E U R O P E A N   U N I O N - T A C I S

Technical Assistance to the Southern Republics of the CIS

and Georgia - TRACECA

T R A D E   A N D   T R A N S P O R T   S E C T O R S

IMPLEMENTATION OF PAVEMENT MANAGEMENT SYSTEMS

PROJECT NO.: TELREG 9305

D R A F T   F I N A L   R E P O R T

STUDY OF THE COST AND FINANCING OF ROAD USAGE

V O L U M E 1, M A I N   R E P O R T

DECEMBER 1996

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Consulting Engineers
Koblenz / Germany

in association with

TECNECON, Economic
and Transport Consultants
London / U. K.

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Koblenz,
19.12.1996

Dear Sir,

TRACECA Project: Implementation of Pavement Management Systems
Project Number: TELREG 9305
Study of the Cost and Finance of Road Usage

We take pleasure in submitting to you the draft final report of the above study comprising Volume 1 Main Report and Volume 2 Annex for your review and comment.

The report is submitted in six copies, five bound and one loose leaf. A copy of Volume 1 has been forwarded by E-Mail to the Tacis Coordinating Units in the eight recipient states as well as to the Tacis Monitoring & Evaluation Central Asia in Almaty.

The Russian version is presently under translation and will be submitted together with the diskette as soon as completed.

Yours faithfully

KOCKS CONSULT GMBH
Consulting Engineers

Ulrich Sprick

i.A. Ulrich Willems

Copies to: Tacis CU, all 8 recipient states

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STUDY OF THE COST AND FINANCING OF ROAD USAGE (DRAFT 12/96)

REPORT COVER PAGES

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STUDY OF THE COST AND FINANCING OF ROAD USAGE (DRAFT 12/96)

Date of report : 10. December 1996

Reporting period : January to December 1996

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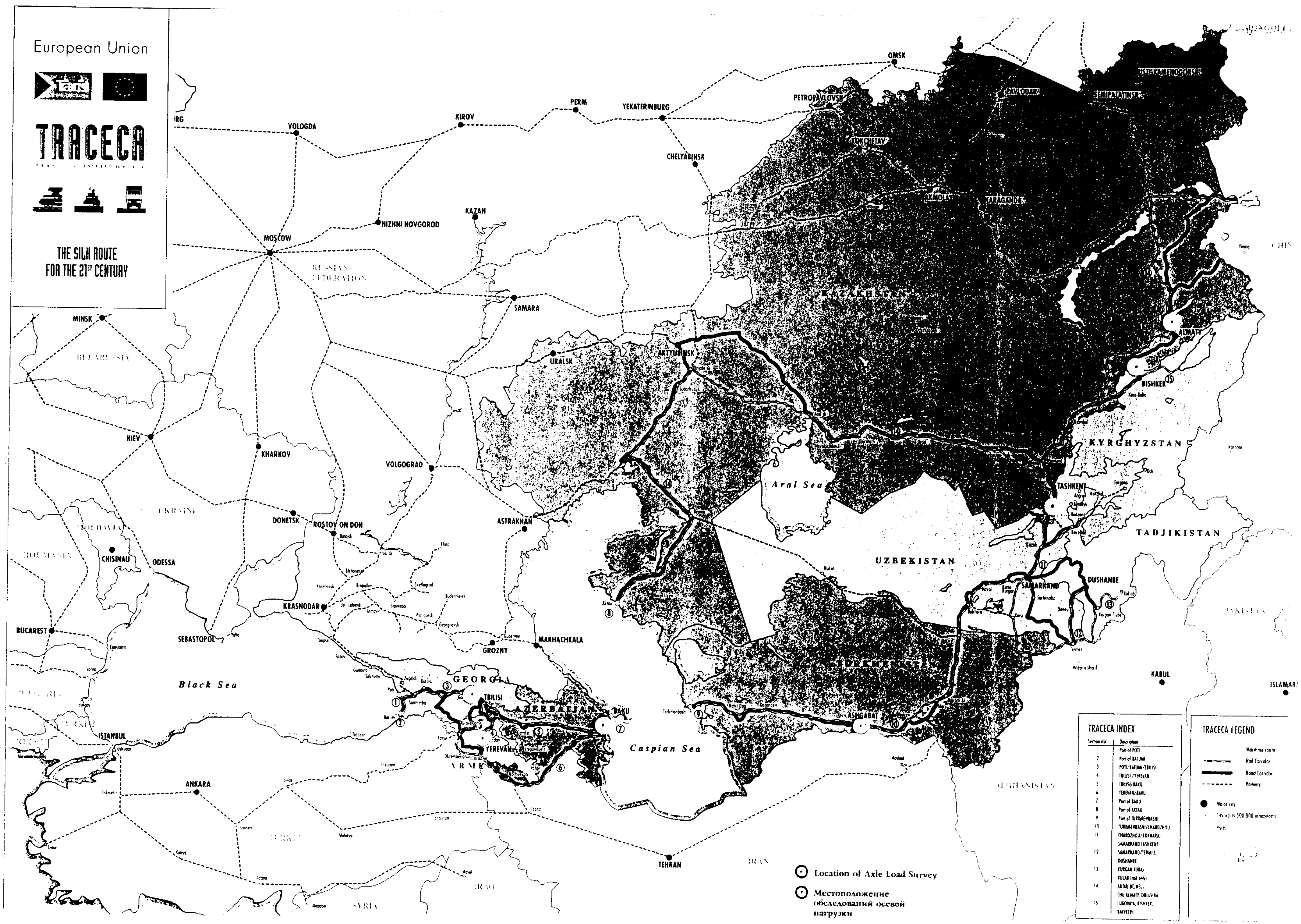
European Union
TRACECA
THE SILK ROUTE
FOR THE 21ST CENTURY
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KIEV
MINSK
VOLOGDA
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PERM
YEKATERINBURG
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15 LUGOVAYA, BISHKEK, BALYKCHI
TRACECA LEGEND
Maritime route
Rail Corridor
Road Corridor
Railway
Major city
City up to 500 000 inhabitants
Ports
km

1 INTRODUCTION

This report on the Cost and Financing of Road Usage is one of the reports being produced under the European Union - TACIS sponsored TRACECA Project for the Implementation of Pavement Management Systems which is being carried out by Kocks Consult GmbH of Germany in association with Phønix Pavement Consultants a/s of Denmark and TecnEcon Limited of the United Kingdom. The geographical coverage of this study and the project of which it is a part includes eight countries falling within the area of the European Union's TRACECA initiative. These countries are Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tadjikistan, Turkmenistan and Uzbekistan.

The data required for the study were obtained during the course of visits to the project countries between March and October 1996 as well as from a previous study undertaken by the Consultant in Turkmenistan in 1995 and the relevant updated data, findings and recommendations from that study have been incorporated into the present study. Considerable use has also been made of road feasibility studies carried out by other international consultants in Azerbaijan, Kazakhstan, and Kyrgyzstan and by one of the present consultants in Armenia. A certain amount of information on Tadjikistan has been made available to the Consultants by various multinational donor agencies.

In view of the number of countries covered by this study the problem of the currency units to be used in the presentation of the findings had to be given careful attention. The use of a domestic currency plus at least one international currency for each country would have been unwieldy in view of the amount of data to be analysed and presented. It has been decided, therefore to standardise on one international currency and because of its familiarity in all the countries covered, the currency chosen was the United States dollar. The use of the dollar also has the advantage that it is less vulnerable to the effects of local inflation than the individual currencies in use in the TRACECA countries. The ECU is not yet familiar to most officials in these countries and therfore it was decided not to use it in the analyses undertaken. The dollar exchange rates used were based on the following rates which were those prevailing in mid 1996 or at the time of the field visits.

Armenian Dram	405	Kyrgyz Som	11.5
Azerbaijan Manat	4,300	Tajik Roubles	290
Georgian Lari	1.24	Kazakhstan Tenge	66
Turkmenistan Manat	4,000	Uzbekistan Som	42

The aims and scope of the study are set out in the extract from the Terms of Reference for the Pavement Management System Implementation project included in Annex 1. They can be summarised as requiring a rigorous analysis of the various elements making up the total costs of road use and the extent to which road use costs are being covered by present levels of expenditure in each country. The study is also required to explain the relationships between road user costs and road condition on the one hand, and between road condition and maintenance practice on the other. These elements are closely interlinked and an important aim of the study is to demonstrate the economic impact of changes in road condition resulting from different levels of maintenance expenditure. An important requirement of the Terms of Reference is the presentation of recommendations for an appropriate structure of road user charges based on the results of the road use costs analyses undertaken.

The time available for this study dictated that a short cut approach to road use cost analysis had to be adopted and this implied that traffic and road condition data had to be readily available. In general, locally available traffic data supplemented by the Consultants' axle load surveys have met the requirements of the study, but only for the main inter state and intra state inter urban road networks. Consideration of urban roads was outside the scope of this study given available time and other resource constraints. The rudimentary data availability for the district and local roads also precluded their inclusion. The lack of information on pavement strength data for the main inter urban road networks in all but two of the countries has posed some difficult but not insuperable problems. The limitations of the data base for a study of this nature should, however, be kept firmly in mind when considering the final results and recommendations.

Considerable assistance has been received from the respective highway institutions in all recipient states covered by the study and the Consultants would like to express their gratitude for the friendly co-operation extended to them during the course of their work.

2 ROAD TRANSPORT COSTS

2.1 General

This report is concerned with the costs of road usage in the TRACECA states and with methods of financing these costs. In this chapter the different categories of road costs are briefly introduced and their significance explained. In subsequent chapters road engineering and road user costs are examined in greater detail and the relationship between road maintenance and rehabilitation standards, road condition and road user costs is established.

Road transport costs are made up of the costs of road infrastructure provision and maintenance, road user costs and other costs such as environmental costs imposed on society by road transport. In this report the main concern is with the first two broad categories of road transport costs. The environmental impact of road infrastructure maintenance and rehabilitation is usually considered to be relatively minor as compared with the potential impact of major new road construction or realignment initiatives. To the extent that this study is mainly about the cost and financing of road network maintenance and rehabilitation, environmental costs are not considered in any detail.

The aim of appropriate highway management policy should be to minimize total life cycle road transport costs over a defined network. This immediately focuses attention on the relationship between road costs and road user costs on the one hand, and on the network to be considered on the other. In most of the TRACECA states the road network comprises inter state ("Magistrale") roads, republican or intra state roads, regional or oblast roads and district and-or local roads. Urban roads usually fall within one or more of these categories.

Logically discussions of road costs and methods of financing them should be at the total road network level since most road user charges are levied on road vehicles and their use regardless of what roads the are used on. An exception to this is toll road charging. In practice, however, data constraints usually mean that initially analysis has to be concentrated on the main road network. These will usually account for a very high proportion of inter urban vehicle kilometres. For administrative reasons urban roads often come within the area of responsibility of municipal road departments rather than the national highway department or agency. This often results in differences in the coverage of routine data collection which can make it difficult to include urban road networks in the analysis without a large increase in research effort. This is a more serious problem than the omission of local and district road networks because urban traffic contributes a much higher proportion of vehicle kilometres and should, therefore, have a significant influence on total road transport costs.

The time and resources available for this study have meant that considerable reliance has had to be placed on data already available within the individual highway institutions and departments in the TRACECA states. These organisations are mainly responsible for the inter urban main road networks and traffic and other data availability is also mainly confined to these networks. For this reason, the study's analyses and findings are also confined to the inter urban main road networks comprising the inter state and intra state roads. Urban roads are not included except where they form part of one or other of the above main road categories. The extent to which urban roads are included in the main road networks varies from country to country, but in general they are best regarded as being separate.

2.2 Road Costs

Road costs are the costs of road infrastructure provision and maintenance. They are the costs incurred by the government department, institution or agency which has the task of managing the relevant highway network. These costs are sometimes called agency costs and it is quite common for more than one agency to be involved. In addition to the national road institution or department which is responsible for road network administration, other government departments supplying traffic police services and customs inspection posts at international borders, for example, are also involved in the highway sector.

Road costs can be divided into fixed and variable costs and this distinction is important in the analyses of road use costs which form the basis of the type of road user charging policy discussed later in this report. Fixed costs are those costs which are independent of road traffic and include most of the costs of administering or managing the road network. In practice, there is a fixed and variable (traffic dependant) element in most categories of road costs. Estimates made by the World Bank suggest that for main roads fixed costs could account for the following approximate proportions of the main categories of recurrent costs.

- per cent of main road policing costs
- per cent of administration costs
- per cent of routine maintenance costs
- per cent of periodic maintenance costs and
- per cent of interest charges on road loans, where relevant.

The above proportions can be regarded as an approximate guideline and should not be taken to be applicable to all circumstances.

Traditionally, road costs were equated with the costs incurred by the road agency or highway department responsible for the provision and maintenance of road infrastructure. This rather narrow view of road costs was reinforced by the usual methods of annual road budget estimation and allocation.

The main problem with this traditional approach was that it did not take sufficient account of or attempt to quantify the costs being incurred by the users of the road network. These are now recognised as being significantly higher in most cases than the agency costs of road management. In recent years it has been widely recognised that road user costs should be taken into account when decisions are being made about the appropriate level of expenditure on roadworks.

A common problem in all the TRACECA states is that the cost of maintaining and rehabilitating the main road networks is significantly higher than the budgets being made available for the purpose. The economic and engineering results of this situation are examined in some detail in Chapters 3 and 4. However, the implications are fairly clear. Unless adequate financing for road maintenance and rehabilitation can be made available from the traditional general government budgetary sources, either alternative financing mechanisms have to be found, or the size of the core main road networks which can be maintained to an adequate standard will have to be reduced.

2.3 Road User Costs

2.3.1 Definition of Road User Costs Used in this Study

Road user costs comprise vehicle operating costs, passenger time costs, the costs of goods in transit and accident costs. In practice, in relatively low income countries such as the TRACECA states passenger time costs are not particularly significant in comparison with the costs of vehicle operation. The situation is completely different in the richer economies of north America and western Europe, for example, where passenger time costs are the dominant element in road user costs both because the scale of people movements and because of high personal incomes.

In this study attention is focused on the vehicle operating cost component of road user costs. The relative insignificance of the contribution of passenger time costs at current and foreseeable per capita income levels in the short to medium term has already been mentioned and this is illustrated below and in greater detail in Chapter 3. The cost of goods in transit is an even less important component of road user costs given the scale of road rehabilitation and maintenance effects on road conditions. International evidence suggests that a major reduction in travel time is required before there is a significant effect on the cost of goods in transit. The reductions in travel time resulting from improved road maintenance and rehabilitation are incremental rather than major and the effects on the cost of goods in transit are very minor. The relative unimportance of the cost of goods in transit as a component of road user costs is also illustrated below and in Chapter 3.

Accident costs are very difficult to quantify adequately unless data on the cost and frequency of accidents in relation to specific road features and locations is already available at the required level of detail. This is seldom the case unless an appropriate research initiative has been undertaken .The available data on road accidents in the TRACECA states does not permit accident costs to be quantified at a meaningful level of precision without a level of field research input which is well beyond the resources of this study. However, it is unlikely on the basis of international evidence that the omission of accident costs from road user cost estimates would have a significant impact on the results of road user cost based analyses in the TRACECA states

The omission of time costs of goods and passengers and accident costs means that the estimates of road user costs based on vehicle operating costs are slightly conservative, but not excessively so. Most of the analyses involving road user costs are concerned with changes in costs rather than absolute costs. This fact further reduces the potential impact of omitting time costs of goods and passengers.

2.3.2 The Importance of Road User Costs in Total Transport Costs

Road user costs are by far the most important component of total road transport costs and vehicle operating costs are the most important element in road user costs in the TRACECA states. Estimates prepared by consultants Carl Bro International a/s in their 1995 engineering and economic feasibility study of the improvement of the Bishkek-Osh road in Kyrgyzstan suggest that the percentage contribution of passenger time costs and goods time costs to total road user costs was as follows:

- Passenger time costs

	Cars	5 % - 8 %
	Buses	11.% - 15.%
	Trucks	0.2 % -0.4 %

- Goods time costs

	Cars and buses	0 %
	Trucks	0.3% - 0.5 %

These findings are in agreement with our own sample analyses for other TRACECA states.. When the structure of traffic and the distribution of vehicle kilometres is taken into account the overall share of vehicle operating costs in road user costs is 92% to 95% for passenger cars, 85% to 89% for buses and over 99% for trucks.

Road user costs are overwhelmingly the most important component of total road transport costs in every country. In the TRACECA states annual road user costs on inter urban main roads currently amount to around US$ 7.9 billion. If the appropriate amounts were being spent on maintenance and rehabilitation, average annual expenditure on the main road networks in the TRACECA states would be of the order of US$ 531 million. Actual annual expenditure is nearer US$127 million. Even at optimum annual expenditure levels, road costs would amount to no more than 6 per cent of total road transport costs.

It can be seen from the above that quite small changes in road condition will have a disproportional large impact on road user costs and, hence, on total transport costs. The changes in road condition resulting from inadequate maintenance levels will, therefore, have a significant, adverse economic impact via increasing road user costs. This has important implications for planning road expenditure strategies and devising optimum road maintenance programmes. It is also the main reason why road maintenance and rehabilitation strategies should be based on the results of engineering and economic analysis rather than just on engineering estimates.

2.4 Other Costs

Potentially the most important external cost of road transport is environmental pollution, including noise pollution. In practice, however, the main environmental impacts are attributable to new road projects on new alignments and urban road traffic rather than to road maintenance and rehabilitation. An important contributor to the environmental costs of road transport in the TRACECA states is the low standards of vehicle emission control, but this is not something that can be solved by road improvements.

The omission of accident costs from our estimates of road user costs has already been discussed above. External environmental costs are also excluded on the grounds that they are not quantifiable within the context of a study such as this and because their impact on road maintenance and rehabilitation policy is unlikely to be significant.

2.5 Economic and Financial Costs

In economic and engineering feasibility studies of road investment projects it is customary to distinguish between financial and economic costs. Economic analyses should be based on economic costs which reflect real resource costs to the economy. In practice this means that taxes are excluded from economic costs but any subsidy element in costs is included.Economic costs should also include adjusted or shadow prices, where perceived costs do not reflect market prices. Economic analyses are usually carried out in constant price terms and there should, therefore, be no inflation factors built into economic costs.

In the context of planning highway expenditure requirements, notably optimum road maintenance and rehabilitation strategies, economic costs should be used in the relevant engineering and economic feasibility analyses. Once the optimum strategies have been established, however, it is necessary to present the roadworks costs as conventional financial costs for budgeting and programming purposes.

In most of the TRACECA states there are considerable practical difficulties in establishing what economic costs are. While it is relatively simple to discover what taxes should be paid and, hence, eliminated from economic costs, it is very difficult to establish accurately what taxes actually are paid. There is a danger in understating economic costs by deducting taxes which have not actually been paid. Similarly, there are considerable difficulties in untangling complex cross subsidy elements in prevailing prices. These factors plus the considerable amount of fieldwork and analysis required to develop a set of appropriate shadow prices for individual countries means that rigorous economic costing cannot be undertaken within the relatively short time periods which have been made available for road transport studies in the region in recent years.

In this study the analysis of vehicle operating costs has been based on financial costs. However, the analysis of optimum road use costs is based on the World Bank's analyses of optimum maintenance and rehabilitation strategies using international evidence and economic costs. Even if all taxes were paid in the TRACECA countries, the tax component of financial vehicle operating costs would not be as significant as it is in most western European countries and economic and financial vehicle operating costs are not, therefore, significantly different. Given the low level of vehicle taxes, the main tax element is in automotive fuels and even this is relatively small by international standards.

3 VEHICLE OPERATING COSTS

3.1 Sources of Data

In this chapter an analysis of financial vehicle operating costs for each of the TRACECA countries is presented. As explained in Chapter 2, attention has been focused on vehicle operating costs as by far the most important component of road user costs. However, the potential significance of including the cost of passenger time savings and the cost of goods in transit is also examined. The main purpose of the analysis is to demonstrate the importance of vehicle operating costs in total transport costs and to show how they vary with road condition.

The inputs for the vehicle operating costs analyses for the TRACECA countries are based on data collected during field visits and on information in other consultants' road feasibility study reports. Information for Turkmenistan was derived from the Consultant's 1995 study for the European Bank for Reconstruction and Development entitled "Review of Administration and Financing of Road Improvement".This information, notably on prices, was updated to reflect changes in Turkmenistan since 1995.

Considerable use has also been made of the following consultancy studies in the TRACECA countries which incorporate vehicle operating cost analyses in their findings:

- Road Rehabilitation Study in Kyrgyzstan for the Asian Development Bank. This feasibility study of the improvement of the Bishkek-Osh road was undertaken in 1995 by Carl Bro International a/s, Hoff and Overgaard a/s and Upham International Corporation

- Prefeasibility Study of the Baku-Astara Road in Azerbaijan which was carried out by Wilbur Smith and Associates for EC TACIS in 1995 and 1996.

- Road Rehabilitation Project Kazakhstan undertaken in 1995 for the Asian Development Bank by Louis Berger International Inc. in collaboration with Kazdornii.

Reference has also been made to a number of earlier studies, notably the 1991"Road and Road Transport Study in Russia, Ukraine, Kazakhstan and Belarus" which was produced by TecnEcon and CowiConsult for the European Bank for Reconstruction and Development, and TecnEcon's "Armenia Highway Survey" produced in 1994 for EC TACIS.

The findings of the following two studies carried out in former communist countries have also been of interest in the development of vehicle operating costs estimate in the TRACECA countries:

- The 1993 Road User Charges Study in Romania by NEDECO, DHV Consultants and the Netherlands Economic Institute for the World Bank and the Romanian Administration of Roads.

- The 1995 Study of Investment and Maintenance Strategy for the National and Provincial Roads in Vietnam produced in 1995 by Scott Wilson Kirkpatrick for the United Kingdom Overseas Development Administration

Finally, estimates of vehicle operating costs by Kazdornii in Kazakhstan and the Armenian Road Directorate's Project Implementation Unit in Yerevan both utilising all or part of the vehicle operating cost sub model in the World Bank's Highway Design and Maintenance Standards Model - HDM III - have been a particularly useful source of information.

3.2 Estimating Vehicle Operating Costs

The vehicle operating costs estimates developed for each of the TRACECA countries are based on the use of the vehicle operating sub model from the World Bank's HDM-III model. This vehicle operating cost model predicts the various components of vehicle operating costs based on assumptions about road and vehicle characteristics and unit costs. For each country six representative categories of vehicles were selected for costing and the operating costs for those vehicles were taken to be representative of the costs of all vehicles in that classes in each country. The following classes of representative vehicle types were selected for vehicle operating cost analysis:

- Passenger cars
- Utility vehicles comprising minibuses and pickups
- Large buses
- axle trucks
- axle trucks
- Trucks with more than 3 axles

This vehicle classification is the same as that used in the traffic analyses undertaken for this study and in the traffic and vehicle operating cost inputs for the Pavement Management System model being implemented in the TRACECA countries. In each country a representative vehicle model was selected within each vehicle category and the cost estimates were developed for that model. Every attempt has been made to ensure that the representative models are the most widely used within their class in each country. Only in Georgia was it possible to base the selection of representative vehicle models on vehicle registration data. In the other countries vehicle registration data was not available at an adequate level of detail for this to be possible. In these countries the selection of representative vehicle models was based on the results of the Consultant's moving observer traffic counts and on visual observations in bus and truck parks. Reference was also made to the representative models selected for costing in the other consultants' studies in Kyrgyzstan, Kazakhstan, Azerbaijan, Armenia and Turkmenistan referred to above. Most of the vehicles in use in the TRACECA countries are of Russian manufacture and there is, therefore, a much higher degree of uniformity in the representative models than would normally be expected in a multi-country study. Details of the representative vehicle types and models used in the analysis are set out in Annex 3, Table A.3.1.

Data inputs required for the operation of the vehicle operating cost sub model (VOCM) can be divided in to the following six categories:

- Roadway characteristics
- Vehicle characteristics
- Tyre wear data
- Vehicle utilisation data
- Unit costs
- Additional model coefficients

Where local data is not available for specified non-cost inputs, default values from within the model can be used. Most of the additional model coefficients used in this study are based on default values.

A detailed listing of all inputs for each representative vehicle for each country is set out in Annex 3, Table A.3.2.

