.63F + 0.0029F^2] \times 1.08 \quad (4)$$

$r^2 = 0.95$.

For light vehicles,

$$FL = [72 + (949/V) + 0.0048V^2 + 1.118\ (GVW \times RS) - 1.18\ F + 0.0057F^2] \times 1.08 \quad (5)$$

$r^2 = 0.96$.

For trucks,

$$FL = [29 + (2219/V) + 0.0203V^2 + 0.848\ (GVW \times RS) - 2.60F + 0.0132F^2] \times 1.13 \quad (6)$$

$r^2 = 0.96$.

Oil Consumption

Data obtained on oil consumption showed a large variation among the vehicles sampled with no discernable pattern across either vehicle age or road characteristic. We therefore suggest that the following overall averages derived in the Kenya study be used for all conditions:

Cars--1.2 liters/1000 km
Light vehicles--1.8 liters/1000 km
Trucks and buses--4.0 liters/1000 km

Parts Consumption

The data collected on the cost of spare parts consumed by each vehicle were expressed as a fraction of the cost of an equivalent new vehicle. This was then regressed against the age of the vehicle expressed in terms of the total kilometers run by the vehicle, the average roughness of the roads over which the vehicle operated, and the average horizontal curvature and gradient of these roads. Relations were developed for two categories of vehicle--(a) cars and light vehicles and (b) trucks.

For the car and light vehicle category the equation that gives the best estimate is as follows:

$$PC = [-3.451 + 0.002\,54R - 0.0142C + 0.000\,205\ (RF \times C)] \times K \times VP \times 10^{-11} \quad (7)$$

$r^2 = 0.93$.

However, this relation is valid only with the combination of geometry (RF and C) from which it was derived. In this study these parameters are highly correlated, and evaluation of the parts consumption relation for combinations of high horizontal curvature and low vertical gradient or vice versa will give unrealistic estimates for parts consumption.

This relation obviously cannot be used as a general estimator for parts consumption and therefore the second-best estimator is preferred. Although it does not include the road geometry parameters, it does give acceptable estimates over the range of values of the remaining parameters. This relation is as follows (see Figure 1):

$$PC = (-5.501 + 0.002\,62R) \times K \times VP \times 10^{-11} \quad (8)$$

$r^2 = 0.91$.

A similar relation was derived for trucks, as follows (see Figure 2):

$$PC = (-6.538 + 0.003\,16R - 0.000\,000\,21R^2) \times K \times VP \times 10^{-11} \quad (9)$$

$r^2 = 0.95$.

It was not possible to produce a relation for buses due to the limited data available but the effect of the total kilometers run on the cost of spare parts was of the same order as that of the truck category.

Maintenance Labor

Maintenance labor proved to be a difficult item on which to obtain usable information because most of the operators carried out a mixture of in-house and garage repairs and no hourly record was kept of the former for individual vehicles. The data obtained for maintenance labor, therefore, come from a small sample of garage work and suggest an overall figure of 45 percent of the parts cost for any particular vehicle. The relation obtained is

$$\text{Labor cost} = \text{Parts cost} \times 0.45 \quad (10)$$

Tire Consumption

Two equations have been derived (one for cars and light vehicles and one for trucks) that relate the total consumption of tires per kilometer run to the roughness of the road surface and, for trucks, to the weight of the vehicle. The relations are shown in Figures 3 and 4. The limited data on buses suggest that the truck relation will also apply to this class of vehicle.

For cars and light vehicles,

$$\text{Tires/km} = (-0.0601 + 0.000\,076\,4R) \times 10^{-3} \quad (11)$$

$r^2 = 0.81$.