A number of general observations on the input data are in order. Most of the technical coefficients relating to vehicle performance are based on default values within the VOCM. Technical information on the representative truck models, which are all of Russian or Ukrainian manufacture, has been obtained from other studies and technical literature.

Vehicle utilisation levels are low by international standards and this reflects the depressed economic conditions in all the TRACECA countries during the past 5 years and the problems faced by vehicle operators in a transition economic environment. The age of the vehicle fleet in each country is high by international standards and the sale of new vehicles is very low.

The scarcity of new vehicles means that it is difficult to obtain realistic information on the prices of new as opposed to second hand vehicles. The prices of second hand vehicles were checked at the weekly vehicle auctions in the capitals of the TRACECA countries visited and prices of low kilometrage vehicles was noted as a guide to estimating new vehicle prices. Vehicle prices are low by international standards and this reflects their predominantly Russian origin. This is particularly true for heavy trucks where Russian models within a given category tend to be significantly smaller than their international counterparts and also much cheaper.

The prices of petrol and diesel are important inputs in the VOCM and they are an important determinant of unit vehicle operating costs. Although there are large variations in the retail price of automotive fuels in the TRACECA countries, it is fair generalisation to state that these prices are also low by comparison with the prices in most advanced industrial countries and many developing countries. The average prices of petrol and automotive diesel in each country are summarized in Table 3.1. In certain cases these prices are the mid point of a range of retail prices observed during fieldwork. In most TRACECA countries the average 1996 petrol price is within the range US$ 0.20 - 0.35 per litre and the diesel price is within the range US$ 0.20 - 0.30 per litre. Prices in Tadjikistan are significantly higher and in Turkmenistan significantly lower than these ranges. The price of diesel in Azerbaijan is also very low, both in relation to the price of petrol and in relation to diesel prices in most other TRACECA countries.

TABLE 3.1: PETROL AND DIESEL PRICES

Country	Automotive Fuel Prices (1996 average level)	
	Petrol (US$/litre)	Diesel (US$/litre)
Armenia	0.35	0.30
Azerbaijan	0.35	0.14
Georgia	0.28	0.21
Kazakhstan	0.29	0.20
Kyrgyzstan	0.22	0.20
Tajikistan	0.43	0.40
Turkmenistan	0.10	0.07
Uzbekistan	0.38	0.30

Note: In some countries the indicated fuel price is the mid point of a range of prices observed during fieldwork.
Source: Fuel price data and Consultant's estimates

3.3 Relative Importance of Vehicle Operating Cost Components

The main vehicle operating cost components analysed in the VOCM are the following:

- Automotive fuel consumption
- Lubricants consumption
- Tyre consumption
- Crew time
- Maintenance spare parts consumption
- Maintenance labour time
- Depreciation and interest
- Overheads (in financial costs)

The relative importance of these operating cost components varies according to relative prices and to the vehicle operating environment as dictated by road geometry and surface roughness. Fuel consumption is conventionally regarded as a major component of vehicle operating cost and this is largely true in most of the TRACECA countries. In Turkmenistan, however, where fuel prices are exceptionally low, fuel is a relatively minor cost item in vehicle operation. Fuel consumption also becomes relatively less important in overall operating costs as road conditions deteriorate and vehicle speeds decline. This is counterbalanced by a more than proportionate increase in the importance of maintenance spare parts consumption and vehicle maintenance costs in general.

For each TRACECA country the base financial vehicle operating costs by vehicle type are set out in Table 3.2. Base vehicle operating costs are the costs on a paved road in fair condition with surface roughness of IRI 5 metres / kilometre. The most significant components of base costs are fuel, maintenance parts, depreciation and, for heavy vehicles only, tyres. Fuel generally accounts for 20 - 35 per cent of total costs for all vehicles except utility vehicles, where the proportion is higher. Maintenance parts consumption is responsible for around 20 - 25 per cent and depreciation for 10 - 25 per cent of total costs. Heavy goods vehicles and large buses have more tyres and higher wear and tear on them and for theses vehicles tyre costs can make up between 20 and 30 per cent of base operating costs.

The vehicle operating cost proportions shown in Table 3.3 and in Annex 3 Table A.3.4 are not fixed over the whole range of operating conditions. Rising surface roughness levels reflecting deteriorating road condition results in declining vehicle speeds which reduces the relative importance of fuel consumption in total costs. Maintenance costs, however, increase in relative significance with declining road condition.

A comparison has been made of the relative importance of different operating costs components for different vehicle types in good and bad road conditions. In order to keep it manageable the comparison is restricted to three countries - Armenia, Kyrgyzstan and Turkmenistan - where fuel prices are respectively higher than the TRACECA average, in the middle of the TRACECA range and well below the TRACECA range. The comparison covers roads in good condition, denoted by an International Roughness Index (IRI) of 3 metres / kilometre, and bad condition (IRI 12 metres / kilometre). The results of the comparison are set out in Annex 3 Table A.3.4 where the cost of individual components are expressed as a percentage of total vehicle operating costs.

Table 3.2 BASE VEHICLE OPERATING COSTS BY COMPONENT

Vehicle Operating Cost Component	US$ per 1,000 Vehicle Kilometres					
	Car	Utility	Large Bus	Truck 2 axle	Truck 3 axle	Truck >3 axle
ARMENIA						
Fuel	28.31	62.31	136.27	96.28	161.79	258.73
Lubricants	3.23	3.23	5.35	5.35	5.35	8.27
Tyres	3.65	4.06	118.48	52.23	125.45	266.98
Crew time	0.00	3.97	7.32	8.55	7.28	15.18
Maintenance labour	0.99	1.02	3.57	3.45	4.35	9.97
Maintenance parts	20.89	18.89	47.79	39.76	122.24	181.63
Depreciation	18.12	11.80	43.02	16.30	52.81	79.35
Interest	14.23	7.64	26.90	14.28	34.08	59.53
Overheads	0.00	10.00	20.00	25.00	25.00	25.00
TOTAL	**89.42**	**122.92**	**408.70**	**261.20**	**538.35**	**904.64**
AZERBAIJAN						
Fuel	28.76	58.02	64.19	40.65	79.27	121.95
Lubricants	3.04	3.04	5.05	5.05	5.05	7.79
Tyres	4.63	4.63	117.47	47.73	161.53	268.38
Crew time	0.00	3.98	10.12	8.71	8.21	16.75
Maintenance labour	1.09	1.14	3.68	3.72	4.69	10.80
Maintenance parts	23.28	22.91	32.59	39.59	105.89	147.78
Depreciation	28.83	18.64	91.91	46.62	93.84	97.07
Interest	22.58	11.81	40.87	20.96	51.86	64.50
Overheads	0.00	10.00	20.00	25.00	25.00	20.00
TOTAL	**112.21**	**134.17**	**385.88**	**238.03**	**535.34**	**755.02**
GEORGIA						
Fuel	22.68	55.54	101.29	60.76	118.76	182.89
Lubricants	3.11	3.11	5.16	5.16	5.16	7.97
Tyres	4.06	6.50	74.81	30.77	82.89	145.04
Crew time	0.00	3.10	7.05	6.06	5.72	8.81
Maintenance labour	0.77	0.83	2.92	2.90	3.46	7.84
Maintenance parts	21.07	33.13	47.80	55.79	114.18	149.68
Depreciation	23.46	25.12	76.54	28.35	77.60	101.03
Interest	20.67	15.80	47.89	22.99	51.45	64.15
Overheads	0.00	10.00	20.00	25.00	25.00	25.00
TOTAL	**95.82**	**153.13**	**383.46**	**237.78**	**484.22**	**692.41**
KAZAKHSTAN						
Fuel	23.61	53.32	92.85	60.77	124.12	172.53
Lubricants	3.04	3.04	5.05	5.05	5.05	7.79
Tyres	4.30	6.50	157.68	49.96	155.93	240.05
Crew time	0.00	22.29	72.40	38.62	52.36	75.61
Maintenance labour	6.10	6.50	22.66	22.60	27.31	60.19
Maintenance parts	27.30	34.14	40.76	58.28	113.90	150.34
Depreciation	25.27	18.81	52.24	18.42	58.13	76.76
Interest	17.07	10.26	27.75	12.31	27.21	42.40
Overheads	0.00	10.00	25.00	25.00	25.00	25.00
TOTAL	**106.69**	**164.86**	**496.39**	**291.01**	**589.01**	**850.67**

Table 3.2 BASE VEHICLE OPERATING COSTS BY COMPONENT

Vehicle Operating Cost Component	US$ per 1,000 Vehicle Kilometres					
	Car	Utility	Large Bus	Truck 2 axle	Truck 3 axle	Truck >3 axle
KYRGYZ REPUBLIC						
Fuel	17.73	40.08	97.29	60.14	91.65	158.71
Lubricants	3.46	3.46	5.74	5.74	5.74	8.86
Tyres	4.63	6.90	183.39	71.42	161.76	361.82
Crew time	0.00	9.43	19.24	20.22	16.54	35.55
Maintenance labour	2.51	2.79	9.85	8.42	11.84	27.12
Maintenance parts	21.07	36.54	57.00	42.43	118.40	170.65
Depreciation	25.01	18.46	60.58	36.21	52.71	54.95
Interest	25.53	14.69	42.06	33.60	41.06	51.00
Overheads	0.00	10.00	12.00	22.00	22.00	22.00
TOTAL	**99.94**	**142.35**	**487.15**	**300.18**	**521.70**	**890.66**
TAJIKISTAN						
Fuel	34.27	79.57	185.63	121.56	197.08	335.86
Lubricants	3.46	3.46	5.74	5.74	5.74	8.86
Tyres	4.47	6.50	175.86	96.27	170.13	377.75
Crew time	0.00	14.17	17.22	18.92	23.03	37.12
Maintenance labour	2.30	2.50	8.81	8.00	10.61	23.79
Maintenance parts	23.32	36.40	56.65	47.35	125.85	161.67
Depreciation	24.16	18.12	61.01	27.19	49.61	52.12
Interest	20.69	12.39	34.52	21.08	32.65	42.18
Overheads	0.00	10.00	12.00	22.00	22.00	22.00
TOTAL	**112.67**	**183.11**	**557.44**	**368.11**	**636.70**	**1061.35**
TURKMENISTAN						
Fuel	8.23	20.14	31.84	23.62	37.82	60.96
Lubricants	1.15	1.15	1.91	1.91	1.91	2.95
Tyres	4.87	4.87	118.33	72.39	125.39	295.46
Crew time	0.00	8.22	13.91	16.87	13.84	28.79
Maintenance labour	1.89	2.07	6.98	7.04	8.81	19.41
Maintenance parts	20.89	26.43	46.77	60.52	128.27	154.96
Depreciation	25.89	16.19	72.96	26.26	64.86	79.27
Interest	16.95	9.19	35.75	19.12	29.71	43.89
Overheads	0.00	10.00	22.00	25.00	25.00	25.00
TOTAL	**79.87**	**98.26**	**350.45**	**252.73**	**435.61**	**710.69**
UZBEKISTAN						
Fuel	31.28	73.75	136.46	96.58	162.07	261.27
Lubricants	3.23	3.23	5.35	5.35	5.35	8.27
Tyres	4.47	6.50	118.33	69.56	125.39	268.60
Crew time	0.00	6.41	12.41	14.50	12.34	25.56
Maintenance labour	1.67	1.83	6.15	6.20	7.88	17.22
Maintenance parts	23.88	34.35	45.26	54.47	125.85	153.86
Depreciation	29.59	20.59	70.60	23.49	61.77	77.66
Interest	19.37	11.24	34.59	16.91	28.29	42.99
Overheads	0.00	10.00	20.00	10.00	20.00	20.00
TOTAL	**113.49**	**167.90**	**449.15**	**297.06**	**548.94**	**875.43**

Note: Financial vehicle operating costs
Source: Consultant's estimates

The significance of fuel prices is evident from the wide differences in the relative importance of fuel consumption in total operating costs in the three countries. In Armenia, where automotive fuel prices are at the top end of the range in TRACECA countries, fuel accounts for one third or more of total operating costs on roads in good condition. This drops to 20 - 30 percent of total costs on paved roads in bad condition. In Turkmenistan, on the other hand, fuel consumption only accounts for around 10 percent of total operating costs on good roads and 6 - 8 percent on bad roads.

Tyres are a more significant cost component for heavy vehicles than for light passenger vehicles. Tyre costs actually decline in relative importance with increasing road roughness and declining vehicle speeds. Maintenance parts consumption increases sharply in relative importance as a component of operating costs as road roughness increases. Although maintenance labour increases in the same way, the low wage levels in the TRACECA countries means that this does not have as big an effect on costs as in higher income countries.

3.4 Summary of Base Vehicle Operating Costs By Vehicle Type and Country

The basic vehicle operating costs estimated for the representative vehicle types in the TRACECA countries are summarised in Table 3.3. These base costs are representative costs on paved roads in fair condition with a surface roughness of IRI 5 metres / kilometre.

The range of financial operating costs for each vehicle type over the TRACECA region can be summarised as follows:

- Cars US$ 0.08 - 0.11 per kilometre
- Utility vehicles US$ 0.10 - 0.18 per kilometre
- Large buses US$ 0.35 - 0.50 per kilometre
- axle medium truck US$ 0.24 - 0.30 per kilometre
- axle heavy truck US$ 0.44 - 0.64 per kilometre
- axle heavy truck with trailer US$ 0.09 - 1.06 per kilometre

A significant part of the reason for the differences in operating costs for given categories of vehicles is the variation in automotive fuel prices. These vehicle operating costs are quite low by international standards and the main reason is low vehicle prices, low fuel prices and low maintenance labour and crew costs.

TABLE 3.3: SUMMARY BASE VEHICLE OPERATING COSTS

Vehicle Operating Cost Component	Vehicle Operating Costs (US$ per Kilometre)					
	Car	Utility	Large Bus	Truck 2 axle	Truck 3 axle	Truck >3 axle
Armenia	0.09	0.12	0.41	0.26	0.54	0.90
Azerbaijan	0.11	0.13	0.39	0.24	0.54	0.76
Georgia	0.10	0.15	0.38	0.24	0.48	0.69
Kazakhstan	0.11	0.16	0.50	0.29	0.59	0.85
Kyrgyz Republic	0.10	0.14	0.49	0.30	0.52	0.89
Tajikistan	0.11	0.18	0.56	0.37	0.64	1.06
Turkmenistan	0.08	0.10	0.35	0.25	0.44	0.71
Uzbekistan	0.11	0.17	0.45	0.30	0.55	0.88

Note: Financial vehicle operating costs
Source: Consultant's estimates

3.5 The Effect of Road Conditions on Vehicle Operating Costs

3.5.1 Road Condition and Road Surface Roughness

Deterioration in road conditions results in increases in vehicle operating costs. For the road user changes in road condition are mainly reflected in changes in surface roughness or bumpiness. There are several measures of road surface roughness, but the International Roughness Index (IRI) has emerged as the most commonly used international standard measure. The IRI reflects the cumulative vertical movements in a vehicle's rear axle per kilometre and it is expressed in metres per kilometre. Our discussion of the relationship between road condition and vehicle operating costs must involve frequent references to different levels of IRI and it is important to be quite clear about what they mean in qualitative terms.

The range of surface roughness usually considered in highway studies is from IRI 2 m/km to IRI 20 m/km. A roughness level of less than IRI 3 m/km means that the road is in excellent to good condition. For paved roads an IRI of 10 m/km or more denotes a road in bad to very bad condition and anything over IRI 12 m/km would indicate extensive pavement failure or loss of pavement. On unpaved roads roughness levels are generally higher than on paved roads and slightly more relaxed qualitative standards are usually applied. For example, an unpaved road with an IRI of less than 5 m/km would be considered to be in good to quite good condition and very bad condition might be considered to be IRI 15 and over. When surface roughness levels approach IRI 20 m/km it is doubtful if the road retains any engineered properties and for operating purposes can be considered to be a track.

This study is mainly concerned with the inter state and intra state main road networks in the TRACECA countries and the overwhelming majority of these are paved. This section will, therefore, concentrate on roughness levels on paved roads. The following indications of road condition at different roughness levels will be helpful in understanding the subsequent discussion of the relationship between road surface roughness and vehicle operating costs.

Roughness IRI < 3.0 m/km

Vehicle speeds of over 120 km/h are comfortable. No depressions, potholes or corrugations are noticeable. This roughness level would be associated with high quality asphalt and, possibly, very good quality surface treatment. International evidence suggests that concrete pavements rarely achieve roughness levels this low.

Roughness IRI 4.0 - 5.5 m/km

In vehicles travelling at 80 km/h moderately perceptible movements or large undulations may be felt. Defective surface is evident with occasional depressions, patches or potholes or many shallow potholes. In the absence of visible surface defects there may be moderate corrugations or large undulations. Concrete pavements built during the Soviet era were unlikely to have had initial roughness levels below IRI 4 m/km

Roughness IRI 7.0 - 8.0 m/km

At vehicle speeds of 70 - 90 km/h the ride remains reasonably comfortable, but there are strongly perceptible movements and swaying usually associated with defects. These may take the form of frequent, moderate and uneven depressions or patches, and occasionally potholes.

Roughness IRI 9.0 - 10.0. m/km

The ride only remains comfortable at vehicle speeds of 50 - 60 km/h and there can be frequent sharp movements and swaying. These are associated with severe defects taking the form of frequent, deep and uneven depressions, patches and potholes.

Roughness IRI 11.0 - 12.0 m/km

Vehicle speeds generally have to be below 50 km/h because there are many deep depressions and severe disintegration.

In the following discussions of surface roughness and vehicle operating costs the above qualitative categorisation of pavement condition will be simplified as follows:

- IRI 3 m/km or less - good condition
- IRI 5 - 6 m/km - fair condition
- IRI 7 - 9 m/km - moderate to poor condition
- IRI 10 m/km or over - bad to very bad condition

Table 3.4 TOTAL VEHICLE OPERATING COSTS AT DIFFERENT ROAD SURFACE ROUGHNESS LEVELS

Country	Length of main road network (a) (km)	Vehicle-Km on the main road network (million)	Total Vehicle Operating Costs (US$ million) if average main road condition was: Good (IRI 3 m/km)	Fair (IRI 6 m/km)	Poor (IRI 9 m/km)	Very bad (IRI 12 m/km)
Armenia	3,147.8	1,970.0	309	354	404	461
Azerbaijan	4,689.0	4,496.0	967	1,095	1,236	1,392
Georgia	5,005.3	2,088.4	293	336	387	444
Kazakhstan	17,496.0	10,089.0	2,004	2,360	2,756	3,190
Kyrgyzstan	3,109.9	1,506.1	297	341	390	444
Tajikistan	1,785.2	620.6	147	166	188	212
Turkmenistan	7,682.6	3,545.4	841	972	1,112	1,263
Uzbekistan	21,825.0	10,466.7	2,635	3,009	3,418	3,862

Country	Percentage Increase in Vehicle Operating Costs compared with those on roads in good condition: Condition Fair (IRI 6 m/km)	Condition Poor (IRI 9 m/km)	Condition Very bad (IRI 12 m/km)
Armenia	14.5	31.0	49.4
Azerbaijan	13.2	27.8	43.9
Georgia	14.9	32.1	51.5
Kazakhstan	17.8	37.5	59.2
Kyrgyzstan	14.7	31.2	49.4
Tajikistan	13.3	28.2	44.6
Turkmenistan	15.5	32.2	50.1
Uzbekistan	14.2	29.7	46.6
ALL	15.2	32.0	50.4

Source: Consultant's estimates

3.5.2 The Relationship Between Vehicle Operating Costs and Road Roughness

The World Bank's HDM-III model is a road simulation model and the vehicle operating cost sub model within it simulates the behaviour of vehicles in response to actual and predicted changes in road condition and surface roughness. The slightly simplified vehicle operating cost sub model (VOCM) used for this study presents the relationship between road roughness and vehicle operating costs in the form of the following two alternative formulations:

- VOC = a + b (IRI) + c (IRI^2)
- VOC = exp[a + b (IRI)]

where VOC = unit vehicle operating cost per kilometre
IRI = road surface roughness in metres per kilometre
a and b are parameters to be solved for each vehicle type

In practice, the first form of the simplified model has been found to give the better statistical relationship in the TRACECA countries and it has been adopted for use in this study.

On the basis of the inputs described earlier, vehicle operating cost estimates have been prepared for each of the six representative vehicle types in each TRACECA country. The detailed results are presented in Annex 3 Table A.3.5 . This shows the results from the model for each vehicle type in each country and the unit vehicle operating costs per kilometre at IRI 3 up to IRI 15 m/km. All operating costs are in US dollars.

The results can be summarised quite briefly. For each increase in road surface roughness of IRI 1 m/km unit vehicle operating costs rise by 5 - 7 percent for light vehicles and 2 - 5 percent for heavy vehicles. When allowance is made for the structure of traffic and the mix of vehicle kilometres in the TRACECA countries, each increase of IRI 1 m/km in surface roughness can be shown to result in an increase in total vehicle operating costs of 4 - 5 percent. Translating this into a comparison of vehicle operating costs on roads in good, fair, poor and bad condition, the overall average increase in operating costs compared with a road in good condition are as follows:

- Road in fair condition (IRI 6 m/km) - operating costs 15 percent higher
- Road in poor condition (IRI 9 m/km) - operating costs 32 percent higher
- Road in very bad condition (IRI 12 m/km) - operating costs 50 per cent higher

Total vehicle operating costs in each country have been estimated by multiplying the unit vehicle operating costs for each vehicle type by the total annual vehicle kilometres for the same vehicle types. The vehicle kilometre estimates for each country are described in Chapter 6. Total vehicle operating costs in each country at different roughness levels are shown in detail in Annex 3 Table A.3.6. The results are summarised in Table 3.4. In Kazakhstan, for example, an increase in average main road roughness levels from , say, IRI 5 m/km to IRI 6 m/km would result in an increase in annual vehicle operating costs on main inter urban roads of US$ 123 million at present traffic levels. This is US$ 52 million or 75 percent more than the country's total road budget in 1995. Examples from the other countries would show a similar picture.

Road surface roughness levels have been reported to be increasing at around 7 percent a year on the main roads in the TRACECA region and in some countries such as Armenia and Georgia it could be nearer 20 per cent. Assuming an annual rate of increase of 10 per cent in average main road network roughness it would take 7 years for average network condition to deteriorate from good (IRI 3 m/km) to fair (IRI 6 m/km) and a further 4 years for it to deteriorate to poor (IRI 9 m/km). At the much higher rates of deterioration reported in the Caucasus region the same developments would take 4 and 2 years respectively. In Armenia an increase in average main road network roughness from IRI 3 to IRI 6 m/km implies an increase in annual vehicle operating costs of US$ 45 million at present traffic levels and if roughness progression really is 20 percent a year, this loss would be incurred over only 4 years. A further increase in average roughness from IRI 6 m/km to IRI 9 m/km over two or three years would result in a further increase of US$ 50 million in vehicle operating costs at present traffic levels.

These operating costs magnitudes obviously have a potentially serious impact on costs elsewhere in the economy. They also provide a clue as to why appropriate road maintenance and rehabilitation designed to arrest road network roughness progression has such a high economic priority. Such maintenance and rehabilitation can be undertaken for costs which are very significantly less than the potential savings in vehicle operating costs which they can bring about. For this reason appropriate road maintenance and rehabilitation programmes have high economic rates of return which is another way of saying that they are of high economic priority.

3.6 Economic Significance of Vehicle Operating Costs

In the TRACECA countries as a group vehicle operating costs on the main inter urban road networks amount to not less than 14 percent of Gross Domestic Product (GDP) or 6 percent of GDP at purchasing power parity. The estimates of GDP are based on data from the World Bank and the European Bank for Reconstruction and Development (EBRD).

There are some variations about this average in the different countries, but only in Azerbaijan is it significantly different. The available data suggest that total inter urban main road vehicle operating costs in Azerbaijan could amount to more than 30 percent of GDP or 10 per cent of GDP at purchasing power parity. This ratio double the TRACECA region average and it seems unlikely to be correct. There are two possible explanations. The first is that the available estimates of Azerbaijan's GDP may be too low. The second is that the data on Azerbaijan traffic on which our estimates of vehicle kilometres and, hence, total vehicle operating costs are based may be significantly overstated. However, the degree of overstatement of traffic volumes would have to be very large indeed to explain such a high ratio of operating costs to GDP, and this to be inherently unlikely. Given the presently available data, an underestimate of GDP seems to be the more plausible explanation.

The ratios of total vehicle operating costs to GDP in the TRACECA countries are high enough for the economic significance of rising, or indeed falling, road roughness levels to be self evident. A comparison of total vehicle operating costs and GDP in each of the TRACECA countries is set out in Annex 3 Table A.3.7. Background economic data are presented in Table A.3.8.

3.7 Potential Significance of Passenger and Goods Delay Costs

The overwhelming importance of vehicle operating costs in road user costs has already been discussed briefly in Chapter 2. The main evidence for this is the work undertaken in the road feasibility studies in Azerbaijan and Kyrgyzstan undertaken respectively by Wilbur Smith and Associates and Carl Bro International a/s. In the Baku - Astara road study in Azerbaijan the consultants estimated vehicle operating costs and passenger delay costs. In Carl Bro International's study of the Bishkek - Osh road in Kyrgyzstan vehicle operating costs and the costs of delays to goods in transit were estimated.

The assessment of passenger delay costs involves the following steps:

- Estimating the average number of passengers per vehicle.
- Estimating the value of time for different categories of passengers which involves obtaining information on passenger occupations.
- Estimating what proportion of passenger time saved could be used productively. This is usually based on information on trip purposes derived from detailed roadside interview surveys of vehicle drivers and passengers.

The valuation of the cost of delays to goods in transit involves valuing the goods making up vehicle loads and the cost of time represented by an interest rate.

The information required for these valuations is very detailed which explains why estimates of the cost of delays to passengers and goods is only attempted in the context of detailed road feasibility studies. Experience from many road feasibility studies in low income countries throughout the world has shown that the economic value of passenger and goods time saved is usually a very small fraction of the value of vehicle operating costs. This is another reason why they are sometimes omitted from studies which are being undertaken under limited budgets and time constraints.

Using the methodology described above, the consultants undertaking the studies in Azerbaijan and Kyrgyzstan estimated the value of delays to passengers and goods in transit as follows:

- **Azerbaijan.** The valuation of passenger time was based on average wage rates and on this basis, and taking account of occupational categories, the time of car and bus passengers was estimated to be equivalent to US$ 0.51 and 0.35 per hour. However, it was assumes that only 30 percent of car passengers' and 20 percent of bus passengers' trips were for economically productive purposes and the real value of time saved was accordingly reduced to these proportions of the full time value. In effect the real hourly value of passenger time saved was US$ 0.15 for car passengers and US$ 0.07 for bus passengers. The average number of passengers per vehicle was assumed to be two for cars and thirty four for large buses. The value of delays to goods in transit was not estimated, presumably because it was assumed to be insignificant.
- In the **Kyrgyzstan** study passenger time values were also based on weekly wage rates and an undifferentiated hourly value of US$ 0.36 was initially estimated for passengers of all vehicle types. However, only 50 percent of passenger time saved was assumed to be potentially used

productively and the real value of passenger time saved was, therefore, US$ 0.18. Average vehicle occupancy was assumed to 3.5 passengers per car, 6.5 passengers per utility vehicle and 32 passengers per bus.

- **Kyrgyzstan cargo delay costs.** The basis of the estimate was an assumption from origin-destination survey evidence that 10 percent of trucks were carrying perishable commodities, mainly fruit and vegetables, and 50 percent were carrying non-perishable goods. A representative value of US$ 200 per tonne was estimated for perishable cargoes, 0.5 percent of the cargo was assumed to be spoiled per day and an hourly interest rate of US$ 0.013 was calculated. The hourly cargo delay cost was accordingly estimated at US$ 0.01 per tonne of truck capacity and this translated into the following cargo delay costs by truck type:

- 2 axle truck	US$ 0.05 per hour
- 3 axle truck	US$ 0.10 per hour
- >3 axle truck	US$ 0.15 per hour

In order to test the significance of passenger and goods time costs compared with vehicle operating costs in Azerbaijan and Kyrgyzstan we have entered assumed time values into the operating cost model for each country and rerun the model. In fact the passenger time value for Azerbaijan was rounded up to a uniform US$ 0.15 per hour for passengers on all vehicle types. Kyrgyzstan passenger time value was rounded up from US$ 0.18 per hour to US$ 0.20 per hour. The value of goods delay costs per hour were as set out above. The respective models for the two countries were then run and the results are summarises in Annex 3 Table A.3.9

In Azerbaijan annual passenger time costs only account for 3.9 per cent of the total of vehicle operating costs and passenger time costs. In Kyrgyzstan the proportion is 5.9 per cent. Cargo delay costs were only valued in the Kyrgyzstan study and they vary insignificant indeed. Compared to annual vehicle operating costs of US$ 324.1 million and passenger time costs of US$ 20.3 million, cargo delay costs amounted to only US$ 679,000 or 0.2 per cent of total road user costs. A number of tests for other TRACECA countries showed the same picture.

In view of the low prevailing income levels and the resulting very low economic time values in the TRACECA states their marginal contribution to road user costs in the inter urban road context hardly justifies the considerable effort required to quantify them. This conclusion would not, however, be necessarily valid in the urban road transport context.

4 ECONOMIC IMPACT OF ROAD MAINTENANCE

4.1 Introduction

The purpose of road maintenance is to make sure that a road does not fail before its design life. Successful road maintenance achieves this by reducing the road's rate of deterioration and, by slowing down the rate of surface roughness progression, it enables road user costs to be lower than they would otherwise have been. The overwhelming importance of road user costs in total road transport costs has already been demonstrated in Chapter 3 and anything which reduces these costs has a significant effect. The economic impact of a reduction in road user costs must, however, be assessed in relation to the costs of achieving it. In this respect, maintenance, which is a relatively low cost activity in comparison, for example, with new road construction, is highly desirable from the economic perspective as well as being good engineering practice. This is reflected in the high economic rates of return to maintenance programmes which are appropriate in scale and timing. In short, road maintenance is one of the most appropriate uses of scarce budgetary resources in the transport sector.

In the past the main problem with road maintenance in many low income countries had nothing to do with engineering or economics, but rather with image. Road maintenance was perceived to be a rather mundane activity with none of the political attractions of higher profile new construction projects. In Africa and Latin America this led to a neglect of road maintenance and a very high economic costs were subsequently incurred. The sharp contraction in highway budgets in the late 1970s and 1980s came about just as the effects of neglected maintenance were becoming highly visible. Attitudes toward highway maintenance have subsequently changed and this reflects both the new budgetary realities and the prompting of international donors such as the World Bank.

In the TRACECA countries highway maintenance has been inadequate in the 1990s and the effects are becoming evident in rising road surface roughness levels. This means that in the more serious cases rehabilitation is needed as well as maintenance. In the most serious cases the situation will have deteriorated to a point where the pavement may have to be completely reconstructed. The progression from routine and periodic maintenance to rehabilitation and reconstruction involves very large increases in the cost of roadworks. Inadequate allocations of funds to road maintenance have been a result of severe contractions in state budgetary resources and this in turn has reflected the economic crisis experienced by most of the TRACECA countries.

4.2 Road Maintenance, Road Condition and Road User Costs

The use of computerised models to simulate pavement behaviour has enabled the effects of different maintenance levels on road condition and road user costs to be predicted with greater precision in recent years. The development of the World Bank's HDM-III model and its use to analyse the economic implications of network deterioration in low income countries in the late 1980s did much to focus attention on the vital importance of appropriate maintenance. It has also been widely used to develop optimum maintenance and rehabilitation strategies for different road conditions with and without budget constraints.

Under the current TRACECA project all 8 recipient states are provided with hardware and software for a computerised data base and a pavement management system (PMS).The model used in this PMS to predict pavement deterioration and surface roughness progression is from the latest version of the World Bank's Highway Design and Maintenance Standards model (HDM-IV) which is currently being tested. The model basically takes account of existing pavement condition as measured by roughness (IRI in m/km), pavement age and strength, the incidence of rutting and cracking, cumulative pavement damage from axle loading and environmental factors represented by an environmental coefficient. The specification of the roughness prediction model is as follows:

$$IRI_t = 0.98 * e^{mt} * [RI_0 + 135 SNCK_4^{-5} * NE_t] + [0.143 * RDS_t] + [0.0068 * CRX_t] + [0.056 * PAT_t]$$

Where	$SNCK_4$	=	$1 + SNC - 0.00004 * HS * CRX_t$
	RI_t	=	roughness at pavement age t, IRI in m/km
	RI_0	=	initial roughness, IRI in m/km
	NE_t	=	cumulative equivalent standard axle loads (ESAL) at age t, in million ESA/lane
	t	=	pavement age since construction or rehabilitation in years
	m	=	environmental coefficient
	SNC	=	structural number modified for subgrade strength
	HS	=	thickness of bound layers in mm
	CRX_t	=	area of indexed cracking (%) at time t
	RDS_t	=	standard deviation of rut depth in mm at time t
	PAT_t	=	area of patching (%) at time t

The use of this and other pavement models in engineering and economic analysis of road maintenance and rehabilitation is needed to predict the progression of surface roughness with or without some form of treatment, and the reduction of roughness resulting from a treatment. Once the year by year roughness has been predicted, there is a direct link with road user costs via the type of models illustrated in Chapter 3.

The economic analysis of alternative maintenance and rehabilitation options takes the form of a discounted cash flow analysis over a defined period or life cycle. It is customary in this type of analysis to compare one or more defined alternatives with an option representing doing the minimum possible. The latter is sometimes called the "without situation" and the former the "with situation(s)". It is important to realise that over long appraisal or life cycle periods of 10 or more years doing the minimum in the "without situation" is very unlikely to mean doing nothing. Therefore, the occasional references to the "do nothing situation" which are encountered in some analyses are misleading and they should be avoided. The total engineering and road user costs under the two options are compared and the results are expressed in the form of different measures of economic feasibility or project worth. These include the Net Present Value (NPV) which is the sum of the discounted net benefits over the defined appraisal period, the NPV per kilometre, and the Internal Rate of Return (IRR), which is the discount rate at which costs and benefits are equated. The Benefit/Cost Ratio (B/C ratio) is also sometimes used, particularly when establishing priorities under budget constraint. The B/C ratio is the ratio of discounted benefits to discounted costs.

These measures indicate economic priority, although on technical grounds the NPV and B/C ratio are superior to the IRR for this purpose. The general decision rule is that the higher the NPV, B/C ratio and IRR, the higher the economic priority of the proposed expenditure. When choosing between a number of alternative maintenance strategies for a given combination of road condition and traffic, the strategy showing the highest NPV or NPV per kilometre is normally chosen. The IRR is not a particularly reliable measure for ranking alternatives in order of economic priority, but it is widely used, particularly by international donor organisations, because its use avoids the necessity of defining the appropriate discount rate to be used in different countries.

A detailed description of economic project appraisal methodologies is not required in a study such as this. The brief summary given above is designed to provide sufficient background explanation to facilitate understanding of the two illustrative examples of the economic effects of road maintenance which are set out in Tables 4.1 and 4.2.

These two examples are taken from the maintenance strategy analyses undertaken within the pavement management system currently being implemented by the Consultant in the TRACECA countries. In Table 4.1 the economic analysis compares the following alternative strategies for a specified road section:

- Undertake routine maintenance and patching only in a do minimum strategy.
- Provide an initial overlay, undertake routine maintenance and patching, and then provide a subsequent overlay at a defined roughness threshold level.

The table shows how roughness progresses under the alternative scenarios and how this affects the level of road user costs. The net economic benefits in each year are obtained by subtracting total transport costs under Strategy 1 from total transport costs under the minimum maintenance strategy (Strategy 0). The results of the discounted cash flow analysis show that Strategy 1 is economically highly desirable and preferable to the minimum maintenance strategy because the NPV at the indicated discount rates is positive. If the do minimum strategy had been the better one, the NPV would have been negative at the indicated discount rates and the IRR would have been below 10 or 15 percent. The analysis shows that spending US$ 788,086 more than required by the minimum maintenance alternative results in this instance in an undiscounted saving in total transport costs of US$ 2.5 million over the appraisal period.

The second example set out in Table 4.2 involves a similar comparison of a minimum maintenance strategy of routine maintenance and patching with a strategy involving deferred rehabilitation in addition to routine maintenance and patching. Roughness under the two alternatives is the same until Year 6 when the deferred rehabilitation takes place and there are, therefore, no saving in road user costs until Year 6. The result of this comparison shows that the strategy of deferred rehabilitation in this situation is of only marginal priority and its economic feasibility is dependent on what is defined as the appropriate discount rate. If the discount rate is only 10 percent, the deferred rehabilitation strategy is acceptable, but if it is 15 percent, the minimum maintenance strategy is preferable.

The analysis of optimum maintenance strategies involves repeating this type of analysis many times for alternative road expenditure options. In the pavement management system being implemented in the TRACECA countries an exhaustive list of options is compared for each road section, and only the 20 options showing the highest economic priority are stored in the computer database for future reference.

Traffic volumes obviously have an important effect on road pavements, but the precise nature of the effect is not always clearly understood. The inclusion of cumulative equivalent standard axles as an important variable in the model set out above gives an idea of the nature of the traffic effect. This is discussed more fully below.

Table 4.1 EXAMPLE OF THE ECONOMIC IMPACT OF MAINTENANCE AND REHABILITATION.

Road section length (km) = 7.00

Year		Traffic Loading		Pavement Roughness (IRI m/km)		Economic Costs (US$'000)								
						Minimum Maintenance (Strategy 0)				Required Maintenance (Strategy 1)				Undiscounted
No.	Actual	Equivalent Standard Axles (ESALs million)	Cumulative ESALs (million)	Minimum Maintenance -Strategy 0	Requi..d Maintenance -Strategy 1	Routine Maintenance Costs	Other Maintenance Costs	Vehicle Operating Costs	Total Transport Costs (A)	Routine Maintenance Costs	Other Maintenance Costs	Vehicle Operating Costs	Total Transport Costs (B)	Net Cah Flow (A)-(B)
0	1996	0.11	0.11	7.52	3.92	0.70	0.00	277.50	**278.20**	0.70	382.40	231.54	**613.94**	-335.74
1	1997	0.12	0.23	7.81	4.06	0.70	0.00	287.17	**287.87**	0.70	0.00	237.85	**238.55**	49.32
2	1998	0.12	0.35	8.12	4.21	0.70	0.00	297.43	**298.13**	0.70	0.00	244.40	**245.10**	53.03
3	1999	0.12	0.47	8.43	4.36	0.70	0.00	308.21	**308.91**	0.70	0.00	251.20	**251.90**	57.01
4	2000	0.12	0.59	7.76	4.52	0.70	0.00	319.56	**320.26**	0.70	0.00	258.26	**258.96**	61.30
5	2001	0.13	0.72	9.11	4.68	0.70	0.00	331.52	**332.22**	0.70	0.00	265.60	**266.30**	65.92
6	2002	0.13	0.85	9.46	4.86	0.70	0.00	354.24	**354.94**	0.70	0.00	281.41	**282.11**	72.83
7	2003	0.14	0.99	10.12	5.04	0.70	0.00	384.24	**384.94**	0.70	0.00	298.26	**298.96**	85.98
8	2004	0.14	1.13	10.51	5.24	0.70	0.00	411.23	**411.93**	0.70	0.00	316.22	**316.92**	95.01
9	2005	0.15	1.28	10.93	5.45	0.70	0.00	440.50	**441.20**	0.70	0.00	335.62	**336.32**	104.88
10	2006	0.16	1.44	11.35	5.67	0.70	0.00	472.20	**472.90**	0.70	0.00	356.34	**357.04**	115.86
11	2007	0.17	1.61	11.80	3.92	0.70	0.00	506.64	**507.34**	0.70	405.70	342.58	**748.99**	-241.65
12	2008	0.17	1.78	12.84	4.06	0.70	0.00	559.07	**559.77**	0.70	0.00	362.29	**362.99**	196.78
13	2009	0.18	1.96	13.33	4.21	0.70	0.00	600.78	**601.48**	0.70	0.00	383.23	**383.93**	217.55
14	2010	0.19	2.15	13.85	4.36	0.70	0.00	646.38	**647.08**	0.70	0.00	405.49	**406.19**	240.89
15	2011	0.20	2.35	14.40	4.52	0.70	0.00	696.31	**697.01**	0.70	0.00	429.18	**429.88**	267.14
16	2012	0.21	2.56	14.97	4.68	0.70	0.00	750.89	**751.59**	0.70	0.00	454.38	**455.08**	296.51
17	2013	0.22	2.78	15.58	4.86	0.70	0.00	810.74	**811.44**	0.70	0.00	481.48	**482.18**	329.26
18	2014	0.24	3.02	16.22	5.05	0.70	0.00	876.55	**877.25**	0.70	0.00	510.36	**511.06**	366.19
19	2015	0.25	3.27	16.92	5.25	0.70	0.00	950.15	**950.85**	0.70	0.00	541.16	**541.86**	408.99
Undiscounted Totals						14.00	0.00	10,281.30	**10,295.30**	14.00	788.10	6,986.84	**7,788.25**	2,507.06

Net Present Value (NPV) @ 10% discount rate	480.06
Net Present Value (NPV) @ 15% discount rate	185.70
Net Present Value (NPV) @ 21.94 % discount rate	0.00
Internal Rate of Return (IRR %)	21.94
NPV per Km @ 10% discount rate	68.58
NPV per Km @ 15% discount rate	26.53
NPV per Km @ 21.94 % discount rate	0.00

Source: Consultant's estimates

Table 4.2 EXAMPLE OF THE ECONOMIC IMPACT OF DEFERRED REHABILITATION.

Road section length (km) = 7.00

Year		Traffic Loading		Pavement Roughness (IRI m/km)		Economic Costs (US$'000)								
						Minimum Maintenance (Strategy 0)				Required Maintenance (Strategy 1)				Undiscounted
No.	Actual	Equivalent Standard Axles (ESALs million)	Cumulative ESALs (million)	Minimum Maintenance -Strategy 0	Required Maintenance -Strategy 1	Routine Maintenance Costs	Other Maintenance Costs	Vehicle Operating Costs	Total Transport Costs (A)	Routine Maintenance Costs	Other Maintenance Costs	Vehicle Operating Costs	Total Transport Costs (B)	Net Cah Flow (A)-(B)
0	1996	0.11	0.11	7.52	7.52	0.40	0.00	158.57	**158.97**	0.40	0.00	158.57	**158.97**	0.00
1	1997	0.12	0.23	7.81	7.81	0.40	0.00	164.10	**164.50**	0.40	0.00	164.10	**164.50**	0.00
2	1998	0.12	0.35	8.12	8.12	0.40	0.00	169.96	**170.36**	0.40	0.00	169.96	**170.36**	0.00
3	1999	0.12	0.47	8.43	8.43	0.40	0.00	176.12	**176.52**	0.40	0.00	176.12	**176.52**	0.00
4	2000	0.12	0.59	7.76	7.76	0.40	0.00	182.61	**183.01**	0.40	0.00	182.61	**183.01**	0.00
5	2001	0.13	0.72	9.11	9.11	0.40	0.00	189.44	**189.84**	0.40	0.00	189.44	**189.84**	0.00
6	2002	0.13	0.85	9.46	2.45	0.40	0.00	202.42	**202.82**	0.40	800.00	142.44	**942.84**	-740.02
7	2003	0.14	0.99	10.12	2.54	0.40	0.00	219.57	**219.97**	0.40	0.00	150.23	**150.63**	69.33
8	2004	0.14	1.13	10.51	2.63	0.40	0.00	234.99	**235.39**	0.40	0.00	158.47	**158.87**	76.52
9	2005	0.15	1.28	10.93	2.73	0.40	0.00	251.71	**252.11**	0.40	0.00	167.20	**167.60**	84.52
10	2006	0.16	1.44	11.35	2.83	0.40	0.00	269.83	**270.23**	0.40	0.00	176.44	**176.84**	93.39
11	2007	0.17	1.61	11.80	2.93	0.40	0.00	289.51	**289.91**	0.40	0.00	186.22	**186.62**	103.29
12	2008	0.17	1.78	12.84	3.05	0.40	0.00	319.47	**319.87**	0.40	0.00	196.69	**197.09**	122.78
13	2009	0.18	1.96	13.33	3.17	0.40	0.00	343.30	**343.70**	0.40	0.00	207.80	**208.20**	135.51
14	2010	0.19	2.15	13.85	3.30	0.40	0.00	369.36	**369.76**	0.40	0.00	219.58	**219.98**	149.78
15	2011	0.20	2.35	14.40	3.44	0.40	0.00	397.89	**398.29**	0.40	0.00	232.25	**232.65**	165.64
16	2012	0.21	2.56	14.97	3.59	0.40	0.00	429.08	**429.48**	0.40	0.00	245.72	**246.12**	183.36
17	2013	0.22	2.78	15.58	3.75	0.40	0.00	463.28	**463.68**	0.40	0.00	260.04	**260.44**	203.24
18	2014	0.24	3.02	16.22	3.91	0.40	0.00	500.89	**501.29**	0.40	0.00	275.34	**275.74**	225.55
19	2015	0.25	3.27	16.92	4.09	0.40	0.00	542.95	**543.35**	0.40	0.00	291.63	**292.03**	251.32
Undiscounted Totals						8.00	0.00	5,875.02	5,883.02	8.00	800.00	3,950.83	4,758.83	1,124.19
										Net Present Value (NPV) @ 10% discount rate				73.70
										Net Present Value (NPV) @ 15% discount rate				-33.49
										Net Present Value (NPV) @ 21.94 % discount rate				0.00
										Internal Rate of Return (IRR %)				12.82
										NPV per Km @ 10% discount rate				10.53
										NPV per Km @ 15% discount rate				-4.78
										NPV per Km @ 21.94 % discount rate				0.00

Source: Consultant's estimates

4.3 The Effect of Axle Loads on Road Pavements

Heavy vehicle traffic is a an important contributor to the deterioration of road pavements. This contribution to pavement damage over time is sometimes mistakenly attributed to gross vehicle weight, but this is only true under special circumstances. In general, the damage caused to road pavements by vehicles is a function of a complex combination of factors of which the weight on the vehicle axles is the best known and most easily measured. Damage to bridges and other road structures on the other hand is a function of gross vehicle weight, but it is damage to pavements which is the main item of interest in the context of this study.

The effects on pavements considered in this section concentrate on structural damage, which is the most important factor influencing effective pavement life. Other forms of damage, such as those to wearing courses, are not discussed further because they can be attributed to all types of vehicles.

The axle load has traditionally been treated as the sole damage factor since the research undertaken in the 1950s by the American Association of State Highway Officials (AASHTO). However international research undertaken over the last 20 years has demonstrated that the picture is more complex and that the following factors are also important:

- the type of axle, including the number of wheels and the type of tyres,
- the axle grouping - single, tandem and triple (tridem),
- The surface contact pressure of the tyres and
- the vehicle suspension system.

The precise effect and relative importance of these also varies according to whether the damaging potential being considered is to flexible or rigid pavements. The main problem with utilising the results of the more recent research is that it is extremely difficult in practice to obtain adequate data on all the above variables for each vehicle using a road. For this reason, the traditional AASHTO based research evidence continues to be used.

According to the AASHTO research the damage to flexible pavements from the passage of a single vehicle axle could be described by the following expression using the so-called "fourth power law":

- Equivalence Factor = $[(\text{Axle weight})/\text{Reference axle weight})]^4$

  Where

Equivalence factor	= pavement damage factor
Axle weight	= the weight of a single axle in tonnes
Reference axle weight	= a single axle weight of 8.16 tonnes

Occasionally a reference axle of 10 tonnes is also used. The exponent used is commonly in the range 4.0 - 4.3. In more sophisticated formulations different exponents are sometimes used to express the potential damage to different layers in flexible pavements. In the case of semi rigid or rigid pavements the exponent used can be between 8 and 12. The 'fourth power law"suggests that the damage to flexible pavements increases extremely rapidly with single axle loads above the reference axle weight.