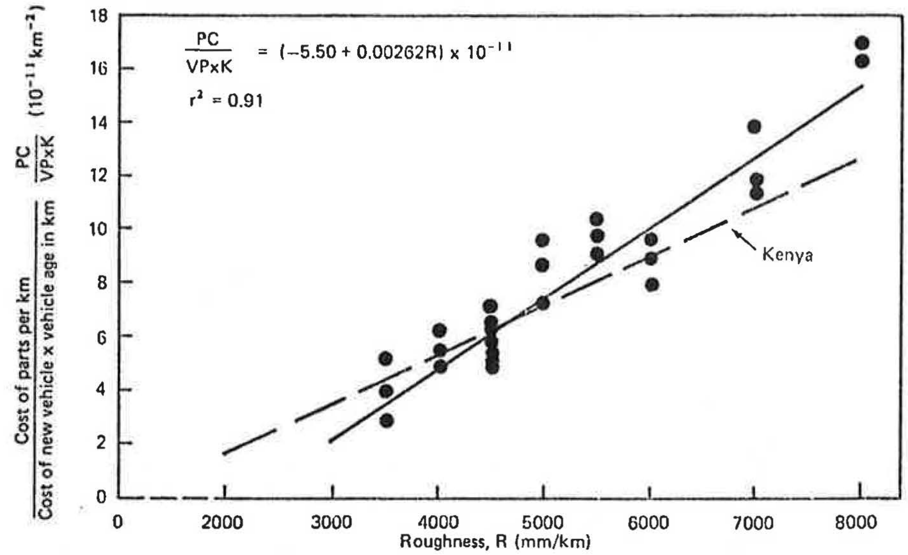


Figure 1. Parts consumption for cars and light vehicles.

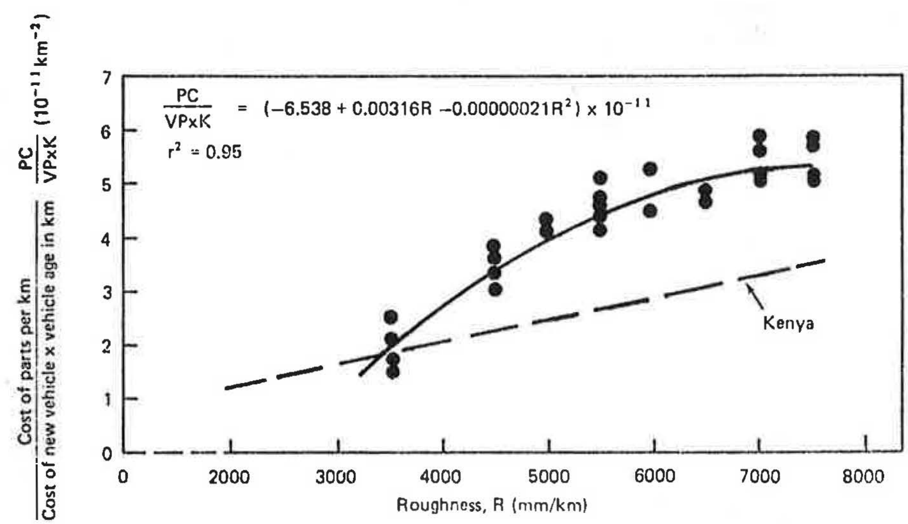


Figure 2. Parts consumption for trucks.

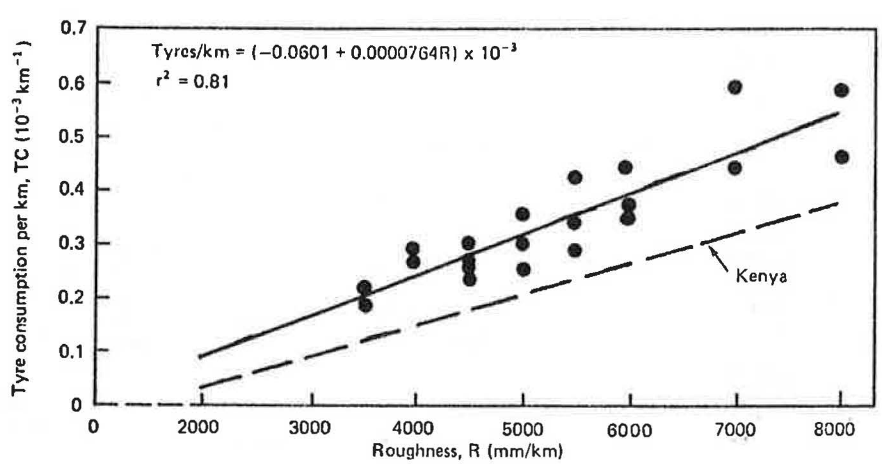


Figure 3. Tire consumption for cars and light vehicles.

Figure 4. Tire consumption for trucks.

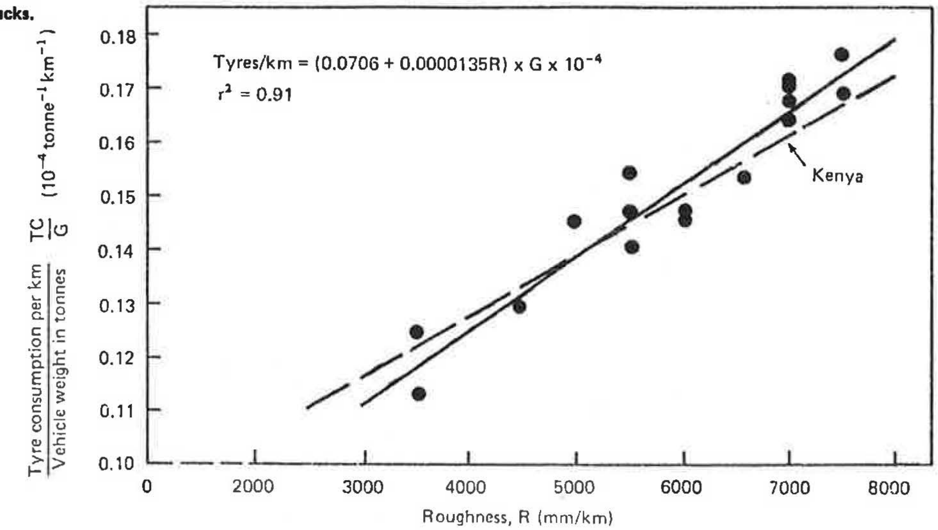


Figure 5. Car and light vehicle depreciation.

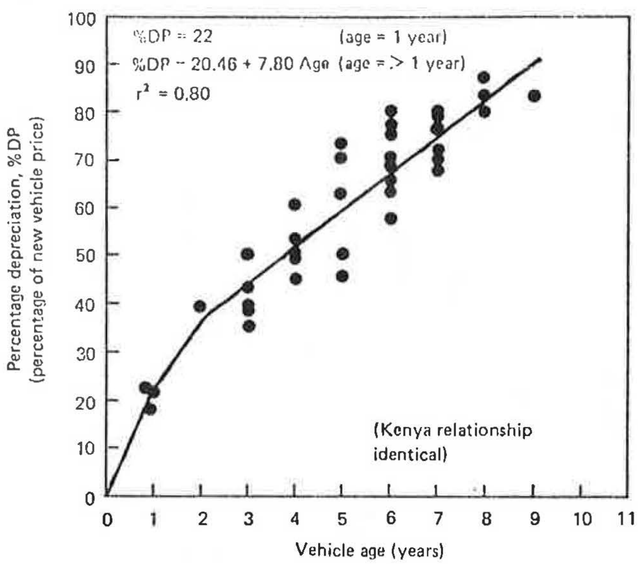
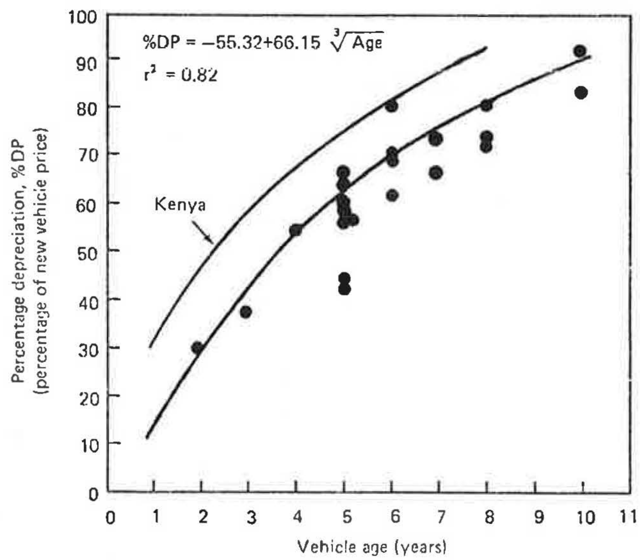


Figure 6. Truck and bus depreciation.



For trucks,

$$\text{Tires/km} = (0.0706 + 0.000\,013\,5R)\,G \times 10^{-4} \quad (12)$$

$r^2 = 0.91.$

Vehicle Depreciation

Depreciation is defined as the difference between the current market resale value of a vehicle and the price of an equivalent new vehicle, expressed as a percentage of the price of the new vehicle.

The depreciation relations were derived from market resale prices of a variety of vehicles of different ages and operating environments. The data obtained from the vehicles included in the user survey have been supplemented by information from other operators and vehicle dealers.

The relations derived are functions of the age of vehicles only; all other variables tested were found to be either inferior estimators not significant. The relations are given below and shown in Figures 5 and 6.