The damage to flexible pavements caused by a given load on tandem axles is less than the damage caused by the same load on two single axles. Similarly, the damage caused by a load on a tridem (triple) axles is even less than the equivalent load carried on three single axles. The AASHTO research and the more recent research carried out in a number of member countries of the Organisation for Economic Co-operation and Development (OECD) indicate that the damage to flexible pavements attributable to tandem axles is just over 60 percent of the damage caused by the same load on two single axles. In the case of tridem axles the equivalent damage is 45 percent of the damage which would be caused by the same load on three single axles. The national axle loading regulations in various OECD countries take these damage ratios into account. These ratios embody a high, if necessary, degree of simplification because the damaging effect is also a function of the way the load is distributed over the axles and whether single or double tyres are used. In most of the discussion in this section twin wheeled axles are assumed. The difference in damaging power between single, tandem and tridem axles also grows rapidly with rising load weight. This is the obvious reason why only the heavier trucks have tandem or tridem axles.

The grouping and type of tyres also influences potential damage to pavements. For example, wide base tyres do about 92 percent of the damage of normal single tyres and twin tyres only do around 77 percent of single tyre damage. Finally, there are also differences in the pavement damaging potential of different types of vehicle suspension systems. Modern suspension systems are thought to have only 95 percent of the pavement damaging potential of traditional suspension systems.

The simplified methodology for calculating the potential pavement damaging impact of different axle grouping and characteristics shown below provides a very useful basis for assessing the impact of different types of vehicles. In practice, conventional axle load surveys are seldom able to provide the amount of information required for this level of pavement damage evaluation. It is important nevertheless to have a clear idea of the pavement damage potential of different types of heavy vehicle because it has an important bearing on road user charges for heavy vehicles and on national axle loading regulations.

The total pavement damaging power of different types of heavy vehicle can be summarised in the following simplified model:

$$PD = [(AL_1/AL_0) * k_1 * k_2 * k_3]^a$$

where

AL_1	= load on the axle or axle grouping		
Al_0	= the reference axle load		
k_1 (type of grouping)	single axle	=	1.0
	tandem axle	=	0.6
	tridem axle	=	0.45
k_2 (type of tyres)	twin tyres	=	1.0
	wide base tyres	=	1.2
	single tyres	=	1.3
k_3 (type of suspension)	traditional	=	1.0
	improved	=	0.95

a is the exponent

Based on the use of this model, the OECD in its report "The Impacts of Heavy Freight Vehicles" evaluated the pavement damaging potential of different types of trucks and the findings are discussed briefly below.

4.4 The Effects of Different Types of Trucks on Pavements

Any reasonably rigorous assessment of the pavement damage attributable to different types of heavy goods vehicles has to take payload into account. While it is interesting to know the absolute pavement damage factors for different vehicle types, it is even more interesting to have information on these damage factors in relation to payload tonnes. Assuming that a given annual tonnage has to be transported over a road network, it is important from a vehicle licencing perspective to know what types of heavy goods vehicles would transport that tonnage at minimum damage to the pavements. With this knowledge it should be possible to use the vehicle licencing system to encourage vehicles with axle configurations which do least pavement damage in relation to load capacity.

The results of analyses carried by the OECD are summarised in Table 4.3. These show that gross vehicle weight is not necessarily a very good guide to the pavement, as opposed to bridge, damaging potential. The damage factors for different types of goods vehicles with different axle configurations is a much better guide, but the most valid basis for considering pavement damaging potential by heavy goods vehicles is in relation to payload capacity. The estimated damage factors per payload tonne of capacity show that large articulated trucks are usually less harmful to pavements than smaller rigid single axle trucks. The results in the table assume correct loading and the greater pavement damaging potential of 2 axle rigid trucks increases when overloading is taken into account. These results reflect the respective damaging potential of single, tandem and tridem axles discussed earlier.

None of the systems of heavy goods vehicle licencing encountered in the TRACECA countries appears to take these factors into account. In the longer term considerable gains in economic efficiency would result from reforming the structure of heavy vehicle licences to take pavement damage factors per tonne of payload capacity into account.

4.5 Vehicles and Pavement Damage in the TRACECA Countries

Axle load surveys had been undertaken by the Consultant in Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Turkmenistan and Uzbekistan. The results of these surveys show that most heavy goods vehicles manufactured in the C.I.S are smaller and have lighter axle loads than the equivalent non - C.I.S vehicles traversing the TRACECA road networks. The overall level of axle loading is very low by international standards, but it can be expected to increase in line with international experience in the medium to long term. The contribution of vehicle axle loading to pavement damage in the TRACECA countries has been much smaller than it would have been if international vehicle damage factors and incidence of vehicle overloading had been experienced.

The overall results of the axle loading surveys in six TRACECA countries are set out in Annex 4 Tables A.4.1 and A.4.2. The overall pavement damage factors for heavy goods vehicles in Table A.4.2 are low, but they still overstate the pavement damaging potential of the different vehicle types because they are estimated on a single axle basis. In other words, no reduction is made for vehicles with tandem or tridem axles because this information was not recorded. It should also be noted that the large samples of heavy vehicles weighed at each location included empty vehicles and vehicles with low load factors. The samples were, therefore, representative of the heavy vehicle flows. The average damage factors using an exponent of four from all the surveys were as follows:

Large Buses	All = 1.50	
2 axle trucks	All = 0.11	non-C.I.S = 4.87
3 axle trucks	All = 0.24	non-C.I.S = 1.27
4 axle trucks	All = 0.83	non-C.I.S = 1.92
5 axle trucks	All = 0.45	non-C.I.S = 1.31

The corresponding damage factors using a 10 tonne reference axle are lower.

Estimates of damage factors per payload tonne have also been estimated in Annex 4 Table A.4.4 assuming payload to be around 60 percent of gross vehicle weight, an 8.16 tonne reference axle and an exponent of 4. The resulting damage factors per payload tonne are summarised below:

2 axle trucks	All	= 0.02 per payload tonne
	Non C.I.S	= 0.67 per payload tonne
3 axle trucks	All	= 0.03 per payload tonne
	Non C.I.S	= 0.11 per payload tonne
4 axle trucks	All	= 0.06 per payload tonne
	Non C.I.S	= 0.12 per payload tonne
5 axle trucks	All	= 0.03 per payload tonne
	Non C.I.S	= 0.08 per payload tonne

It should be remembered that these are overestimated to the extent that no adjustment to damage factors has been made for tandem and tridem axles. The damage factors per payload tonne are clearly significantly higher for non C.I.S vehicles than for C.I.S vehicles and this reflects higher load factors as might be expected from commercial operators of the more expensive international trucks. The relationship between the damage factors and damage factors per payload tonne between non C.I.S two axle trucks and multi axle trucks is similar to the OECD examples. The two axle truck fleets of C.I.S manufacture are dominated by trucks which are small by international standards and their damage factors and damage factors per payload tonne are very low both in comparison with international 2 axle trucks and in relation to multi axle trucks of C.I.S manufacture.

A revival of economic activity in the TRACECA countries could be expected to be accompanied by a significant increase in trucking activity and growing load factors. A greater use of larger articulated trucks of non C.I.S origin can also be expected. In the medium to long term it can be expected that damage factors for heavy goods vehicles in the TRACECA countries will move into line with internationally accepted norms and the implications of this for pavement maintenance and rehabilitation need to be recognised.

It will have been noticed that no mention has been made of passenger cars and other light vehicles in the above discussion. The reason for this is that they make very little contribution to pavement damage. The pavement damage factor for a typical passenger car of around 1.6 tonnes is only about 0.0001 and for a small pickup or minibus it might be of the order of 0.0015 to 0.002. A car, therefore causes only one thousandth of the pavement damage of an average 2 axle truck of C.I.S manufacture. For light utility vehicles the proportion is 1 - 2 percent. Even allowing for the much greater number of light vehicles on the roads, the total pavement damage attributable to them is negligible.

Table 4.3 PAVEMENT DAMAGING POTENTIAL OF DIFFERENT TYPES OF CORRECTLY LOADED TRUCK

Truck Type	**Axle Configuration**	**No.of Axles**	**Gross Vehicle Weight (tonnes)**	**Payload (tonnes)**	**Pavement Damage Factors**		
					Per Vehicle	**Per GVW tonne**	**Per Payload tonne**
Rigid 2 axle	S-S	2	14	9	**1.35**	0.10	**0.15**
Rigid 3 axle	S-T	3	22	14	**1.22**	0.06	**0.09**
Rigid 2 axle truck + 2 axle drawbar trailer	S-S / S-S	4	37	24	**3.36**	0.09	**0.14**
Rigid 2 axle truck + 3 axle drawbar trailer	S-S / S-T	5	45	29	**3.22**	0.07	**0.11**
Rigid 3 axle truck + 3 axle drawbar trailer	S-T / S-T	6	54	34	**3.06**	0.06	**0.09**
Articulated 2 axle tractor + 2 axle semi trailer	S-S / T	4	34	21	**2.23**	0.07	**0.11**
Articulated 3 axle tractor + 2 axle semi trailer	S-T / T	5	42	26	**2.08**	0.05	**0.08**
Articulated 3 axle tractor + 3 axle semi trailer	S-T / TR	6	50	31	**2.17**	0.04	**0.07**

Note: The estimated damage factors take account of the reduced pavement damaging effect of tandem and triple axles.
S = single axle T = tandem axle TR = triple (tridem) axle
Source: Organisation for Economic Co-operation and Development (OECD) - "Impacts of Heavy Freight Vehicles"

5 THE FINANCING OF ROADWORKS

5.1 General

The financing of roadworks in most of the TRACECA states is nominally through a road fund set up by government. In Armenia, however, there is no road fund and financing of roads from the general government budget. In practice, the lack of financial independence of most of the road funds means that financing of roadworks operates in much the same way as if it were from the general government budget.

The main direct charges on road users are in the form of taxes on automotive fuels, vehicle licences and registration taxes, transit taxes on foreign (non-C.I.S) vehicles and taxes on vehicle acquisition. Nearly all these charges are at levels which are very low by international standards. Other taxes used for financing roadworks include turnover and - or profits taxes on enterprises linked functionally or locationally with the highway networks. In the economic climate experienced by most TRACECA states in recent years profits taxes are unlikely to have been a major contributor to highway budgets. In most cases these taxes and charges are at levels which are very low by international standards. In part this reflects a traditional philosophy of road financing inherited from the past, and it is also the result of a failure to make adequate adjustments in taxes and charges to take account of inflation. The overall effect has been a declining real financial contribution from road user charges to the road sectors. This has been accompanied by an irresistible downward pressure on general government budgets as a result of the economic depression of the 1990s.

5.2 Road Funds

5.2.1 Introduction

Road funds have been established in most of the TRACECA states since 1991. None of them can be said to possess the degree of financial and operational independence which the World Bank, for example, regards as critical to their success. In practice, most of the TRACECA road funds appear to operate as an extension of the central government's tax collection machinery. They have little effective control over how much of the money which they collect from the road sector is used in the road sector. A possible exception to this could be Uzbekistan where it is claimed that lessons learned from the problems of other road funds have been incorporated in the design of its own fund. The following sections briefly summarise the main features of road funds in individual TRACECA countries.

5.2.2 Azerbaijan

The Road Fund Law setting up Azerbaijan's road fund was passed in November 1994, but the fund effectively started operations in mid 1994.. Before the establishment of the road fund the financing of roadworks was from the State Budget. The fund is supposed to collect revenue from road user charges and highway related taxes and to pass this revenue on to the Ministry of Finance. These charges include an automotive fuel sales tax, a road use tax on enterprises, a vehicle sales tax, vehicle ownership taxes and a transit tax on non - C.I.S foreign vehicles. The potential revenue from this transit tax is significantly reduced by the fact that Iranian vehicles which constitute the majority of foreign vehicles, are exempted from paying it.

Fifteen percent of the revenue from the fuel tax is supposed to be passed onto the fund by the State Fuel Committee, but this has not happened so far. The Ministry of Finance decides the annual budget to be allocated to Azeravtoyol, the state highway organisation, so highway financing is still effectively from the State Budget.

In the second half of 1994 the road fund collected the equivalent of US$ 10 million. This increased to US$ 27.9 million in 1995. The road fund's estimated revenue collection for 1996 is equivalent to US 79.8 million, but as of August 1996 the predicted budget allocation for roadworks by the Ministry of Finance was no more than US$ 10.4 million of which approximately 80 percent was for state highways.

5.2.3 Georgia

The law establishing Georgia's road fund was passed in September 1995. The law sets out the basis of the fund, its main purpose, the provision of financial resources for it and the use of those resources. The main charges and taxes contributing to the fund's revenues include a sales tax on automotive fuel, a road use tax on enterprises, taxes on vehicle ownership, a tax on the location of public utility facilities within road rights of way, contributions from lotteries and traffic fines, and a transit tax on foreign vehicles entering Georgia and on Georgian vehicles carrying foreign export cargoes.

In the first seven months of 1996 the proceeds from road user charges and taxes amounted to the equivalent of US$ 9.46 million. Of this, just over 40 percent came from transit taxes on foreign vehicles, 29 percent from road use taxes on enterprises, 25 percent from vehicle ownership taxes and only 4.1 percent from taxes on fuel. Indications from the first half of 1996 are that expenditure on roadworks was running at around 60 percent of the total proceeds from the fund.

5.2.4 Kazakhstan

Up to 1992 expenditure on roads in Kazakhstan was financed from the National Budget. In December 1991 two categories of road funds were established by government decree, the National Road Fund for national road maintenance and development and the Regional (Oblast) Road Funds for local road maintenance and development. Road fund revenue was originally designed to come from the proceeds of a road use tax on enterprises, a purchase tax on vehicles, a vehicle ownership tax based on vehicle horse power, a tax on petroleum products and vehicle tyres, a tax on the income of transport companies and a transit tax on foreign vehicles entering Kazakhstan.

The structure of road use taxes and user charges was modified in 1994, but the new arrangements were rescinded in the second half of 1995. As of mid 1996 a number of road funding arrangements were under consideration by the Government. In general, Kazakhstan's experience with operating a road fund has not been satisfactory.

Road fund revenue dropped from the equivalent of US$ 185 million in 1993 to US$ 92 million and US$ 100 million respectively in 1994 and 1995. The latest available information on the main sources of road fund revenue only relate to 1993 when road use taxes accounted for 47 percent and taxes on fuel and vehicle tyres contributed a further 36 percent of the total. In 1993 road fund revenue and expenditure on roads were almost in balance. Since then, however, expenditure on roads has been only 50 percent of road fund revenue in 1994 and 70 percent in 1995. The balance has presumably gone into the Government's general tax revenues.

5.2.5 Kyrgyzstan

The establishment of a road fund has been under consideration for the past two years, but as of May 1996 the necessary legislation had not been passed.

5.2.6 Tadjikistan

Tadjikistan has a road fund responsible for collecting road user charge revenue, but details on the operation of the fund are not available.

5.2.7 Turkmenistan

Turkmenistan's road fund was only established in 1995 and it became operational at the beginning of 1996. Its objectives were the financing of requirements for the maintenance, rehabilitation and development of State roads. The fund's financial resources were originally intended to come from the excise duty on automotive fuels, transit charges on foreign vehicles and the annual vehicle registration tax. Subsequently, the abolition of special government departmental or agency accounts meant that the road fund could not be operated as a financially independent entity. A further blow to the fund's resources was the removal of the proceeds of the excise tax on automotive fuels from its control. The fund's managing authority is Turkmenautellari.

The estimated financial resources of the fund in 1996 are the equivalent of US$ 17 million to US$ 20 million depending on whether official or commercial exchange rates are used, This represents a significant increase on the US$ 7 million made available for roads out of the state budget for in 1995.

5.2.8 Uzbekistan

Uzbekistan originally established a road fund in 1993. It has been mainly financed out of taxes on enterprises and institutions at the state, oblast (regional) and rayon (district) level, taxes on vehicle ownership and transit taxes on foreign vehicles entering the country. The fund is responsible for financing all roadworks, but its resources do not include a tax on automotive fuel. The only part of the country levying a tax on fuel is the Semi Autonomous Republic of Karakalpakistan where a 7 percent fuel tax is in force.The road fund is administered by Uzavtoyul, the state highway organisation.

The amount of fund revenue raised at just over the equivalent of US$ 100 million may be insufficient, but Uzbekistan appears to be one of he few TRACECA countries with a road fund where a significant part of fund revenue is not appropriated by the finance ministry for non - road uses.

5.3 Road User Charges and Road Related Taxes

5.3.1 General

In the following sections the details of road user charges and road related taxes in individual TRACECA countries are briefly summarised. The information on these charges was collected during visits to the various countries in the course of the Project.

5.3.2 Armenia

Armenia is in the process of introducing a new road tax and draft legislation was supposed to have been presented to Parliament in September 1996. The present structure of charges and taxes is similar to those in force in most of the other TRACECA countries and the most distinguishing feature of the new Armenian proposals will be the much greater reliance to be placed on the proceeds from a fuel tax.

The main features of the proposed new road tax are as follows:

- The 2 percent tax on the revenues of enterprises involved in vehicle operation and the 0.43 percent tax on the incomes of all other enterprises will be replaced by a fuel levy.

- The levy or tax on petrol and diesel will be at the rate of 12 percent.

The Ministry of Finance estimates that the new fuel tax will raise just over the equivalent of US$ 7 million in a full year and the stated intention is that this will be specifically assigned to road expenditure. This would be an advance on the road budgets of US$ 1.65 million in 1994 and US$ 4.15 million in 1995. It should be noted, however, that only one third of the 1995 road budget allocation had been paid out as of June 1996. The predicted 1996 fuel tax yield will also be required to cover a local counterpart contribution of around US$ 864,000 to an International Development Association (IDA) credit.

5.3.3 Azerbaijan

The existing road taxes and road user charges comprise the following:

- A 0.5 percent tax on the turnover of road vehicle operating companies and a 0.3 percent tax on the turnover of trading companies and certain other types of company.

- A 2 percent vehicle sales tax.

- A vehicle ownership tax levied on the basis of a complicated formula involving the multiplication of a percentage of the minimum wage rate by vehicle horse power. For private cars the relevant percentage is 2 and for other vehicles it is 5.

- International transit tax on foreign vehicles entering the country, but specifically exempted from this tax are Iranian vehicles which make up the largest group of foreign (non C.I.S) vehicles. The following transit tax rates have been in force in 1996:

  - **Cars** - US$ 15 per entry

  - **Buses** - from US$ 30 per entry for buses of 12 passenger capacity to US$ 100 for buses with a capacity of more than 30 passengers.

  - **Trucks** attract a transit tax of from US$ 100 (less than 10 tonnes) to US$ 180 for trucks of more than 24 tonnes. It is not clear whether the truck tonnage refers to payload capacity or gross vehicle weight. There are additional weight related transit charges based on truck weight. These range from US$ 0.15 per kilometre for trucks weighing 37 - 41 tonnes to US$ 1.8 per kilometre for trucks weighing more than 81 tonnes.

    In the absence of vehicle weighing equipment at each border post it is not clear how the truck weight assessments for transit tax purposes is made or how the relevant number of kilometres for charging is calculated. In addition to transit charges on vehicles, there are transit charges on vehicle loads. These range from US$ 100 per load for a "not very dangerous"load to US$ 400 per load for a "very dangerous" load.

  - A petrol sales tax of from US$ 3.07 - 3.74 per tonne, depending on octane level, and a tax on automotive diesel of US$ 2.20 per tonne. There is also a retail sales tax on automotive fuels of 15 percent.

Azerbaijan has a system of complex road taxes and user charges, but in the absence of information on the relative contribution of the different charges to total road fund revenue it is difficult to judge their effectiveness as a source of revenue. What is beyond dispute is that total revenue raised from road users is insufficient and the proportion passed on as road budgets is even more inadequate.

5.3.4 Georgia

A tax for the use of public roads is levied on the profits and - or turnover of specified enterprises. There is a 2 percent profits tax on enterprises operating passenger transport services. Municipal buses are exempt. The profit tax rate is 0.5 percent for banking organisations and 0.1 percent for other business organisations. Trading enterprises must also pay a 0.1 per cent tax on their turnover. Enterprises located within 50 metres of a public road in densely settled areas and within 100 metres in less densely populated areas have to pay double the above tax rates. Organisations selling automotive fuels also have to pay a fuel tax, and their liability to pay profit taxes is reduced in line with their liability to pay the fuel tax. The fuel tax is in the form of a value added tax of 5 percent.

There is a vehicle ownership tax based on engine capacity. The rates for different vehicle types is as follows:

Cars- US$ 0.20 per horse power
Buses-from US$ 0.50 per horse power for vehicles with less than 13 seats to US$ 2.00 per horse power for vehicles with more than 30 seats.
Trucks from US$ 1.00 per horse power for vehicles of less than 11 tonnes to US$ 3.00 per horse power for vehicles of more than 40 tonnes.

The annual registration - ownership tax has to be paid before the annual safety check and when a vehicle is re-registered on change of ownership.

A transit tax is levied on foreign vehicles entering Georgia and on owners of Georgian vehicles loaded with foreign cargoes for re-export abroad. The transit tax rates levied on entry into Georgia are as follows:

Cars	US$ 20.00
Buses (less than 13 seats)	US$ 40.00
Buses (13 - 29 seats)	US$ 80.00
Buses (30 or more seats)	US$ 130.00
Trucks (less than 11 tonne payload capacity)	US$ 130.00
Trucks (11 - 20 tonne payload capacity)	US$ 160.00
Trucks (21 - 39 tonne payload capacity)	US$ 220.00
Trucks (40 or more tonnes payload capacity)	US$ 300.00

Payment of this tax can be made in US dollars or in other currencies.

Finally, there are taxes on public utility facilities located within State road right of way and on roadside advertising hoardings. The utility tax is levied at the rate of the equivalent of US$ 0.10 per linear metre of facility within the right of way. The tax rate on roadside advertising hoardings ranges from the equivalent of US$ 20 per square metre of hoarding on national roads to US$ 15 per square metre on intra state (republican) roads and US$ 5 per square metre on local roads.

The State Tax Office is responsible for raising these taxes and road user charges and for the accounting and financial contrive of the road fund.

5.3.5 Kazakhstan

Under the 1994 restructuring of road financing the main road taxes and user charges were as follows:

- Special road tax of 1.0 percent of turnover levied on all enterprises. The proceeds were split in the proportions 30 per cent for national roads and 70 percent for Oblast funds.
- A tax of 1.0 percent on vehicle purchases with the proceeds going to Oblast funds.
- An annual transport tax linked to vehicle size.
- A value added tax on fuel, lubricants and tyres the proceeds being destined for the Oblasts.
- A levy of 2.0 per cent on transporters' turnover with the revenue going to national roads.

As mentioned earlier, these arrangements were rescinded during the second half of 1995 and alternative financing arrangements are still being considered by the Government.

5.3.6 Kyrgyzstan

In recent years road related taxes and road user charges have comprised the following:

- an annual road tax of 0.8 percent of turnover levied on most enterprises. Trading companies and privatised or small scale agricultural enterprises pay at the rate of 0.08 per cent of turnover.
- a levy of 2 percent on the turnover of all transport companies, which has now become a voluntary contribution
- an excise tax on petrol of the equivalent of US$ 4.1 per tonne. A similar tax on diesel was abolished in 1995
- a vehicle registration tax of 5 percent of the vehicle's value on transfer of ownership
- an annual vehicle licence tax of approximately US$ 0.90 per horse power of engine capacity for trucks and US$ 0.02 per horsepower on cars
- A 10 percent import levy on imported cars from outside the C.I.S.

Revenue from these sources goes into the Government's central budget and it is not specifically allocated to the Ministry of Transport for expenditure on roads.

A draft of a Republican Road Fund Law was prepared by the Ministry of Transport as part of the Automobile Road Act which has been under consideration by the Ministry of Finance since early 1995. The objective of this would be to establish a dedicated road fund which would legally tie specified sources of revenue to expenditure on roads. Under the draft proposals there would be 13 different sources of revenue, either existing or newly proposed. Proposed new charges and taxes would include the following:

- a value added tax on fuels and tyres
- licencing fees for transport activities
- duties on heavy axles and large vehicles
- toll fees for selected roads and tunnels
- a transit tax on foreign vehicles entering Kyrgyzstan

As of May 1996 the Ministry of Transport was attempting to add supplementary proposals focusing on existing taxes and charges. Revenue from taxes paid by vehicle owners amounted to around US$ 5.4 million in 1994. Revenue from automotive fuel taxes might have contributed a further US$ 0.8 million. These revenues are clearly inadequate in relation to expenditure requirements, but total

Government revenue in 1994 only amounted to the equivalent of US$ 181.8 million.

5.3.7 Turkmenistan

The main road user charges in force in Turkmenistan include transport licence fees, taxes for vehicle inspection , vehicle registration fees, fuel tax, import duties on vehicles and transit fees for international (non - C.I.S) vehicles. The main features of current charges and taxes are as follows:

- **Road transport licence fees**. These have been applicable to international road transport enterprises since May 1996. Before then they were also applied to domestic transport enterprises, but at a much lower rate. Foreign freight carriers now pay monthly fees at the following rates per vehicle:

- Trucks with a carrying capacity of less than 10 tonnes	US$ 20
- Trucks with carrying capacity of 10 - 20 tonnes	US$ 50
- Truck with carrying capacity of more than 20 tonnes	US$ 100

- **Annual vehicle inspection fees** are collected by the Police Department of the Ministry of the Interior. The fee for Turkmen vehicle owners is the equivalent of US$ 0.12 per vehicle and for foreign owners the fee is US$ 4.00 per vehicle. It is not immediately apparent why inspection of foreign owned vehicles should be thirty three times more expensive than for domestic vehicle owners.

- **Vehicle registration fees** in the form of fees for vehicle licence plates are the equivalent of US$ 7.50 for Turkmen and US$ 100.00 for foreign owners.

- **Duties on passenger vehicles imported** from outside the C.I.S and Iran are levied at the rate of 10 percent of the vehicle's declared import value which cannot be less than US$ 1,000. There are also additional Customs charges of 0.2 percent to cover the administrative paperwork.

- **Transit charges on international vehicles** entering Turkmenistan are as follows:

- Trucks of less than 10 tonnes carrying capacity	US$ 50
- Trucks of 10 to 20 tonne carrying capacity	US$ 100
- Trucks of more than 20 tonnes carrying capacity	US$ 150

Passenger vehicles attract the following transit charges:

Cars	US$ 30
Buses with less than 20 seats	US$ 25
Buses with 13 to 30 seats	US$ 50
Buses with more than 30 seats	US$ 100

In 1995 vehicles from the C.I.S countries (except Azerbaijan, Georgia and Ukraine) and from Afghanistan, Iran and Turkey were exempt and if this is still the case, the potential revenue yiel from this charge seems rather limited.

- **Excise tax on motor fuels** are at the rate of 55 percent and 60 per cent of the respective ex refinery prices of petrol and diesel. In October 1996 these were the equivalent of US$ 0.047 - 0.052 per litre for petrol and 0.038 per litre for diesel. Even allowing for distribution costs, the economic opportunity cost of Turkmen refined automotive fuels is probably nearer US$ 0.30 per litre. The above percentage rates seem to be quite high, but the ex refinery prices on which the tax is based are so extraordinarily low by international standards that this results in a very low duty in practice.

- **Annual tax on road vehicles.** This is based on a specified multiple of the minimum wage and in US dollar equivalent terms the tax rates are approximately as follows:

Cars	US$ 10
Buses (depending on seating capacity)	US$ 40 - 100
Rigid trucks (depending on capacity)	US$ 100 - 1,000
Road tractors (depending on horse power)	US$ 150 - 400
Semi trailer (depending on load capacity)	US$ 50 - 250

Until the beginning of 1996 revenues from some of the above taxes went into special Ministry of Road Transport accounts at the Bank of Turkmenistan. However, all special accounts were abolished in January 1996 and these revenues now go into the State Budget. Revenues from vehicle inspection are allocated to the special Road Traffic Safety Fund which comes under the jurisdiction of the Ministry of the Interior. Revenues from transit charges are supposed to be directly allocated to the Road Fund administered by Turkmenautoellari, but there is some doubt as to whether the full hard currency receipts are being transferred to the fund.

5.3.8 Uzbekistan

Uzbekistan has the traditional mix of road taxes on enterprises, taxes on vehicle purchase and ownership and a transit tax on foreign vehicles. Except in Karakalpakistan there is no automotive fuel tax.

The profits tax on enterprises operating road vehicles is levied at the rate of 2.0 percent. The purchases tax on vehicles is at 5.0 percent for cars and 10 per cent for buses and trucks. The transit tax on foreign (non-C.I.S) vehicles entering the country has been fixed at US$ 150.0, but this figure appears to have been arrived at arbitrarily and not based on rigorous analysis.

5.4 Road Budgets and Expenditure on Roads

The traumatic economic conditions experienced by most of the TRACECA countries since 1991 have been reflected in severely constrained government budgets and sharply reduced levels of expenditure on roads. Consequently, expenditure levels on roads appear to be low both by historical standards and by the standards of other countries of similar income levels.

The available evidence on expenditure on roads, total central government expenditure and Gross Domestic Product which is set out in Table 5.1 has to be treated with considerable caution because of the uncertain quality of the data, but it does indicate a fairly consistent pattern. All the countries except Turkmenistan and Uzbekistan are spending significantly less per kilometre on their state road networks than was being spent in the mid 1980s. In Azerbaijan, Kazakhstan, Kyrgyzstan and Tadjikistan the prevailing levels of expenditure on state roads are less than half of the levels between 1983 and 1985. In Armenia it is just over half.

Expenditure on roads appears to lie within the range 0.2 - 1.9 per cent of total central government expenditure in 1995/1996. In Tadjikistan, however, it appears to be only 0.2 per cent. For the TRACECA countries, excluding Tadjikistan, expenditure on roads is 0.16 - 0.35 per cent of Gross Domestic Product. Once again, Tadjikistan is well below the range at only 0.05 percent of GDP.

Historical and international comparisons are only interesting up to a point. The main interest in any analysis of expenditure levels on roads is how they compare with required expenditure levels. This is the subject of the next chapter.

Table 5.1 TRACECA COUNTRIES - EXPENDITURE ON ROADS 1983/85 - 1995/96

Country	Period	State Road Network Length			Average Annual Budget / Expenditure on Roads				Expenditure on roads as % of:	
						Per Km of:				
		Inter State (km)	Intra-State (Republic) (km)	Total	Total (US$ million)	Inter State roads (a) (US$)	Intra State roads (US$)	Combined inter- and intra state roads (d) (US$)	central government expenditure (1995-96)	GDP (1995)
Armenia	1983-85	1,281	1,907	3,188	12.20	5,547	2,697	3,827	0.90	0.24
	1995-96	1,629	1,579	3,208	6.60	4,052		2,058		
Azerbaijan	1983-85	1,698	4,330	6,028	26.70	8,894	2,677	4,429	1.20	0.35
	1995-96	1,409	3,280	4,689	10.40	7,381		2,218		
Georgia	1983-85	1,610	3,843	5,453	5.10	1,724	604	935	1.90	0.25
	1995-96	946	4,059	5,005	4.83	5,106		965		
Kazakhstan	1983-85	13,032	32,009	45,041	51.33	1,616	946	1,140	0.80	0.16
	1995-96	6,132	11,364	17,496	25.80	4,207		1,475		
Kyrgyzstan	1983-85	2,849	6,310	9,159	13.80	2,627	843	1,507	0.70	0.21
	1995-96	748	2,363	3,110	5.20	6,956		1,672		
Tajikistan	1983-85	1,310	2,787	4,097	6.04	1,728	1,354	1,474	0.20	0.05
	1995-96	1,089	696	1,785	0.90	826		504		
Turkmenistan (b)	1983-85	1,740	5,329	7,069	4.97	1,785	350	703	2.00	0.20
	1995-96	1,720	3,748	5,468	10.00	5,815		1,829		
Uzbekistan	1983-85	1,656	15,313	16,969	42.11	5,612	989	2,482	0.80	0.30
	1995-96	1,393	20,432	21,825	62.73	14,917	2,053	2,874		

Note: (a) In 1983-1985 this is based on actual allocations. In 1995-1996 it isonly based on actula allocations in Kazakhstan and Uzbekistan. Elsewhere is is the per km expenditure if the inter state roads absorbed the whole budget.
(b) Total government expenditure is underestimated and expenditure on roads as a percentage of it is , therefore, overstated.

Source: Consultant's estimates based on data obtained in each country.
Government expenditure data from EBRD and GDP data from EBRD and the World Bank.

6 ROAD USE COSTS AND EXPENDITURE

6.1 General

In this chapter estimates are presented of the total costs of using the inter state and intra state road networks in each of the TRACECA countries. These costs are undiscounted life cycle costs presented on an average annual basis. The road use costs are then compared with the budget - expenditure levels in each country as presented in the last chapter and the excess of required maintenance and rehabilitation expenditure over existing expenditure levels shows the scale of the financing gap, if any.

At this early stage it is important to distinguish clearly between **road use costs** and **road user costs.** Road user costs were discussed at some length in Chapter 3 where they were defined as including the following categories of costs incurred by road users:

- Vehicle operating costs
- Passenger delay costs
- The costs of delays to goods in transit.

Accident costs to road users are also included in road user costs, but they have not been quantified in this study in the absence of adequate data.

Road use costs are the other main component of total road transport costs, namely the costs of building, maintaining and managing or administering roads. These costs include the costs of routine annual maintenance, periodic maintenance and rehabilitation, which are usually incurred by the highway agency or department, and the administrative, policing and other costs incurred by other agencies or government departments.

Although the potential importance of environmental costs in total transport costs is acknowledged, especially where new addition to road infrastructure is involved, they are not discussed further in this study which is mainly concerned with road maintenance and rehabilitation in an inter urban context.

The cost of maintaining and rehabilitating road networks is a function of their initial characteristics and condition, the levels and characteristics of traffic using them, factors associated with the road's physical environment, and the unit costs of roadworks. A rigorous assessment of future road network maintenance and rehabilitation requirements should normally be based on detailed information by road section on road condition, pavement roughness, pavement strength and a number of other engineering factors likely to affect future pavement life and the nature and costs of future roadworks. The assessment would also include detailed analysis of present and future traffic by vehicle type and axle loading and an analysis of road user costs at different road pavement roughness levels. Predictions also have to be made of future pavement performance and pavement surface roughness based on an assessment of the expected impact of traffic.

The most rigorous basis for estimating future road network maintenance and rehabilitation requirements would be an engineering and economic analysis of alternative treatment strategies on a section by section basis. This is the type of approach envisaged in the use of the computerised pavement management system being demonstrated in each country as part of this Project. The nature and cost of all the section level strategies would be brought together to create a network level road expenditure programme over time and the total costs of this would be calculated on a year by year basis. This approach is very demanding of resources and as a minimum it needs to be based on a detailed highway database of the type which is not yet available in the TRACECA countries at the network level. In summary this is the future aim of the current project which can be seen as the first, the important step for the implementation of the PMS.

A slightly simpler approach, which is still fairly demanding of highway data, involves describing the network in a matrix of hypothetical representative sections combining defined road and traffic characteristics. Optimum maintenance and rehabilitation strategies would be developed for each of these representative road sections on the basis of engineering and economic cost benefit analyses, probably using a computerised model of some sort. In this optimisation analysis different potential, initial and subsequent road expenditure plans would be compared with a "do minimum" scenario in a discounted cash flow analysis and the plan or strategy showing the highest economic Net Present Value (NPV), NPV per kilometre or Benefit -Cost Ratio would be selected. The optimum strategy for each section would be the one minimising total discounted life cycle transport costs in which, it will be remembered, road user costs are the main component.The optimum strategy and the implied road agency expenditure programme over time for each section would be set out and the road costs for all sections would be added up to form an overall expenditure programme from which the average annual road expenditure requirements for the network would be ascertained.

It is important to be clear about the role of road user costs in this process. Road user costs are a vital component of the optimum strategy analysis because they are the largest component of total transport costs associated with each scenario being compared. However, once the optimum maintenance and rehabilitation strategy for each section has been found on the basis of engineering and economic cost benefit analysis, the focus of attention moves to road or road use costs. These are the future highway agency costs which will dictate road expenditure requirements and , hopefully, budgets.

The approach to the estimation of road use costs described later in this chapter is of necessity a highly simplified version of the representative section approach described above. The road use cost analysis has had to be based mainly on readily available data in the highway departments in each country. An exception to this is vehicle axle load data which was collected in a series of special surveys conducted by the Consultant. With the possible exception of Kazakhstan, none of the TRACECA countries has a highway database capable of sustaining the above type of analysis. The detailed databases created for the pilot road sections selected for the introduction and training of the pavement management system under the Project covered approximately 30 kilometres of main road in each country. These sections were not though for and also are too short to form a representative sample of pavement characteristics suitable for extrapolation to the network level. However, all socalled TRACECA roads (marked as ROAD CORRIDOR on the TRACECA Map) were inspected and data recorded for road surface condition category/class with relation to IRI (roughness).

Table 6.1 PAVEMENT STRENGTH INDICATORS IN SELECTED C.I.S COUNTRIES

Country	Modified Structural Number (SNC) by Design Standard Assumed in Road Use Cost Analyses				
	I	II	III	IV	V
Armenia (a)	4.5	4.0	2.6	2.6	2.4
Armenia (b)	7.5	4.8	4.0	3.0	2.3
Azerbaijan	4.9	4.0	3.8	3.5	2.9
Georgia	5.0	4.2	3.5	3.2	2.6
Kazakhstan	4.6	4.0	3.0	2.4	2.0
Kyrgyz Republic	4.6	3.9	3.0	2.8	1.5
Tajikistan	4.6	3.9	3.0	2.8	1.5
Uzbekistan	4.7	4.0	3.0	2.5	2.0

Country		Estimates of Structural Numbers By design Category made in other studies				
		I	II	III	IV	V
Carl Bro International a/s Kyrgyz Republic (Bishkek - Osh Road)	612		3.9	3.6	2.8	
TecnEcon - The Armenia Highway Survey"						
CowiConsult and TecnEcon "Road and Road Transport St4dy in Russia, Ukraine, Kazakhstan and Belarus"						
Russia - Moscow area	1454.0	6.2	6.8	4.6		1.9
Russia - St Petersburg area	850.0	4.2	5.1	4.6	3.9	2.3
Russia - Samara area	476	5.6	4.6	4.2	3.2	2
Russia - Tjumen area	235		3.8	4.1	3.6	
Russia - Irkutsk area	592			4.4		
Kazakhstan - 2 areas (a)	962	4.6	4.2	3.2	2.8	2.3
Ukraine - 2 areas	1,190	4.2	2.3	1.4		
10 tonne design:						
Normal layer coefficients		8.0	7.0			
Reduced layer coefficients		6.5	5.5			
6 tonne design:						
Normal layer coefficients		5.0	4.5	4.0	3.0	2.0
Reduced layer coefficients		4.0	3.5	3.0	2.5	

Note: (a) Assumed from design standards
(b) Based on benkelman beam survey results.

Sources: Consultant's estimate.
CowiConsult and TecnEcon - "Roads and Road Transport Study" (Russia, Ukraine, Kazakhstan and Belarus) - for EBRD, 1992
Carl Bro International a/s - Road (Bishkek-Osh) Rehabilitation Project - for Asian Development Bank (1995)

The methodology used for estimating road use costs is based on a short cut approach suggested by the World Bank and this is described in greater detail below. However, even this short cut approach requires the following network level information:

- representative daily traffic levels by vehicle type
- axle loading by vehicle type
- pavement strength

The next section sets out the estimates of the above traffic and pavement strength inputs for each country and the process by which they were obtained.

6.2 The Characteristics and Utilisation of the Main Road Networks

6.2.1. Characteristics of the Main Road Networks

The highway institutions and agencies in the TRACECA countries have more or less readily available road inventory information on road geometrics and pavement type, visual road condition survey information and information on the design standard to which individual road sections were built. Except in Armenia and Kazakhstan, there is very little information on pavement strength as measured by Benkelman Beam surveys and virtually no pavement roughness survey data. In general, more and better information is available for the inter state roads than for the intra state or old republican roads. The lack of information on the characteristics of district and local roads precluded their inclusion in the road use cost study, even though they form the largest part of each country's public road network.

The World Bank's short cut approach to road use cost analysis being adopted for this study uses information on pavement strength (modified structural number) as a proxy for pavement characteristic and condition. The absence of pavement strength data in most TRACECA countries is, therefore, a potential obstacle to this form of analysis. Information on road design standards is, however, widely available and this provides the somewhat imperfect guide to potential pavement strength which has had to be used in this study. The main features of the geometric and pavement design standards used in the C.I.S are shown in Annex 6 Table A.6.2. There are, however, differences in pavement design details from country to country. reflecting the differences in geography and climate.

The structural numbers for different pavement design categories shown in Annex 6 Table A.6.2 are based on normal pavement layer coefficients for road construction in the West. However, there are reasons to believe that layer coefficients for roads built in the former Soviet Union can be considerably lower. The reason for this is that roadworks often deviated from the design standards in their implementation. The use of poorer than specified quality materials, variations in sub base thickness and low compaction levels have been three of the more common examples mentioned by highway engineers in the TRACECA and other C.I.S countries. In the "Roads and RoadsTransport Study of Russia, Ukraine, Kazakhstan and Belarus" carried out by CowiConsult and TecnEcon for the EBRD in 1992 it was suggested that a general reduction in theoretical layer coefficients of, around, 20 percent was warranted when assessing pavement strength from the design standards. According to the AASHTO Guide for Design of Pavement Structures, this corresponds to a reduction of E-module by 20 percent or CBR values by 30 percent for unbound materials. Our assumptions about road design standards and pavement strength are based on the above suggestion that a 20 percent reduction in the layer coefficients should be made.

The assumptions used in this study about pavement strength for roads of different design standards are summarised in Table 6.1. This table also shows estimates which have been made in a number of other studies in recent years in the C.I.S. In Armenia there are two alternative pavement strength assumptions. The first is based on design standards as in the other countries, and the second is based on the results of a benkelman beam survey carried out in 1995. The results of our statistical analysis of the results of this survey are presented in Annex 6 Table A.6.3. The deflections recorded in the survey were converted to Modified Structural Number using a formula recommended in the World Bank's documentation of its HDM-III model.The survey was extensive and the sample of over 2,500 observations was very large . It was, therefore, hoped that the results could form the basis of a more rigorous approach to linking pavement strength to design standards in the TRACECA countries. In practice, however, we have some reservations about the data largely arising from the high degree of uniformity of deflection levels recorded across large lengths of road and different design standards. This may have been the result of the equipment used or its calibration. In the case of Armenia, therefore, the road use cost analysis described later in this chapter is undertaken on the basis of the alternative assumptions about pavement strength shown in Table A.6.3. Deflection surveys have also been undertaken in Kazakhstan in recent years, but the results were only available in the form of a qualitative summary. No alternative pavement strength estimates based on deflection survey results could, therefore, be made.

The length of inter state and intra state roads falling within the five different design categories in each country are shown in Annex 6 Table A.6.1 In each country this summary has been based on an analysis of the detailed section by section road data made available by the respective highway institutions. For certain countries the quality of data available for the intra state network was of variable coverage and in these cases it has been necessary to make assumptions about applicable design categories based on the distribution over the rest of the intra state network. In the case of Azerbaijan it should be noted that the intra state road network defined for this study does not include roads in the occupied territories. There is no up to date information on these roads.

6.2.2 Utilisation of the Main Road Networks

The analysis of traffic levels on the main road networks has largely been based on the results of routine classified traffic surveys undertaken by the respective highway institutes. Most TRACECA countries inherited efficient traffic counting and analysis procedures for inter urban main roads, but subsequent budget cuts have had a significant adverse effect on the coverage of traffic counting programmes in certain countries. Inter state roads are covered in greater detail than are the intra state roads in most countries and for this reason the traffic estimates for inter state roads are more reliable than those for the intra state network.

The traffic estimates for intra state roads in Tadjikistan, Uzbekistan, Armenia, and Georgia are considered to be less reliable than those for the other countries. In Georgia the traffic counting programme virtually ceased between 1991 and 1995 and the counts undertaken within the last eighteen months have concentrated on selected inter state roads. Even now, the traffic survey coverage of Georgia's inter state road network is inadequate and the Consultant carried out supplementary classified volume counts on three inter state roads. The estimates of traffic on Georgia's intra state road network are based on the results of the extensive routine surveys undertaken in the period before 1990, in particular between 1986 and 1990. The average traffic levels indicated in these surveys have then been significantly reduced in accordance with the observed reduction in traffic on inter state roads where recent data made possible a comparison of 1986-1990 and 1995-1996 traffic levels. In Armenia an excellent traffic counting programme has been established, but it is focused on the inter state road network. The only information on intra state road traffic levels is from traffic counts undertaken on roads which were inter state roads but which have recently been classified as intra state roads. Some of the traffic data collected as part of the 1994 "Armenia Highway Survey" comes under this category.

Where traffic data on the intra state networks were inadequate estimates have been based on analysis of traffic levels by road design category on inter state roads and on the original traffic levels inherent in the design category. The traffic thresholds for each design category are as follows:

- Design Standard category I. — Average daily traffic (ADT) over 7,000
- Design Standard category II — ADT 3,000 - 7,000
- Design Standard category III — ADT 1,000 - <3,000
- Design Standard category IV — ADT 100 - <1,000
- Design Standard category V — ADT < 100

The significant reductions in traffic which have taken place in most TRACECA countries since 1990/1991 may well have nullified a large part of the traffic growth which took place in 1970s and 1980s after the roads were constructed. For this reason, the traffic ranges in the design standard categories may well offer a better guide to current traffic ranges on the intra state roads than would have been the case in a continuous traffic growth environment.

The vehicle classification system used in routine traffic counts in all TRACECA countries except Armenia has a vehicle weight based classification for goods vehicles.In this system trucks are, with some local variations, classified as follows:

- trucks of less than 3 tonnes
- trucks of 3 - <5 tonnes
- trucks of 5 - 8 tonnes
- trucks of over 8 tonnes

An axle based truck classification system is more commonly used internationally and is required for use in the World Bank's HDM-III model. In this study and in the PMS programme system provided to each of the recipient states under the current Project the following vehicle classification system has been used for traffic and axle load inputs. Armenia has also adopted a similar axle based vehicle classification system since traffic surveys were undertaken for the "Armenia Highway Survey" in 1994.

- Passenger cars, jeeps etc.
- Utility vehicles (minibuses, pickups and small vans)
- Large buses
- axle trucks
- axle trucks or truck-trailer combinations
- trucks or truck-trailer combinations of more than 3 axles

The Consultant carried out a large number of moving observer counts on different types of road in each country. Classified volume counts of buses and trucks were carried out as part of the axle load surveys undertaken in Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Turkmenistan and Uzbekistan. Additional comprehensive classified volume counts were also carried out in Georgia. The results of all these counts were used to convert the results of the official routine counts to the above axle based classification.

The estimates of traffic by road design class were based on detailed analysis of the combined road section and traffic count data. The results of this analysis for each country are presented in Annex 6 Table A.6.4. The overall utilisation of each country's inter state and intra state networks in terms of vehicle kilometres by vehicle type is presented in Table 6.2 below. In the TRACECA region as a whole cars account for just over half the inter urban vehicle kilometres and light utility vehicles make up a further 9 per cent of the total. Large buses account for just under 4 per cent and trucks for just under one third.

Overall, approximately 45 percent of inter urban vehicle kilometres are on inter state roads and 55 per cent are on intra state roads. However, this overall picture is heavily influenced by the very large intra state road networks in Kazakhstan and Uzbekistan. In the other TRACECA countries the inter state networks carry a significantly larger share of total inter urban vehicle kilometres than the intra state networks.

The distribution of equivalent standard axle (ESAL) kilometres shows a very different picture of the potentially damaging impact of vehicles in terms of network utilisation.The summary of ESAL kilometres which is presented in Table 6.3 shows a very different pattern between vehicle types as might be expected from the discussion of pavement damage from axles in Chapter 4. Light vehicles contribute less than 0.2 percent of total ESAL kilometres on inter urban main roads in the TRACECA countries. Large buses account for 32 percent of total ESAL kilometres and trucks account for just over 67 percent. The overall distribution of ESAL kilometres between inter state and intra state roads is once again heavily influenced by Kazakhstan and Uzbekistan in showing inter state roads carrying only 39 per cent of the total. In most countries the inter state network carries between two thirds and three quarters of inter urban ESAL kilometres. Detailed estimates of ESAL kilometres by road design standard on inter state and intra state road networks in each country are presented in Annex 6 Table A.6.5.