For cars and light trucks, the depreciation is 22 percent for one-year-old vehicles:

$$\text{Percentage depreciation} = 20.46 + 7.80 \times (\text{Age in years}), \text{ for vehicles} > 1 \text{ year old} \quad (13)$$

$r^2 = 0.80.$

For trucks,

$$\text{Percentage depreciation} = -55.32 + 66.15 \times \sqrt[3]{\text{Age in years}} \quad (14)$$

$r^2 = 0.82.$

These relations will strictly apply only to the area in which they have been derived and are a function of the economic, social, and geographical parameters of the area. Their use outside this environment should therefore be undertaken with great caution, and if it is not possible to build specific relations for another area, then these relations should certainly be calibrated before they are applied elsewhere.

Table 2. Comparison of fuel-consumption estimates between Kenya and St. Lucia studies.

Speed (km/h)	Study	Fuel Consumption (ml/km) 0 m/km	20 m/km	40 m/km	60 m/km	80 m/km
30	Kenya	75	107	139	171	203
	St. Lucia	63	90	116	143	169
40	Kenya	75	107	139	171	203
	St. Lucia	60	87	113	140	166
50	Kenya	77	109	141	173	205
	St. Lucia	62	89	115	142	168
60	Kenya	82	114	146	178	210
	St. Lucia	68	95	121	148	174

COMPARISON WITH RESULTS OF KENYA STUDY

Vehicle Speed

For all three vehicle classes the coefficients significant in both studies differ consistently to reveal the effect on vehicle performance of the extreme differences in the two environments. For example, the free speed represented by the constant term illustrates the difference in operating speeds in the two types of terrain. Likewise, the rise coefficient illustrates that at higher speeds the rate of change of speed with gradient is greater than at lower speeds. The effect of negative gradients tends to be influenced by driver behavior to a large extent and the regression coefficients do not always have the same stable qualities as the rise coefficient, yet for each vehicle class the coefficients reflect the influence of the operating conditions. The coefficients for curvature behave as expected--they reduce speed at a faster rate at higher speeds than at lower speeds.

Although by definition free speeds are the speeds at which unimpeded vehicles will travel on flat straight sections of road, they are nevertheless affected by the general layout of the roads in the area through differences in driver behavior and vehicle performance. For example, the free speeds of vehicles when they operate in a hilly or mountainous region will be considerably lower than the free speeds of vehicles in a flat or rolling open terrain although they are both operating on flat straight sections of road. This suggests a series of speed-environment relations distinguished by vehicle-driver characteristics and defined by the average free speed in each particular environment with the effect of gradient, curvature, and road surface condition varying between environments. Thus, the two sets of data from Kenya and St. Lucia, though compatible and providing speed-environment relations of a similar format, estimate the effect on speed of road geometry differently through coefficients of varying magnitude, although the geometric characteristics of the two data sets overlap.

The consistent gradation of the regression coefficients that describe the effect on vehicle speeds in the two physical environments makes it reasonable to infer that vehicle speeds in environments between these two extremes could be adequately estimated by examining the free speed of such an environment and linearly interpolating the regression coefficients. A methodology for this interpolation is included in the full TRRL report (3).

Fuel Consumption

It is not possible to compare the estimating relations for light vehicles and trucks directly because the data have been analyzed differently in the two studies. A direct comparison of the regression coefficients of the equation for car fuel consumption is possible, but it would be more meaningful to compare the predicted values by using the two equations. Table 2 gives the estimated fuel consumption for cars for given gradients and speeds for St. Lucia and Kenya. The St. Lucia estimates are consistently lower than the Kenya estimates and it is probable that this discrepancy has arisen because of the differences in the test vehicles used in the studies. The vehicle used in Kenya was a 1970 Ford Cortina estate car and, although a similar car was used in the St. Lucia study, it was a 1977 model that had an economy carburetor.

The form of the equations for estimating fuel consumption for light vehicles and trucks was changed from the Kenya format and included a cross-product term of GVW and rise (GVW x RS). The combination of GVW and rise as a variable more effectively describes the fuel consumed by these vehicles in overcoming gradients.

User Survey Results

In order to make a simple and easy comparison with the results of the Kenya study the relations derived from that study have been superimposed on graphs that show the data obtained from the present study. All the data in this study refer to vehicles operating on paved surfaces only, whereas the Kenya study was a mixture of paved and unpaved operation and the maximum roughness of the paved roads was 4000 mm/km.