Table 6.2 TRACECA COUNTRIES - VEHICLE KILOMETRES BY MAIN ROAD CATEGORY AND VEHICLE TYPE 1996

Country	Road Class	Road Length (km)	Vehicle Kilometres (million)						
			Car	Utility	Bus	Truck 2-axle	Truck 3-axle	Truck >3-axle	TOTAL
Armenia	Inter State	1,569.1	1,057.7	129.8	90.1	117.3	108.2	23.5	1,526.6
	Intra State (Rep.)	1,578.7	289.2	46.5	16.8	45.2	36.2	9.5	443.4
	Total Main	**3,147.8**	**1,346.9**	**176.3**	**106.9**	**162.5**	**144.4**	**33.0**	**1,970.0**
		% total	68.4	8.9	5.4	8.2	7.3	1.7	100.0
Azerbaijan	Inter State	1,409.0	1,272.8	279.2	143.5	521.1	109.0	159.3	2,484.9
	Intra State (Rep.)	3,280.0	694.5	325.9	133.1	542.6	151.7	164.2	2,012.0
	Total Main	**4,689.0**	**1,967.3**	**605.1**	**276.6**	**1,063.7**	**260.7**	**323.5**	**4,496.9**
		% total	43.7	13.5	6.2	23.7	5.8	7.2	100.0
Georgia	Inter State	946.0	1,202.4	58.4	113.3	68.1	64.4	26.8	1,533.4
	Intra State (Rep.)	4,059.3	436.1	20.0	35.7	26.8	24.2	12.2	555.0
	Total Main	**5,005.3**	**1,638.5**	**78.4**	**149.0**	**94.9**	**88.6**	**39.0**	**2,088.4**
		% total	78.5	3.8	7.1	4.5	4.2	1.9	100.0
Kazakhstan	Inter State	6,132.0	2,594.0	194.0	45.0	811.0	486.0	93.0	4,223.0
	Intra State (Rep.)	11,364.0	3,715.0	322.0	64.0	986.0	549.0	230.0	5,866.0
	Total Main	**17,496.0**	**6,309.0**	**516.0**	**109.0**	**1,797.0**	**1,035.0**	**323.0**	**10,089.0**
		% total	62.5	5.1	1.1	17.8	10.3	3.2	100.0
Kyrgyz Rep.	Inter State	747.6	423.6	51.8	30.0	103.0	54.6	25.7	688.7
	Intra State (Rep.)	2,362.3	460.9	83.5	43.6	156.0	37.7	35.7	817.4
	Total Main	**3,109.9**	**884.5**	**135.3**	**73.6**	**259.0**	**92.3**	**61.4**	**1,506.1**
		% total	58.7	9.0	4.9	17.2	6.1	4.1	100.0
Tajikistan	Inter State	1,089.1	337.4	27.8	20.5	92.4	50.5	16.5	545.1
	Intra State (Rep.)	696.1	43.2	6.4	2.5	13.5	6.2	3.7	75.5
	Total Main	**1,785.2**	**380.6**	**34.2**	**23.0**	**105.9**	**56.7**	**20.2**	**620.6**
		% total	61.3	5.5	3.7	17.1	9.1	3.3	100.0
Turkmenistan	Inter State	1,211.6	761.3	119.1	162.2	532.6	64.2	149.9	1,789.3
	Intra State (Rep.)	6,471.0	741.4	201.9	49.3	190.8	98.6	474.1	1,756.1
	Total Main	**7,682.6**	**1,502.7**	**321.0**	**211.5**	**723.4**	**162.8**	**624.0**	**3,545.4**
		% total	42.4	9.1	6.0	20.4	4.6	17.6	100.0
Uzbekistan	Inter State	1,393.0	1,416.6	430.5	116.0	852.4	137.6	119.4	3,072.5
	Intra State (Rep.)	20,432.0	2,777.6	727.0	254.5	2,517.1	699.9	580.7	7,556.8
	Total Main	**21,825.0**	**4,194.2**	**1,157.5**	**370.5**	**3,369.5**	**837.5**	**700.1**	**10,629.3**
		% total	39.5	10.9	3.5	31.7	7.9	6.6	100.0

Note: Main roads are defined as the inter state (magistrale) and intra state (republican) road networks.
Source: Consultant's estimates based on the national authorities' road and traffic data.

Table 6.3 TRACECA COUNTRIES - ESAL KILOMETRES BY MAIN ROAD CATEGORY AND VEHICLE TYPE

Country	Road Class	Road Length (km)	ESAL Kilometres (million)						
			Car	**Utility**	**Bus**	**Truck 2-axle**	**Truck 3-axle**	**Truck >3-axle**	**TOTAL**
Armenia	Inter State	1,569.1	0.11	0.18	57.19	18.96	44.06	8.36	128.86
	Intra State (Rep.)	1,578.7	0.03	0.07	10.69	7.30	14.75	3.36	36.20
	Total Main	**3,147.8**	**0.14**	**0.25**	**67.88**	**26.26**	**58.81**	**11.72**	**165.06**
		% total	0.08	0.15	41.12	15.91	35.63	7.10	100.00
Azerbaijan	Inter State	1,409.0	0.13	0.39	177.10	66.29	19.53	53.92	317.36
	Intra State (Rep.)	3,280.0	0.07	0.46	164.29	69.02	27.19	55.56	316.59
	Total Main	**4,689.0**	**0.20**	**0.85**	**341.39**	**135.31**	**46.72**	**109.48**	**633.95**
		% total	0.03	0.13	53.85	21.34	7.37	17.27	100.00
Georgia	Inter State	946.0	0.12	0.08	226.66	6.64	32.22	30.29	296.01
	Intra State (Rep.)	4,059.3	0.04	0.03	71.38	2.61	12.09	13.78	99.93
	Total Main	**5,005.3**	**0.16**	**0.11**	**298.04**	**9.25**	**44.31**	**44.07**	**395.94**
		% total	0.04	0.03	75.27	2.34	11.19	11.13	100.00
Kazakhstan	Inter State	6,132.0	0.26	0.27	11.09	36.72	88.08	19.98	156.40
	Intra State (Rep.)	11,364.0	0.37	0.45	16.00	44.66	99.60	49.58	210.66
	Total Main	**17,496.0**	**0.63**	**0.72**	**27.09**	**81.38**	**187.68**	**69.56**	**367.07**
		% total	0.17	0.20	7.38	22.17	51.13	18.95	100.00
Kyrgyz Rep.	Inter State	747.6	0.04	0.07	4.97	7.07	9.10	16.26	37.51
	Intra State (Rep.)	2,362.3	0.05	0.12	7.24	10.70	6.28	22.59	46.98
	Total Main	**3,109.9**	**0.09**	**0.19**	**12.21**	**17.77**	**15.38**	**38.85**	**84.49**
		% total	0.11	0.22	14.45	21.03	18.20	45.98	100.00
Tajikistan	Inter State	1,089.1	0.03	0.04	2.38	6.34	8.41	10.43	27.63
	Intra State (Rep.)	696.1	0.01	0.01	0.29	0.93	1.03	2.33	4.60
	Total Main	**1,785.2**	**0.04**	**0.05**	**2.67**	**7.27**	**9.44**	**12.76**	**32.23**
		% total	0.12	0.16	8.28	22.56	29.29	39.59	100.00
Uzbekistan	Inter State	1,393.0	0.14	0.60	127.61	164.52	25.86	120.77	439.50
	Intra State (Rep.)	20,432.0	0.27	1.01	274.39	476.78	128.24	581.31	1,462.00
	Total Main	**21,825.0**	**0.41**	**1.61**	**402.00**	**641.30**	**154.10**	**702.08**	**1,901.50**
		% total	0.0	0.1	21.1	33.7	8.1	36.9	100.0

Note: Main roads are defined as the inter state (magistrale) and intra state (republican) road networks.
Source: Consultant's estimates based on the national authorities' road and traffic data.

6.3 Indicative Estimates of Road Use Costs

6.3.1 General

The estimated cost of using road networks in each country should be a basic input into any discussion about highway financing and road user charging policy. Without a realistic estimate of road use costs, decisions about road budgets are made in a vacuum and any cost recovery policy lacks a credible foundation. Road use costs are defined in this study as the average annual costs of maintaining, rehabilitating and managing road networks over a life cycle of several years. It will be noticed that the cost of adding to the road networks by building new roads is not included in this definition which is basically limited to recurrent costs . The cost of new roads should be considered separately under a capital investment cost heading, However, new roads start incurring recurrent costs as soon as maintenance commences. These recurrent costs should obviously be included in our definition of road use costs. In practice, very few new roads are being built in the TRACECA countries.

Road use costs can be divided into fixed and variable costs. Variable costs comprise that portion of costs which is dependent on traffic and loading. In the long run most road costs are variable to some degree, but it is usual practice to include as a minimum the costs of policing and administration and interest on loans in fixed road costs. There are also portions of routine and periodic maintenance and rehabilitation which are considered to be fixed . It is important to be able to distinguish between fixed and variable road use costs because the distribution between the two has a significant influence on the optimum structure of road user charges. The allocation of road costs between fixed and variable elements usually requires rather detailed research and can be time consuming which was not part of this study, and therefore the division of road costs between fixed and variable elements has been based on the results of analyses carried out by and for the World Bank in many low income countries.

6.3.2 Methodology Used for Estimating Road Use Costs

6.3.2.1 World Bank Short Cut Analysis of Road Use Costs

The approach to estimating road use costs adopted in this study is based on a short cut methodology suggested by the World Bank. This methodology is based on a series of analyses of optimum maintenance strategies using the Highway Design and Maintenance Standards model (HDM-III) and data from a wide range of road studies in low income countries. In the analysis optimum maintenance strategies and the associated life cycle average annual road use costs were developed for a range of combinations of traffic, pavement strength and pavement loading. This range of combinations can be considered as a three dimensional matrix made of cells comprising different combinations of traffic, pavement strength and traffic loading. The optimum maintenance strategy for each combination, or cell in the matrix, involves routine maintenance plus the application of periodic thick or thin overlays at pavement roughness thresholds defined as optimum on the basis of extensive analysis using HDM-III. It also includes reconstruction where relevant.The average annual road use costs associated with each optimum maintenance and rehabilitation strategy are then recorded. The results of the World Bank analysis are set out in Table 6.4.

Table 6.4 AVERAGE ANNUAL ROAD USE COSTS UNDER OPTIMUM MAINTENANCE STRATEGIES

Pavement Strength (Modified Structural Number)	Average annual daily traffic (AADT)	ESA per Lane per Year (million)	Optimum Strategy		Road UseCosts (US$ per km per year)				
			Treatment overlay thickness (mm)	Intervention roughness threshhold (m/km)	Non-traffic related (fixed) costs	Traffic related (variable) costs			Total Road Use Costs
						Vehicle related	Axle loading related	Sub Total	
					Moderate traffic loading with normal truck composition				
8	10,000	1.740	80	3.0	3,806	3,216	636	3,852	7,658
8	6,000	1.000	80	3.0	3,155	3,217	432	3,649	6,804
8	3,000	0.260	80	3.0	2,955	2,647	578	3,225	6,180
5	10,000	1.740	80	3.0	3,921	3,365	2,667	6,032	9,953
5	6,000	1.000	80	3.0	3,270	3,038	1,734	4,772	8,042
5	3,000	0.260	40	3.5	3,211	2,391	640	3,031	6,242
5	1,000	0.053	80	7.0	3,062	145	317	462	3,524
5	300	0.014	80	7.0	2,562	128	249	377	2,939
3	3,000	0.260	40	3.5	3,212	2,648	2,128	4,776	7,988
3	1,000	0.053	80	5.0	3,062	379	1,563	1,942	5,004
3	300	0.014	80	7.0	2,562	206	336	542	3,104
2	3,000	0.260	80	3.5	3,272	3,323	2,963	6,286	9,558
2	1,000	0.053	40	4.0	3,122	1,336	1,517	2,853	5,975
2	300	0.014	80	7.0	2,622	290	648	938	3,560
					Light traffic loading with normal truck composition				
8	6,000	0.500	80	3.0	3,155	3,217	214	3,431	6,586
5	3,000	0.130	80	3.5	3,211	2,391	605	2,996	6,207
3	1,000	0.025	80	5.0	3,062	379	1,309	1,688	4,750
2	300	0.013	80	7.0	2,622	290	468	758	3,380

Source: World Bank - "Management and Financing of Roads" 1995.

The pavement strength levels considered range from strong pavements with a modified structural number (SNC) of 8 to weak pavements with an SNC of 2. Average daily traffic ranges from 10,000 to 300 vehicles and traffic loading ranges from 1.74 million to 13,000 equivalent standard axles per lane per year were taken for use in the analysis. Analyses were undertaken under alternative assumptions about traffic composition, notably the proportion of trucks in the total. For the purpose of this study the moderate and light traffic loading assumption with normal (20 percent) truck composition was taken to be the most appropriate in view of the low axle loading recorded in the axle surveys carried out in the TRACECA countries.

In its analysis the World Bank distinguishes between fixed and variable road use costs. The distinction is based on the results of many international studies and, for recurrent maintenance and rehabilitation costs, on the results of HDM-III analysis. In this analysis the results of the model runs with predicted traffic were compared with runs where no traffic data was input. The results of the no traffic runs showed the non traffic related or fixed cost components of recurrent costs . All policing and road administration costs were taken as fixed costs and the order of magnitude of these items was based on the results from several international studies.

The road user costs used in the World Bank's HDM-III based maintenance strategy analyses were derived from a range of international studies and relationship between road user costs and pavement roughness would have been derived from the model. Predicted traffic growth rates used in the analysis are not specified by the World Bank, but they would presumably also be based on a wide range of international experience.

The economic and financial unit costs used in the World Bank analyses were also based on extensive international evidence. Economic costs were used in the strategy analyses. The unit costs on which the Bank's road use cost analysis was based were as follows:

Treatment	Economic cost (US$/km)	Financial cost (US$/km)
Routine maintenance	1,450 + 0.43 (AADT)	1,700 + 0.5 (AADT)
Reseal	19,400	22,400
Thin overlay (40mm)	47,600	56,000
Thick overlay (80mm)	76,200	90,000
Reconstruction (+2 SNC)	238,000	280,000

There are considerable variations in and uncertainties about the unit costs of roadworks in the C.I.S countries and this largely reflects local price distortions. The results of a comparison of unit costs of different roadworks used in a number of studies sponsored by international donors in recent years are set out in Annex 6 Table A.6.7. There is little discernible pattern in these costs and considerable uncertainty about realistic unit costs in the TRACECA countries. In view if this it was decided to use the unit costs in the World Bank's analysis and not to attempt to modify them to take account of possible local price factors.

It is not possible without a considerable amount of research to determine to what extent the results of the World Bank analyses would overstate or understate road use costs when applied to the TRACECA countries. To the extent that unit costs within the TRACECA region are below international levels in low income countries, the results would tend to overstate these costs, but there is little persuasive evidence either way. There is a tendency to overstate the loading related road use costs because the vehicle damage factors used in the Bank's maintenance strategy analyses are higher than present damage factors in the

TRACECA region. However, there may also be a tendency to understate costs in those parts of the TRACECA region subject to severe winter weather because the HDM-III was not specifically designed to simulate pavement behaviour under extreme freeze-thaw conditions. On balance, the assumption in this study is that the road use costs predicted in the Bank's analyses for different combinations of pavement strength, traffic and loading are of the right order of magnitude.

6.3.2.2 Adaptation of the World Bank's Road Use Cost Estimates

The results of the short cut method of road use cost analysis suggested by the World Bank have been adapted for use in this study. The following main inputs for the analysis for each country have been prepared as described earlier in this chapter:

- Average daily traffic by vehicle type and road design category
- Vehicle kilometres by vehicle type and road design category
- ESAL kilometres and ESA per lane per year by road design category
- Pavement strength as measured by modified structural number for each road design category.

A series of regression analyses has been undertaken on the results of the World Bank analysis shown in Table 6.4 to permit interpolation between the values indicated for pavement strength, traffic and loading. The results of these regression analyses have been used to estimate fixed and variable road use costs resulting from the insertion of the estimated input values for each country. The results of this process are presented in Annex 6 Table A.6.6. The analysis has been run separately for inter state roads and intra state roads.

The regression models used for estimating fixed and variable road use cost values are as follows:

FC = 2,716.7 -SNC(51.7) + AADT(0.54)-3,459.7(ESALY)
Adjusted R^2= 0.88

AADTVC = -414.2 - SNC(39.1) + AADT(2.8) -20,385.9(ESALY)
Adjusted R^2 = 0.83

TOTALVC = 995.3 - SNC(431.4) + AADT(4.46) - 32201.7(ESALY)
Adjusted R^2 = 0.85

where:

FC	=	Fixed costs
AADTVC	=	Traffic related variable costs
TOTALVC	=	Total variable costs
SNC	=	modified structural number
AADT	=	average daily traffic
ESALY	=	equivalent standard axle per lane per year

The loading related variable costs were calculated by subtracting traffic related variable costs from total variable costs.

6.3.3 Estimated Annual Road Use Costs

The results of the estimates of average annual road use costs are summarised in Table 6.5. The detailed results for each country are presented in Annex Table A.6.6. It is emphasised that given the nature of the data on which they are based, particularly the pavement strength assumptions, the resulting estimates must be regarded as indicative rather than definitive.

These estimates understate total road use costs in each country because they do not include most urban , district and local roads. It is felt that even for the inter state and intra state road networks these costs should be considered to be conservative for a number of reasons. In the first place, the present situation with regard to the comparable light axle loading in TRACECA countries may change if there is a switch over time to the use of heavier trucks and if vehicle overloading becomes more common in line with international experience. Both of these factors would increase pavement damage costs and are likely to be an increasingly common feature of the road transport sector when sustained economic recovery starts to take place. Secondly, these road use costs do not include bridge costs, except in Turkmenistan where they were estimated to amount to around 9 percent of potential road use costs.

During the course of field visits to the TRACECA countries the engineers in the respective highway institutions were asked for their estimates of realistic road costs in the absence of a budget constraint. In most cases these estimates were significantly higher than the annual road use costs estimated in this study. With the exception of Kazakhstan, however, local estimates tended to include a significant amount of heavy reconstruction and new road construction even though only estimates for maintenance and rehabilitation was requested. Similarly, the local estimates may have been inflated by the inclusion of non state roads and by representing backlog maintenance needs rather than long term average annual requirements.

The situation in Kazakhstan is different. In early 1996, a World Bank mission assisted by Kazdornii carried out an analysis of the maintenance and rehabilitation requirements of the paved part of the state road network comprising 15,881 kilometres using HDM-III. The data for the analysis was supplied by Kazdornii. The results of this analysis indicated that annual expenditure of US$ 400 million (US$ 25,000 per kilometre) would be required to achieve a significant overall improvement in the condition of the paved state road network. A marginal improvement in overall network condition would require annual expenditure of US$ 200 million (US$ 12,600 per kilometre) and the expenditure of only US$ 100 million (US$ 6,300) would result in further deterioration in overall network condition. Our road use cost estimates for Kazakhstan suggest annual expenditure requirements of US$ 162 million for a 17,496 kilometre network and this suggests that with this level of expenditure network condition would be more or less static at its present standard. One possible reason for the differences is that the unit costs used in the World Bank mission's analysis were higher than those used in our study which are based on the unit costs used by the World Bank in its short cut methodology. The World Bank mission did express some doubts about the reliability of the unit cost and traffic data on which the HDM-III analyses were based and these uncertainties may account for the high resulting estimates of expenditure requirements.

In general, the indicative annual road use cost estimates presented in this study are unlikely to be overestimates. They do, however, represent a vary substantial increase over current expenditure levels. The summary presented in Table 6.5

shows that average road expenditure levels in 1995/1996 ranged from 43 percent of annual road use costs in Uzbekistan to only 9 percent in Tadjikistan. The overall average for the TRACECA countries was 24 percent. Expressed differently, the current **annual short fall** in expenditure on the inter state and intra state roads is of the following orders of magnitude:

- Armenia — US$ 23.9 million (US$ 7,600 per kilometre)
- Azerbaijan — US$ 49.0 million (US$ 10.450 per kilometre)
- Georgia — US$ 27.9 million (US$ 5,600 per kilometre)
- Kazakhstan — US$ 135.8 million (US$ 7,800 per kilometre)
- Kyrgyzstan — US$ 21.4 million (US$ 6,900 per kilometre)
- Tadjikistan — US$ 9.5 million (US$ 5,325 per kilometre)
- Turkmenistan — US$ 55.1 million (US$ 7,200 per kilometre)
- Uzbekistan — US$ 82.5 million (US$ 3,800 per kilometre)

Without the sharp decline in road traffic which has taken place in most TRACECA countries in the 1990s the present condition of the main road networks would have been significantly worse than it is today. Unfortunately constraints on government budgets have been so severe in most of the countries that the decline in expenditure on road maintenance and rehabilitation has been much greater than the decline in network utilisation. A continuation of present expenditure levels will, therefore, undoubtedly result in accelerating deterioration in the overall conditions of what in most countries is the nation's most important single category of infrastructure asset. Rising road surface roughness will cause sharp rises in road user costs, as shown in Chapter 3, and this will impact significantly on the broader structure of costs in the respective economies.

There is, therefore, an urgent need to focus attention on the problem of how to finance the required levels of expenditure on the maintenance and rehabilitation of the road networks. Modern ideas on road user charging policy are particularly relevant in this context and these and the potential for financing road expenditure from restructured road user charges are discussed in the next Chapter.

Table 6.5 TRACECA COUNTRIES - ROAD USE COSTS AND CURRENT EXPENDITURE LEVELS ON ROADS

Country	Main Road Network			Average Expenditure 1995/1996 (US$ million)	Annual Road Use Costs (US$ million)			Annual Road Use Costs (US$ / Km)			1995/1996 Expenditure as % of Road Use Costs
	Intra State (km)	Inter State (km)	Total (km)		Intra State	Inter State	Total	Inter State	Intra State	Total	
Armenia (a)	1,569	1,579	3,148	6.7	21.6	9.0	30.6	13,766	5,701	9,721	22
Azerbaijan	1,409	3,280	4,689	10.4	31.3	28.1	59.4	22,214	8,567	12,668	18
Georgia	946	4,059	5,005	5.1	17.9	15.1	33.0	18,922	3,720	6,593	15
Kazakhstan	6,132	11,364	17,496	25.8	68.6	93.0	161.6	11,187	8,184	9,236	16
Kyrgyz Republic	748	2,362	3,110	5.2	10.4	16.2	26.6	13,911	6,858	8,553	20
Tajikistan	1,089	696	1,785	0.9	6.2	4.2	10.4	5,693	6,034	5,826	9
Turkmenistan	1,212	6,471	7,683	10.0			65.1			8,474	15
Uzbekistan	1,393	20,432	21,825	62.7	39.1	106.1	145.2	28,069	5,193	6,653	43
	14,497	50,243	64,741	126.8			531.9	14,632	6,205	8,216	24

Note: (a) Based on assumed pavement strength. If the pavement strength estimates based on the deflection survey results are used, total road use costs would be US$ 29.8 million a year, of which inter state roads would account for US$ 20.9 million.

Source: Consultant's estimates

7 ROAD USER CHARGES AND COST RECOVERY

7.1 Basic Principles

The present system of financing roads in the TRACECA countries is inadequate and in the absence of radical reform, the situation seems unlikely to improve. It would be unwise to expect that ultimately economic recovery will enable adequate allocations to be made out of general taxation to fully cover the costs of road use. Even in the richest countries increasing constraints on highway budgets have become common.

The present problems of road financing in the TRACECA states are by no means unique to those countries. They have been experienced in equally, if not more severe forms in the lower income countries of Africa and Latin America. Attempts by governments and international donors to solve the road financing problems in these regions in the 1980s and early 1990s led to the emergence of a number of stark conclusions which stimulated the adoption of more radical approaches. The starting point was a critical evaluation of two convictions underlying the traditional approach to road financing. These were:

- Roads are public goods which must necessarily be provided free of charge by the state because the mobility they provide is thought to be a citizen's basic right.

- The best way to provide and maintain roads is through the public administration.

In this respect roads have differed from other modes of transport, such as railways, ports and shipping, and from most public utilities, such as gas and electricity, where payment for use of the facility or service has long been readily accepted. The special treatment of roads may have been the result of the difficulty experienced in developing fair and efficient charging mechanisms for road use. The result was the preferential treatment of road users in comparison with users of other transport modes. Toll roads and the adoption of road funds with access to specially earmarked taxes are an exception to traditional public financing of roads out of general taxation. However, tolling is only practicable in certain clearly defined circumstances and properly functioning road funds are the exception rather than the rule.

The traditional provision of roads as a service perceived to be free is often defended on equity grounds, particularly in the states which are in the process of transition. However, road users are by no means the poorest members of society and they are almost certainly being subsidised by poorer members of society . Failure to charge for road use also means that most road users are unaware of the total road use costs which their travel is causing. This means that they make more trips than if they have to pay charges reflecting realistic road use cost information. They are only aware of their perceived costs of which the most immediately visible is usually the cost of fuel. When road charges are set to cover road use costs, road users have a more rational basis for deciding whether to make the marginal trip. Failure to charge adequately for road use has two linked and undesirable effects.

- More trips are made and road utilisation is greater than would otherwise be the case. This has adverse resource consumption and environmental impacts.

- The resulting higher traffic levels give rise to higher road maintenance costs, which place increased pressure on the state budget. These extra demands on the state budget are the direct consequence of encouraging road use by charging too little for it.

The approach to highway financing which has gained much wider international acceptance in recent years is based on the idea that road user charging systems should be designed to achieve the following objectives:

- to ensure that the revenues required to provide and maintain public roads is raised from road users, including foreign road users, rather than from the general tax payer;

- to price the use of public roads so as to improve economic efficiency in transport by removing price distortions and to charge road users in accordance with their use of road facilities;

- to promote equity between different categories of road users by ensuring, for example, that charges on vehicle operators are related to the road maintenance costs for which they are responsible;

- to establish a link between supply and demand for road infrastructure;

- to increase transparency in the road funding process so that road users can see what funds are being raised from which categories of users and for what purpose and

- to provide for fair competition between road and other transport modes by ensuring that road transport users pay for their use of road infrastructure.

In short, road user charging policy with the above objectives should be designed to maximize net economic benefits by setting charges at a level at least equal to the cost of resources consumed by the use of the road network. These costs, which are sometimes called short run marginal costs, are of two types. The first type covers the cost of damage done to road pavements by the passage of vehicles and include the variable costs of managing and maintaining the network. The second type comprise the costs imposed by road users on other road users and others. These include congestion costs and "external" costs arising, for example, from noise and atmospheric pollution. However, charges only set to cover short run marginal costs would still result in under funding because they would not meet the fixed costs of road use which, as we have seen, are a significant proportion of total road use costs. A road user charging system designed to achieve full recovery of road use costs will, therefore, need to comprise two major elements, a charge or group of charges designed to cover variable or traffic related costs, and additional charges designed to cover fixed road use costs.

Although congestion and external costs are undoubtedly of potential significance, they are not yet of great importance in the TRACECA countries where there is virtually no congestion on the inter urban road networks and relatively little congestion even in the major urban centres. The data on which this study's analyses are based relate to the inter urban state roads and the problem of congestion costs in urban centres must be considered to lie outside the scope of the present work. However, the structure of road user charges discussed below can readily accommodate charges related to congestion and external costs should it be decided to include these at a later date.

7.2 An Appropriate Structure of Road User Charges

The system of road user charges outlined in this section is designed to cover the fixed and variable costs of road use in the TRACECA countries. The estimated fixed and variable road use costs on the interurban state road networks in each country were presented in Chapter 6. Before describing the different types of charges and their appropriate levels it is important to be clear about what these charges mean. **The levels at which the recommended road user charges have been set in this study are based on the assumption that all the revenues from these charges go into the road system to cover road use costs.** To the extent that the governments wish to obtain a contribution towards general tax revenue from road user charges, the charges would have to be set at a correspondingly higher level. In most of the TRACECA countries some part of existing fuel taxes and other road user charges are used to finance a portion, however small, of road use costs. The recommended charges should, therefore be seen as additional to that portion of existing charges which is not used to cover road use costs.

The recommended structure of road user charges comprises charges designed to cover variable road use costs and fixed costs by means of a quasi two part tariff. The variable costs arise from traffic and vehicle loading and the proportion of costs attributable to each has already been estimated in Chapter 6. The first part of the two part tariff is based on a fuel levy designed to cover total variable road use costs. The fuel levy will not on its own be sufficient to ensure that different categories of vehicles contribute their fair share to road cost recovery. Heavy vehicles impose much higher loading costs on the road network than light vehicles and these loading costs have to be reflected in the second part of the two part tariff.

The fuel levy required to cover variable road use costs is expressed per litre of automotive fuel. Total variable costs are , therefore, divided by total automotive fuel consumption in litres to obtain the fuel levy per litre. In this study no distinction is made between petrol and diesel, but a refinement of the fuel levy to differentiate between the two would be perfectly practicable given the relevant breakdown of consumption between the two.The estimated fuel consumption per vehicle kilometre is based on the analysis of vehicle operating costs described in Chapter 3 and unit consumption by representative vehicle type is then multiplied by the estimated annual vehicle kilometres for each category of vehicles to obtain total fuel consumption on inter urban state roads. This should be less than total automotive fuel consumption to the extent that it excludes consumption on urban, district and local roads.

The second part of the two part road tariff has to cover fixed costs plus an amount to ensure that heavy vehicles are making their full contribution to the variable road use costs for which they are responsible. The application of the fuel levy on its own will not be sufficient to cover all the load related costs imposed by heavy goods vehicles and the adjustment in the second part of the tariff is intended to make good this shortfall in heavy vehicle contributions. The second part of the quasi two part tariff usually comprises one or more of the following types of charges:

- Vehicle licences
- Weight and distance related charges, especially for foreign goods vehicles.

Both of these types of charges are in use in the TRACECA countries, but they are not making an adequate contribution towards cost recovery. Vehicle licence fees are too low and although the unit transit charges for international vehicles are not usually too low, the number of exemptions from them rather reduces their revenue earning potential. In some countries vehicles from C.I.S countries and from neighbouring countries contributing more than 90 per cent of international (non C.I.S) vehicle movements are exempt from paying transit charges as a result of inter-governmental agreements.

Detailed recommendations on road user charges in the second part of the quasi two part tariff are beyond the scope of this study, partly because the appropriate information on vehicle registrations is not readily available at the required level of detail. Vehicle registration data in the TRACECA countries is usually collected by the traffic police departments of the ministries of the interior, and there is a tendency to treat this information as confidential. The result is that obtaining the information can be time consuming and, even when it is made available, it is in excessively aggregated form. Information on the vehicle fleet is one of the most basic items of transport planning information and it should be readily available as a matter of course.

The analysis of appropriate transit charges for international vehicle needs to be based on a detailed analysis of the movements of international vehicles within each country so that reliable estimates of international vehicle kilometres and international equivalent standard axle (ESAL) kilometres by vehicle type can be calculated. Transit charges on international vehicles should be based on international ESAL kilometres. Information on axle loads of international vehicles has been collected, but detailed origin destination survey is beyond the resources of this study and until this information is also available, there will be no adequate basis for estimating appropriate international transit charges. There is also a need to clarify the whole position on exemptions from these charges. For those TRACECA countries where a very large proportion of international vehicles are from countries which are exempt from the transit charges, decisions have to be made about how long the exemptions are to continue. If they are to be regarded as fixed by international obligations, then it is doubtful if international transit charges are a potentially useful source of road use cost recovery.

In this study the recommendations on the appropriate level of vehicle licences required to cover fixed costs and to ensure that heavy vehicles make an adequate contribution to cost recovery fees must be regarded as very approximate. They are also higher than they would be if international transit charges were taken into account. It is regarded as more important for this study to show what the appropriate structure of road user charges should be rather than to attempt to make highly detailed recommendations on the basis of insufficient information.

7.3 Road User Charges Required for Cost Recovery

A simplified computer spreadsheet model for estimating the components of the quasi two part tariff needed to cover road use costs has been set up for each country. The fixed and variable annual road use costs for each country were estimated in Chapter 6 and these are the starting point for the user charge analysis. The model is simplified because, as explained above, it does not distinguish between petrol and diesel in the fuel levy, it does not include international transit charges, and it does not attempt to make detailed calculations of vehicle licence fees, but rather to indicate what order of magnitude they should be. The allocation of variable road use costs between different categories of vehicles is based on annual vehicle kilometres for the traffic or vehicle related portion and ESAL kilometres for the axle or loading related portion. The results of the simplified model for each country are set out in Annex 7 Table A.7.1 and the method of calculating the individual components is explained below.

Fuel Levy. The fuel levy is required to cover total annual variable road use costs and it is calculated by setting the levy per litre at a rate which, when multiplied by annual automotive fuel consumption in litres, will just cover total variable costs. In this study total automotive fuel consumption has been derived from the vehicle operating cost analyses and estimates of annual vehicle kilometres. If official estimates of total automotive fuel consumption were used, these would be greater than the study estimates because they should also reflect vehicle usage on urban, district and local roads. In practice it is not usually possible to match the fuel levy to total variable road use costs with absolute precision without going to an impossibly small fraction of a currency unit.

A closer look at variable road use costs shows that heavy vehicles account for a very high proportion of the axle or load related portion . The axle or load related part can be calculated for individual vehicle types by dividing total axle related variable cost by annual ESAL kilometres and multiplying the result by the ESAL per vehicle. When the proceeds of the fuel levy for different vehicle types are subtracted from the total variable costs attributable to those vehicle types it is quite common for heavy vehicles to be shown as not covering their fair share of variable costs. In Table A.7.1 this is indicated by the minus signs against individual heavy vehicle categories in the "Variable Cost minus Fuel Levy" columns. This has to be adjusted for in the second half of the quasi two part tariff, particularly when establishing annual licence fee levels for the heavier vehicle categories.

Vehicle Licence Fees. The annual fixed costs of road use have to be covered by a combination of licence fees, international transit charges and, possibly other charges. In this context it is worth noting that duties on imports of automotive vehicles and tyres could be included, but the revenues from such charges are normally incorporated into general tax revenue. In this simplified model, it is assumed that fixed costs plus or minus any small balance remaining from fuel levy revenue need to be covered by vehicle licence revenue. The levels of annual licence fees for the different categories of vehicles have been arrived at by a process of trial and error. However, the underlying principle is based on a capacity to pay concept. For buses this means taking account of passenger carrying capacity and for heavy goods vehicles payload capacity. If international transit charges were included, the amount to be covered by licence fees would be correspondingly lower.

The fuel levies and indicative vehicle licence fees resulting from the analyses in Annex 7 Table A.7.1 are summarised in Table 7.1 below. It has to be emphasised that these estimates assume that all the proceeds go towards full road use cost recovery. If governments were to insist on diverting a portion of the revenue from these user charges to non road uses, the fuel levies and indicative licence levels would have to be correspondingly higher to achieve full cost recovery. Conversely, if some of the revenue required for variable cost recovery is already obtained from existing fuel taxes, the required increase in fuel taxes would be equal to the fuel levy minus the portion of existing fuel tax earmarked for road expenditure. Similarly, if some portion of fixed road use costs were to be covered by transit charges on international vehicles, the indicated annual vehicle licence fees could be lower.

A note of caution is also in order with regard to the fuel levies. The estimated levies per litre have been based on automotive fuel consumption on the inter urban state road networks. If these levies per litre were to be multiplied by official estimates of total fuel consumption based on fuel sales and import data reflecting total road usage, the total revenue would cover variable road use costs on inter urban roads plus an unspecified portion of variable costs on the urban, district and local road networks. Alternatively, if total variable costs were divided by total officially estimated automotive fuel consumption, the fuel levy per litre would be lower than indicated, but the revenue would only cover variable costs on inter urban state roads. While the latter alternative may be politically more attractive, the former is probably the more desirable option pending the preparation of the necessary estimates of road use costs on the urban, district and local road networks.

Table 7.1 INDICATIVE FUEL LEVIES AND ANNUAL VEHICLE LICENCE FEES REQUIRED FOR FULL COST RECOVERY

Country	Required Fuel Levy (US cents per litre)	Indicative Annual Licence Fees Per Vehicle (US $)					
		Cars	Utility Vehicles	Large Buses	Trucks 2 axle	Trucks 3 axle	Trucks > 3 axle
Armenia	5.6	10	15	30	50	100	200
Azerbaijan	3.6	15	20	50	125	205	290
Georgia	5.3	10	13	50	80	140	215
Kazakhstan	4.9	10	15	48	80	115	220
Kyrgyz Republic	5.5	25	45	90	115	200	305
Tajikistan	5.0	(a)	(a)	(a)	(a)	(a)	(a)
Turkmenistan							
Uzbekistan	1.4	10	15	40	100	160	205

Note (a) Impossible to calculate in the absence of vehicle fleet data.
Source: Consultant's estimate

EUROPEAN UNION - TACIS

Technical Assistance to the Southern Republics of the CIS

and Georgia - TRACECA

TRADE AND TRANSPORT SECTORS

IMPLEMENTATION OF PAVEMENT MANAGEMENT SYSTEMS

PROJECT NO.: TELREG 9305

DRAFT FINAL REPORT

STUDY OF THE COST AND FINANCING OF ROAD USAGE

VOLUME 1, MAIN REPORT

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KOCKS CONSULT GMBH
Consulting Engineers
Koblenz / Germany

in association with

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PH∅NIX

and Transport Consultants
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Pavement Consultants
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COVER PAGE 1

STUDY OF THE COST AND FINANCING OF ROAD USAGE (DRAFT 12/96)

REPORT COVER PAGES

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Project Number	:	TELREG 9305
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STUDY OF THE COST AND FINANCING OF ROAD USAGE (DRAFT 12/96)

COVER PAGE 3

STUDY OF THE COST AND FINANCING OF ROAD USAGE (DRAFT 12/96)

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STUDY OF THE COST AND FINANCING OF ROAD USAGE (DRAFT 12/96)

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Reporting period : January to December 1996

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Project Title	:	**Traceca Project - Implementation of Pavement Management Systems**
Project Number	:	**TELREG 9305**
Country	:	**The Southern Republics of the CIS and Georgia**

The Project aims to introduce regional roads maintenance authorities to the latest Western pavement management techniques to promote a reduction in road maintenance backlogs and is being carried out by Kocks Consult GmbH of Germany in association with Phoenix Pavement Consultants a/s of Denmark and TecnEcon Ltd of the United Kingdom.

The planned starting date for the Project was 20 December 1995, but was delayed to middle of March 1996 due to the cold winter weather in the southern CIS states, which did not allow to carry out the field works for data collection. All efforts were made to catch up the time lost and until end of December 1996 more than 95% of the tasks have been completed.

The focus of the Project is on international transit routes with the specific objectives under the three main headings:

Technical: Establishment of a computerised database for road and bridge condition data. Assistance for the formation of PMS/BMS units.. Provision of road/pavement testing equipment, computers and programme system for the **P**avement **M**anagement **S**ystem (PMS) and the **B**ridge **M**anagement **S**ystem (BMS).

Together with the counterparts the Consultant carried out the field works for and data collection of road surface/road pavement and bridge condition, traffic counts and axle load surveys. Consequently the data were evaluated and the optimum maintenance strategy was calculated using the PMS/BMS programme system.

Economic: Analysis of the costs of road use and their coverage by present levels of expenditure. Study of the relationships between road user costs and road condition as well as between road condition and maintenance practice to demonstrate the economic impact of changes in road condition resulting from different levels of maintenance expenditure. Recommendations for an appropriate structure of road user charges.

Transfer of Technology: In addition to seminars and class room training local personnel was involved in all project tasks as on-the-job training in the techniques introduced with the aim to continue the activities after completion of the Project. Further seminars were held with the main topics:

- bitumen bound products/asphalt technology
- road design/road safety aspects

The respective authorities of the recipient states confirmed the introduction of the programme system and started to form the required PMS/BMS units. In three of the recipient states the PMS/BMS system will already be used for new projects:

- Improvement of the 145 km Tedjen - Mary road in Turkmenistan, where field works and data collection started in late November 1996
- Rehabilitation of the 450 km Alyat - Gjandza - Azeri road in Azerbaijan, commencement of activities will be end of January 1997
- Rehabilitation of the 465 km of roads in Georgia, commencement of activities will be end of February 1997

1 INTRODUCTION

This report on the Cost and Financing of Road Usage is one of the reports being produced under the European Union - TACIS sponsored TRACECA Project for the Implementation of Pavement Management Systems which is being carried out by Kocks Consult GmbH of Germany in association with Phønix Pavement Consultants a/s of Denmark and TecnEcon Limited of the United Kingdom. The geographical coverage of this study and the project of which it is a part includes eight countries falling within the area of the European Union's TRACECA initiative. These countries are Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tadjikistan, Turkmenistan and Uzbekistan.

The data required for the study were obtained during the course of visits to the project countries between March and October 1996 as well as from a previous study undertaken by the Consultant in Turkmenistan in 1995 and the relevant updated data, findings and recommendations from that study have been incorporated into the present study. Considerable use has also been made of road feasibility studies carried out by other international consultants in Azerbaijan, Kazakhstan, and Kyrgyzstan and by one of the present consultants in Armenia. A certain amount of information on Tadjikistan has been made available to the Consultants by various multinational donor agencies.

In view of the number of countries covered by this study the problem of the currency units to be used in the presentation of the findings had to be given careful attention. The use of a domestic currency plus at least one international currency for each country would have been unwieldy in view of the amount of data to be analysed and presented. It has been decided, therefore to standardise on one international currency and because of its familiarity in all the countries covered, the currency chosen was the United States dollar. The use of the dollar also has the advantage that it is less vulnerable to the effects of local inflation than the individual currencies in use in the TRACECA countries. The ECU is not yet familiar to most officials in these countries and therfore it was decided not to use it in the analyses undertaken. The dollar exchange rates used were based on the following rates which were those prevailing in mid 1996 or at the time of the field visits.

Armenian Dram	405	Kyrgyz Som	11.5
Azerbaijan Manat	4,300	Tajik Roubles	290
Georgian Lari	1.24	Kazakhstan Tenge	66
Turkmenistan Manat	4,000	Uzbekistan Som	42

The aims and scope of the study are set out in the extract from the Terms of Reference for the Pavement Management System Implementation project included in Annex 1. They can be summarised as requiring a rigorous analysis of the various elements making up the total costs of road use and the extent to which road use costs are being covered by present levels of expenditure in each country. The study is also required to explain the relationships between road user costs and road condition on the one hand, and between road condition and maintenance practice on the other. These elements are closely interlinked and an important aim of the study is to demonstrate the economic impact of changes in road condition resulting from different levels of maintenance expenditure. An important requirement of the Terms of Reference is the presentation of recommendations for an appropriate structure of road user charges based on the results of the road use costs analyses undertaken.

The time available for this study dictated that a short cut approach to road use cost analysis had to be adopted and this implied that traffic and road condition data had to be readily available. In general, locally available traffic data supplemented by the Consultants' axle load surveys have met the requirements of the study, but only for the main inter state and intra state inter urban road networks. Consideration of urban roads was outside the scope of this study given available time and other resource constraints. The rudimentary data availability for the district and local roads also precluded their inclusion. The lack of information on pavement strength data for the main inter urban road networks in all but two of the countries has posed some difficult but not insuperable problems. The limitations of the data base for a study of this nature should, however, be kept firmly in mind when considering the final results and recommendations.

Considerable assistance has been received from the respective highway institutions in all recipient states covered by the study and the Consultants would like to express their gratitude for the friendly co-operation extended to them during the course of their work.

2 ROAD TRANSPORT COSTS

2.1 General

This report is concerned with the costs of road usage in the TRACECA states and with methods of financing these costs. In this chapter the different categories of road costs are briefly introduced and their significance explained. In subsequent chapters road engineering and road user costs are examined in greater detail and the relationship between road maintenance and rehabilitation standards, road condition and road user costs is established.

Road transport costs are made up of the costs of road infrastructure provision and maintenance, road user costs and other costs such as environmental costs imposed on society by road transport. In this report the main concern is with the first two broad categories of road transport costs. The environmental impact of road infrastructure maintenance and rehabilitation is usually considered to be relatively minor as compared with the potential impact of major new road construction or realignment initiatives. To the extent that this study is mainly about the cost and financing of road network maintenance and rehabilitation, environmental costs are not considered in any detail.

The aim of appropriate highway management policy should be to minimize total life cycle road transport costs over a defined network. This immediately focuses attention on the relationship between road costs and road user costs on the one hand, and on the network to be considered on the other. In most of the TRACECA states the road network comprises inter state ("Magistrale") roads, republican or intra state roads, regional or oblast roads and district and-or local roads. Urban roads usually fall within one or more of these categories.

Logically discussions of road costs and methods of financing them should be at the total road network level since most road user charges are levied on road vehicles and their use regardless of what roads the are used on. An exception to this is toll road charging. In practice, however, data constraints usually mean that initially analysis has to be concentrated on the main road network. These will usually account for a very high proportion of inter urban vehicle kilometres. For administrative reasons urban roads often come within the area of responsibility of municipal road departments rather than the national highway department or agency. This often results in differences in the coverage of routine data collection which can make it difficult to include urban road networks in the analysis without a large increase in research effort. This is a more serious problem than the omission of local and district road networks because urban traffic contributes a much higher proportion of vehicle kilometres and should, therefore, have a significant influence on total road transport costs.

The time and resources available for this study have meant that considerable reliance has had to be placed on data already available within the individual highway institutions and departments in the TRACECA states. These organisations are mainly responsible for the inter urban main road networks and traffic and other data availability is also mainly confined to these networks. For this reason, the study's analyses and findings are also confined to the inter urban main road networks comprising the inter state and intra state roads. Urban roads are not included except where they form part of one or other of the above main road categories. The extent to which urban roads are included in the main road networks varies from country to country, but in general they are best regarded as being separate.

2.2 Road Costs

Road costs are the costs of road infrastructure provision and maintenance. They are the costs incurred by the government department, institution or agency which has the task of managing the relevant highway network. These costs are sometimes called agency costs and it is quite common for more than one agency to be involved. In addition to the national road institution or department which is responsible for road network administration, other government departments supplying traffic police services and customs inspection posts at international borders, for example, are also involved in the highway sector.

Road costs can be divided into fixed and variable costs and this distinction is important in the analyses of road use costs which form the basis of the type of road user charging policy discussed later in this report. Fixed costs are those costs which are independent of road traffic and include most of the costs of administering or managing the road network. In practice, there is a fixed and variable (traffic dependant) element in most categories of road costs. Estimates made by the World Bank suggest that for main roads fixed costs could account for the following approximate proportions of the main categories of recurrent costs.

- per cent of main road policing costs
- per cent of administration costs
- per cent of routine maintenance costs
- per cent of periodic maintenance costs and
- per cent of interest charges on road loans, where relevant.

The above proportions can be regarded as an approximate guideline and should not be taken to be applicable to all circumstances.

Traditionally, road costs were equated with the costs incurred by the road agency or highway department responsible for the provision and maintenance of road infrastructure. This rather narrow view of road costs was reinforced by the usual methods of annual road budget estimation and allocation.

The main problem with this traditional approach was that it did not take sufficient account of or attempt to quantify the costs being incurred by the users of the road network. These are now recognised as being significantly higher in most cases than the agency costs of road management. In recent years it has been widely recognised that road user costs should be taken into account when decisions are being made about the appropriate level of expenditure on roadworks.

A common problem in all the TRACECA states is that the cost of maintaining and rehabilitating the main road networks is significantly higher than the budgets being made available for the purpose. The economic and engineering results of this situation are examined in some detail in Chapters 3 and 4. However, the implications are fairly clear. Unless adequate financing for road maintenance and rehabilitation can be made available from the traditional general government budgetary sources, either alternative financing mechanisms have to be found, or the size of the core main road networks which can be maintained to an adequate standard will have to be reduced.