For the categories of vehicle investigated in this study, the effect of a deteriorating bitumen road is greater than that of a gravel road that gives the same roughness measurement. In the case of the two spare parts relations and the tire relation for heavy vehicles these differences are just significant at the 5 percent level. For the light vehicle tire relation there is no significant difference between the slopes of the two curves and, as the displacement can probably be attributed to the almost exclusive use of higher-quality radial tires in Kenya at the time of that study compared with the more usual mixture of radial and cross-ply found in the Eastern Caribbean and in most developing countries, the more robust relation derived in this study is preferred as the general case.

The depreciation relations in Kenya and the Eastern Caribbean are virtually identical for light vehicles and the relation derived in this study is used now. The relations for heavy vehicles are of a similar shape but differ by an almost constant amount after year 1 and, in the absence of any other information, the Caribbean relation is thought to be the better estimation at the present time.

Although it was possible to isolate an effect of road geometry on the consumption of spare parts of light vehicles, the relation derived was not sufficiently comprehensive to use as a general case due to the high correlation between the levels of horizontal and vertical geometry of the roads in the Eastern Caribbean. In order to investigate this effect adequately it will be necessary to obtain information from a sufficiently large cross section of vehicles that operate over roads with high horizontal and low vertical curvature and low horizontal and high vertical curvature in addition to that collected in this study.

SUMMARY

This report gives the results of the TRRL Caribbean Vehicle Operating Cost Study. The study was conducted along similar lines to the first full-scale

field investigation into vehicle operating costs carried out by TRRL in Kenya in 1971-1973, and it was designed to complement that study.

The vehicle performance study provides a new set of relations for estimating vehicle speed and fuel consumption. The severe terrain on which the study was conducted in St. Lucia produced equations for estimating speed of a different order of magnitude than the existing Kenya relations. A method has been evolved to make use of these two sets of relations to provide realistic estimates of vehicle speeds for intermediate physical and environmental conditions. The fuel-consumption relations derived from the St. Lucia study provide improved estimating equations over a larger range of operating conditions.

The major differences between the two sets of user survey relations are the significantly higher effect on spare parts and tire consumption of a deteriorating bitumen-surfaced road compared with a gravel road of the same surface roughness and the lower rate of depreciation of heavy vehicles.

The two sets of relations have been combined and modified to make them suitable for inclusion in the new TRRL road transit investment model (RTIM2) (2). The equations used, together with limiting values, where applicable, are given in a separate paper by Parsley and Robinson in this Record. Full details of the data collected and analyses performed are given in TRRL reports (3,4).

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Investigation of Effects of Oil Field Traffic on Low-Volume Roads

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A conceptual framework is presented for analyzing the effect of heavy axle loads on light pavement sections. By using models specifically developed for surface-treated pavements, a reduction in pavement life is estimated. These models of pavement distress and serviceability have been developed by using regression analysis of pavement condition data collected over a seven-year period on thin pavements in Texas. The utility of the pavement distress analysis and conceptual argument is demonstrated through a case study example of oil well truck traffic. Results of this study assist in identifying the reduction in pavement life and additional life-cycle costs associated with the special-use traffic. The problems associated with oil field exploration and development are not unique but are similar in many respects to the impact of other load-intensive, commercially important hauls such as coal, grain, and cotton.

The oil embargo of the early 1970s dramatized the dependence of the United States on foreign oil production. Curtailment of crude shipments demonstrated that oil-producing nations are a primary source of economic control. The unfavorable consequences of reliance on foreign oil imports encouraged our country to strive for energy self-sufficiency. In an attempt to realize this independence, oil exploration is being accelerated, dormant wells are being rejuvenated, and trapped deposits are being reclaimed. These successful ventures have increased domestic production throughout the oil pool area of the Gulf states and have resulted in the enjoyment of the benefits of economic growth. Unfortunately, an adverse effect of this intense activity has been the physical destruction of light-duty roadway pavements serving the productive oil fields.

Low-volume rural roads in oil-producing areas were not initially constructed to endure the impact of intense oil field truck traffic. Thus, a condition of persistent rehabilitation was not anticipated under normal operating situations, and complete pavement restoration costs were not normally accounted for in the planning of maintenance. Since typical traffic characteristics and usual vehicle distributions are not applicable to roadways that carry oil field traffic, there is a need to determine the definitive elements of oil field traffic demand.

The Texas State Department of Highways and Public Transportation (TSDHPT) found that it was incurring