2.3 Road User Costs

2.3.1 Definition of Road User Costs Used in this Study

Road user costs comprise vehicle operating costs, passenger time costs, the costs of goods in transit and accident costs. In practice, in relatively low income countries such as the TRACECA states passenger time costs are not particularly significant in comparison with the costs of vehicle operation. The situation is completely different in the richer economies of north America and western Europe, for example, where passenger time costs are the dominant element in road user costs both because the scale of people movements and because of high personal incomes.

In this study attention is focused on the vehicle operating cost component of road user costs. The relative insignificance of the contribution of passenger time costs at current and foreseeable per capita income levels in the short to medium term has already been mentioned and this is illustrated below and in greater detail in Chapter 3. The cost of goods in transit is an even less important component of road user costs given the scale of road rehabilitation and maintenance effects on road conditions. International evidence suggests that a major reduction in travel time is required before there is a significant effect on the cost of goods in transit. The reductions in travel time resulting from improved road maintenance and rehabilitation are incremental rather than major and the effects on the cost of goods in transit are very minor. The relative unimportance of the cost of goods in transit as a component of road user costs is also illustrated below and in Chapter 3.

Accident costs are very difficult to quantify adequately unless data on the cost and frequency of accidents in relation to specific road features and locations is already available at the required level of detail. This is seldom the case unless an appropriate research initiative has been undertaken .The available data on road accidents in the TRACECA states does not permit accident costs to be quantified at a meaningful level of precision without a level of field research input which is well beyond the resources of this study. However, it is unlikely on the basis of international evidence that the omission of accident costs from road user cost estimates would have a significant impact on the results of road user cost based analyses in the TRACECA states

The omission of time costs of goods and passengers and accident costs means that the estimates of road user costs based on vehicle operating costs are slightly conservative, but not excessively so. Most of the analyses involving road user costs are concerned with changes in costs rather than absolute costs. This fact further reduces the potential impact of omitting time costs of goods and passengers.

2.3.2 The Importance of Road User Costs in Total Transport Costs

Road user costs are by far the most important component of total road transport costs and vehicle operating costs are the most important element in road user costs in the TRACECA states. Estimates prepared by consultants Carl Bro International a/s in their 1995 engineering and economic feasibility study of the improvement of the Bishkek-Osh road in Kyrgyzstan suggest that the percentage contribution of passenger time costs and goods time costs to total road user costs was as follows:

• Passenger time costs	Cars	5 % - 8 %
	Buses	11.% - 15.%
	Trucks	0.2 % -0.4 %
• Goods time costs	Cars and buses	0 %
	Trucks	0.3% - 0.5 %

These findings are in agreement with our own sample analyses for other TRACECA states.. When the structure of traffic and the distribution of vehicle kilometres is taken into account the overall share of vehicle operating costs in road user costs is 92% to 95% for passenger cars, 85% to 89% for buses and over 99% for trucks.

Road user costs are overwhelmingly the most important component of total road transport costs in every country. In the TRACECA states annual road user costs on inter urban main roads currently amount to around US$ 7.9 billion. If the appropriate amounts were being spent on maintenance and rehabilitation, average annual expenditure on the main road networks in the TRACECA states would be of the order of US$ 531 million. Actual annual expenditure is nearer US$127 million. Even at optimum annual expenditure levels, road costs would amount to no more than 6 per cent of total road transport costs.

It can be seen from the above that quite small changes in road condition will have a disproportional large impact on road user costs and, hence, on total transport costs. The changes in road condition resulting from inadequate maintenance levels will, therefore, have a significant, adverse economic impact via increasing road user costs. This has important implications for planning road expenditure strategies and devising optimum road maintenance programmes. It is also the main reason why road maintenance and rehabilitation strategies should be based on the results of engineering and economic analysis rather than just on engineering estimates.

2.4 Other Costs

Potentially the most important external cost of road transport is environmental pollution, including noise pollution. In practice, however, the main environmental impacts are attributable to new road projects on new alignments and urban road traffic rather than to road maintenance and rehabilitation. An important contributor to the environmental costs of road transport in the TRACECA states is the low standards of vehicle emission control, but this is not something that can be solved by road improvements.

The omission of accident costs from our estimates of road user costs has already been discussed above. External environmental costs are also excluded on the grounds that they are not quantifiable within the context of a study such as this and because their impact on road maintenance and rehabilitation policy is unlikely to be significant.

2.5 Economic and Financial Costs

In economic and engineering feasibility studies of road investment projects it is customary to distinguish between financial and economic costs. Economic analyses should be based on economic costs which reflect real resource costs to the economy. In practice this means that taxes are excluded from economic costs but any subsidy element in costs is included.Economic costs should also include adjusted or shadow prices, where perceived costs do not reflect market prices. Economic analyses are usually carried out in constant price terms and there should, therefore, be no inflation factors built into economic costs.

In the context of planning highway expenditure requirements, notably optimum road maintenance and rehabilitation strategies, economic costs should be used in the relevant engineering and economic feasibility analyses. Once the optimum strategies have been established, however, it is necessary to present the roadworks costs as conventional financial costs for budgeting and programming purposes.

In most of the TRACECA states there are considerable practical difficulties in establishing what economic costs are. While it is relatively simple to discover what taxes should be paid and, hence, eliminated from economic costs, it is very difficult to establish accurately what taxes actually are paid. There is a danger in understating economic costs by deducting taxes which have not actually been paid. Similarly, there are considerable difficulties in untangling complex cross subsidy elements in prevailing prices. These factors plus the considerable amount of fieldwork and analysis required to develop a set of appropriate shadow prices for individual countries means that rigorous economic costing cannot be undertaken within the relatively short time periods which have been made available for road transport studies in the region in recent years.

In this study the analysis of vehicle operating costs has been based on financial costs. However, the analysis of optimum road use costs is based on the World Bank's analyses of optimum maintenance and rehabilitation strategies using international evidence and economic costs. Even if all taxes were paid in the TRACECA countries, the tax component of financial vehicle operating costs would not be as significant as it is in most western European countries and economic and financial vehicle operating costs are not, therefore, significantly different. Given the low level of vehicle taxes, the main tax element is in automotive fuels and even this is relatively small by international standards.

3 VEHICLE OPERATING COSTS

3.1 Sources of Data

In this chapter an analysis of financial vehicle operating costs for each of the TRACECA countries is presented. As explained in Chapter 2, attention has been focused on vehicle operating costs as by far the most important component of road user costs. However, the potential significance of including the cost of passenger time savings and the cost of goods in transit is also examined. The main purpose of the analysis is to demonstrate the importance of vehicle operating costs in total transport costs and to show how they vary with road condition.

The inputs for the vehicle operating costs analyses for the TRACECA countries are based on data collected during field visits and on information in other consultants' road feasibility study reports. Information for Turkmenistan was derived from the Consultant's 1995 study for the European Bank for Reconstruction and Development entitled "Review of Administration and Financing of Road Improvement".This information, notably on prices, was updated to reflect changes in Turkmenistan since 1995.

Considerable use has also been made of the following consultancy studies in the TRACECA countries which incorporate vehicle operating cost analyses in their findings:

- Road Rehabilitation Study in Kyrgyzstan for the Asian Development Bank. This feasibility study of the improvement of the Bishkek-Osh road was undertaken in 1995 by Carl Bro International a/s, Hoff and Overgaard a/s and Upham International Corporation

- Prefeasibility Study of the Baku-Astara Road in Azerbaijan which was carried out by Wilbur Smith and Associates for EC TACIS in 1995 and 1996.

- Road Rehabilitation Project Kazakhstan undertaken in 1995 for the Asian Development Bank by Louis Berger International Inc. in collaboration with Kazdornii.

Reference has also been made to a number of earlier studies, notably the 1991"Road and Road Transport Study in Russia, Ukraine, Kazakhstan and Belarus" which was produced by TecnEcon and CowiConsult for the European Bank for Reconstruction and Development, and TecnEcon's "Armenia Highway Survey" produced in 1994 for EC TACIS.

The findings of the following two studies carried out in former communist countries have also been of interest in the development of vehicle operating costs estimate in the TRACECA countries:

- The 1993 Road User Charges Study in Romania by NEDECO, DHV Consultants and the Netherlands Economic Institute for the World Bank and the Romanian Administration of Roads.

- The 1995 Study of Investment and Maintenance Strategy for the National and Provincial Roads in Vietnam produced in 1995 by Scott Wilson Kirkpatrick for the United Kingdom Overseas Development Administration

Finally, estimates of vehicle operating costs by Kazdornii in Kazakhstan and the Armenian Road Directorate's Project Implementation Unit in Yerevan both utilising all or part of the vehicle operating cost sub model in the World Bank's Highway Design and Maintenance Standards Model - HDM III - have been a particularly useful source of information.

3.2 Estimating Vehicle Operating Costs

The vehicle operating costs estimates developed for each of the TRACECA countries are based on the use of the vehicle operating sub model from the World Bank's HDM-III model. This vehicle operating cost model predicts the various components of vehicle operating costs based on assumptions about road and vehicle characteristics and unit costs. For each country six representative categories of vehicles were selected for costing and the operating costs for those vehicles were taken to be representative of the costs of all vehicles in that classes in each country. The following classes of representative vehicle types were selected for vehicle operating cost analysis:

- Passenger cars
- Utility vehicles comprising minibuses and pickups
- Large buses
- axle trucks
- axle trucks
- Trucks with more than 3 axles

This vehicle classification is the same as that used in the traffic analyses undertaken for this study and in the traffic and vehicle operating cost inputs for the Pavement Management System model being implemented in the TRACECA countries. In each country a representative vehicle model was selected within each vehicle category and the cost estimates were developed for that model. Every attempt has been made to ensure that the representative models are the most widely used within their class in each country. Only in Georgia was it possible to base the selection of representative vehicle models on vehicle registration data. In the other countries vehicle registration data was not available at an adequate level of detail for this to be possible. In these countries the selection of representative vehicle models was based on the results of the Consultant's moving observer traffic counts and on visual observations in bus and truck parks. Reference was also made to the representative models selected for costing in the other consultants' studies in Kyrgyzstan, Kazakhstan, Azerbaijan, Armenia and Turkmenistan referred to above. Most of the vehicles in use in the TRACECA countries are of Russian manufacture and there is, therefore, a much higher degree of uniformity in the representative models than would normally be expected in a multi-country study. Details of the representative vehicle types and models used in the analysis are set out in Annex 3, Table A.3.1.

Data inputs required for the operation of the vehicle operating cost sub model (VOCM) can be divided in to the following six categories:

- Roadway characteristics
- Vehicle characteristics
- Tyre wear data
- Vehicle utilisation data
- Unit costs
- Additional model coefficients

Where local data is not available for specified non-cost inputs, default values from within the model can be used. Most of the additional model coefficients used in this study are based on default values.

A detailed listing of all inputs for each representative vehicle for each country is set out in Annex 3, Table A.3.2.

A number of general observations on the input data are in order. Most of the technical coefficients relating to vehicle performance are based on default values within the VOCM. Technical information on the representative truck models, which are all of Russian or Ukrainian manufacture, has been obtained from other studies and technical literature.

Vehicle utilisation levels are low by international standards and this reflects the depressed economic conditions in all the TRACECA countries during the past 5 years and the problems faced by vehicle operators in a transition economic environment. The age of the vehicle fleet in each country is high by international standards and the sale of new vehicles is very low.

The scarcity of new vehicles means that it is difficult to obtain realistic information on the prices of new as opposed to second hand vehicles. The prices of second hand vehicles were checked at the weekly vehicle auctions in the capitals of the TRACECA countries visited and prices of low kilometrage vehicles was noted as a guide to estimating new vehicle prices. Vehicle prices are low by international standards and this reflects their predominantly Russian origin. This is particularly true for heavy trucks where Russian models within a given category tend to be significantly smaller than their international counterparts and also much cheaper.

The prices of petrol and diesel are important inputs in the VOCM and they are an important determinant of unit vehicle operating costs. Although there are large variations in the retail price of automotive fuels in the TRACECA countries, it is fair generalisation to state that these prices are also low by comparison with the prices in most advanced industrial countries and many developing countries. The average prices of petrol and automotive diesel in each country are summarized in Table 3.1. In certain cases these prices are the mid point of a range of retail prices observed during fieldwork. In most TRACECA countries the average 1996 petrol price is within the range US$ 0.20 - 0.35 per litre and the diesel price is within the range US$ 0.20 - 0.30 per litre. Prices in Tadjikistan are significantly higher and in Turkmenistan significantly lower than these ranges. The price of diesel in Azerbaijan is also very low, both in relation to the price of petrol and in relation to diesel prices in most other TRACECA countries.

TABLE 3.1: PETROL AND DIESEL PRICES

Country	Automotive Fuel Prices (1996 average level)	
	Petrol (US$/litre)	Diesel (US$/litre)
Armenia	0.35	0.30
Azerbaijan	0.35	0.14
Georgia	0.28	0.21
Kazakhstan	0.29	0.20
Kyrgyzstan	0.22	0.20
Tajikistan	0.43	0.40
Turkmenistan	0.10	0.07
Uzbekistan	0.38	0.30

Note: In some countries the indicated fuel price is the mid point of a range of prices observed during fieldwork.
Source: Fuel price data and Consultant's estimates

3.3 Relative Importance of Vehicle Operating Cost Components

The main vehicle operating cost components analysed in the VOCM are the following:

- Automotive fuel consumption
- Lubricants consumption
- Tyre consumption
- Crew time
- Maintenance spare parts consumption
- Maintenance labour time
- Depreciation and interest
- Overheads (in financial costs)

The relative importance of these operating cost components varies according to relative prices and to the vehicle operating environment as dictated by road geometry and surface roughness. Fuel consumption is conventionally regarded as a major component of vehicle operating cost and this is largely true in most of the TRACECA countries. In Turkmenistan, however, where fuel prices are exceptionally low, fuel is a relatively minor cost item in vehicle operation. Fuel consumption also becomes relatively less important in overall operating costs as road conditions deteriorate and vehicle speeds decline. This is counterbalanced by a more than proportionate increase in the importance of maintenance spare parts consumption and vehicle maintenance costs in general.

For each TRACECA country the base financial vehicle operating costs by vehicle type are set out in Table 3.2. Base vehicle operating costs are the costs on a paved road in fair condition with surface roughness of IRI 5 metres / kilometre. The most significant components of base costs are fuel, maintenance parts, depreciation and, for heavy vehicles only, tyres. Fuel generally accounts for 20 - 35 per cent of total costs for all vehicles except utility vehicles, where the proportion is higher. Maintenance parts consumption is responsible for around

20 - 25 per cent and depreciation for 10 - 25 per cent of total costs. Heavy goods vehicles and large buses have more tyres and higher wear and tear on them and for theses vehicles tyre costs can make up between 20 and 30 per cent of base operating costs.

The vehicle operating cost proportions shown in Table 3.3 and in Annex 3 Table A.3.4 are not fixed over the whole range of operating conditions. Rising surface roughness levels reflecting deteriorating road condition results in declining vehicle speeds which reduces the relative importance of fuel consumption in total costs. Maintenance costs, however, increase in relative significance with declining road condition.

A comparison has been made of the relative importance of different operating costs components for different vehicle types in good and bad road conditions. In order to keep it manageable the comparison is restricted to three countries - Armenia, Kyrgyzstan and Turkmenistan - where fuel prices are respectively higher than the TRACECA average, in the middle of the TRACECA range and well below the TRACECA range. The comparison covers roads in good condition, denoted by an International Roughness Index (IRI) of 3 metres / kilometre, and bad condition (IRI 12 metres / kilometre). The results of the comparison are set out in Annex 3 Table A.3.4 where the cost of individual components are expressed as a percentage of total vehicle operating costs.

Table A.3.3 PERCENTAGE BREAKDOWN OF VEHICLE OPERATING COSTS

Vehicle Operating Cost Component	% of Total Vehicle Operating Costs					
	Car	Utility	Large Bus	Truck 2 axle	Truck 3 axle	Truck >3 axle
KYRGYZ REPUBLIC						
Fuel	17,74	28,16	19,97	20,03	17,57	17,82
Lubricants	3,46	2,43	1,18	1,91	1,10	0,99
Tyres	4,63	4,85	37,65	23,79	31,01	40,62
Crew time	0,00	6,62	3,95	6,74	3,17	3,99
Maintenance labour	2,51	1,96	2,02	2,80	2,27	3,04
Maintenance parts	21,08	25,67	11,70	14,13	22,70	19,16
Depreciation	25,03	12,97	12,44	12,06	10,10	6,17
Interest	25,55	10,32	8,63	11,19	7,87	5,73
Overheads	0,00	7,02	2,46	7,33	4,22	2,47
TOTAL	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**
TAJIKISTAN						
Fuel	30,42	43,45	33,30	33,02	30,95	31,64
Lubricants	3,07	1,89	1,03	1,56	0,90	0,83
Tyres	3,97	3,55	31,55	26,15	26,72	35,59
Crew time	0,00	7,74	3,09	5,14	3,62	3,50
Maintenance labour	2,04	1,37	1,58	2,17	1,67	2,24
Maintenance parts	20,70	19,88	10,16	12,86	19,77	15,23
Depreciation	21,44	9,90	10,94	7,39	7,79	4,91
Interest	18,36	6,77	6,19	5,73	5,13	3,97
Overheads	0,00	5,46	2,15	5,98	3,46	2,07
TOTAL	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**
TURKMENISTAN						
Fuel	10,30	20,50	9,09	9,35	8,68	8,58
Lubricants	1,44	1,17	0,55	0,76	0,44	0,42
Tyres	6,10	4,96	33,77	28,64	28,78	41,57
Crew time	0,00	8,37	3,97	6,68	3,18	4,05
Maintenance labour	2,37	2,11	1,99	2,79	2,02	2,73
Maintenance parts	26,16	26,90	13,35	23,95	29,45	21,80
Depreciation	32,42	16,48	20,82	10,39	14,89	11,15
Interest	21,22	9,35	10,20	7,57	6,82	6,18
Overheads	0,00	10,18	6,28	9,89	5,74	3,52
TOTAL	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**
UZBEKISTAN						
Fuel	27,56	43,92	30,38	32,51	29,52	29,84
Lubricants	2,85	1,92	1,19	1,80	0,97	0,94
Tyres	3,94	3,87	26,35	23,42	22,84	30,68
Crew time	0,00	3,82	2,76	4,88	2,25	2,92
Maintenance labour	1,47	1,09	1,37	2,09	1,44	1,97
Maintenance parts	21,04	20,46	10,08	18,34	22,93	17,58
Depreciation	26,07	12,26	15,72	7,91	11,25	8,87
Interest	17,07	6,69	7,70	5,69	5,15	4,91
Overheads	0,00	5,96	4,45	3,37	3,64	2,28
TOTAL	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**

Note: Financial vehicle operating costs
Source: Consultant's estimates

TABLE 3.2: BASE VEHICLE OPERATING COSTS BY COMPONENT

TABLE 3.2: BASE VEHICLE OPERATING COSTS BY COMPONENT

The significance of fuel prices is evident from the wide differences in the relative importance of fuel consumption in total operating costs in the three countries. In Armenia, where automotive fuel prices are at the top end of the range in TRACECA countries, fuel accounts for one third or more of total operating costs on roads in good condition. This drops to 20 - 30 percent of total costs on paved roads in bad condition. In Turkmenistan, on the other hand, fuel consumption only accounts for around 10 percent of total operating costs on good roads and 6 - 8 percent on bad roads.

Tyres are a more significant cost component for heavy vehicles than for light passenger vehicles. Tyre costs actually decline in relative importance with increasing road roughness and declining vehicle speeds. Maintenance parts consumption increases sharply in relative importance as a component of operating costs as road roughness increases. Although maintenance labour increases in the same way, the low wage levels in the TRACECA countries means that this does not have as big an effect on costs as in higher income countries.

3.4 Summary of Base Vehicle Operating Costs By Vehicle Type and Country

The basic vehicle operating costs estimated for the representative vehicle types in the TRACECA countries are summarised in Table 3.3. These base costs are representative costs on paved roads in fair condition with a surface roughness of IRI 5 metres / kilometre.

The range of financial operating costs for each vehicle type over the TRACECA region can be summarised as follows:

- Cars — US$ 0.08 - 0.11 per kilometre
- Utility vehicles — US$ 0.10 - 0.18 per kilometre
- Large buses — US$ 0.35 - 0.50 per kilometre
- axle medium truck — US$ 0.24 - 0.30 per kilometre
- axle heavy truck — US$ 0.44 - 0.64 per kilometre
- axle heavy truck with trailer — US$ 0.09 - 1.06 per kilometre

A significant part of the reason for the differences in operating costs for given categories of vehicles is the variation in automotive fuel prices. These vehicle operating costs are quite low by international standards and the main reason is low vehicle prices, low fuel prices and low maintenance labour and crew costs.

TABLE 3.3: SUMMARY BASE VEHICLE OPERATING COSTS

Vehicle Operating Cost Component	Vehicle Operating Costs (US$ per Kilometre)					
	Car	Utility	Large Bus	Truck 2 axle	Truck 3 axle	Truck >3 axle
Armenia	0.09	0.12	0.41	0.26	0.54	0.90
Azerbaijan	0.11	0.13	0.39	0.24	0.54	0.76
Georgia	0.10	0.15	0.38	0.24	0.48	0.69
Kazakhstan	0.11	0.16	0.50	0.29	0.59	0.85
Kyrgyz Republic	0.10	0.14	0.49	0.30	0.52	0.89
Tajikistan	0.11	0.18	0.56	0.37	0.64	1.06
Turkmenistan	0.08	0.10	0.35	0.25	0.44	0.71
Uzbekistan	0.11	0.17	0.45	0.30	0.55	0.88

Note: Financial vehicle operating costs
Source: Consultant's estimates

3.5 The Effect of Road Conditions on Vehicle Operating Costs

3.5.1 Road Condition and Road Surface Roughness

Deterioration in road conditions results in increases in vehicle operating costs. For the road user changes in road condition are mainly reflected in changes in surface roughness or bumpiness. There are several measures of road surface roughness, but the International Roughness Index (IRI) has emerged as the most commonly used international standard measure. The IRI reflects the cumulative vertical movements in a vehicle's rear axle per kilometre and it is expressed in metres per kilometre. Our discussion of the relationship between road condition and vehicle operating costs must involve frequent references to different levels of IRI and it is important to be quite clear about what they mean in qualitative terms.

The range of surface roughness usually considered in highway studies is from IRI 2 m/km to IRI 20 m/km. A roughness level of less than IRI 3 m/km means that the road is in excellent to good condition. For paved roads an IRI of 10 m/km or more denotes a road in bad to very bad condition and anything over IRI 12 m/km would indicate extensive pavement failure or loss of pavement. On unpaved roads roughness levels are generally higher than on paved roads and slightly more relaxed qualitative standards are usually applied. For example, an unpaved road with an IRI of less than 5 m/km would be considered to be in good to quite good condition and very bad condition might be considered to be IRI 15 and over. When surface roughness levels approach IRI 20 m/km it is doubtful if the road retains any engineered properties and for operating purposes can be considered to be a track.

This study is mainly concerned with the inter state and intra state main road networks in the TRACECA countries and the overwhelming majority of these are paved. This section will, therefore, concentrate on roughness levels on paved roads. The following indcations of road condition at different roughness levels will be helpful in understanding the subsequent discussion of the relationship between road surface roughness and vehicle operating costs.

Roughness IRI < 3.0 m/km
Vehicle speeds of over 120 km/h are comfortable. No depressions, potholes or corrugations are noticeable. This roughness level would be associated with high quality asphalt and, possibly, very good quality surface treatment. International evidence suggests that concrete pavements rarely achieve roughness levels this low.

Roughness IRI 4.0 - 5.5 m/km
In vehicles travelling at 80 km/h moderately perceptible movements or large undulations may be felt. Defective surface is evident with occasional depressions, patches or potholes or many shallow potholes. In the absence of visible surface defects there may be moderate corrugations or large undulations. Concrete pavements built during the Soviet era were unlikely to have had initial roughness levels below IRI 4 m/km

Roughness IRI 7.0 - 8.0 m/km
At vehicle speeds of 70 - 90 km/h the ride remains reasonably comfortable, but there are strongly perceptible movements and swaying usually associated with defects. These may take the form of frequent, moderate and uneven depressions or patches, and occasionally potholes.

Roughness IRI 9.0 - 10.0. m/km
The ride only remains comfortable at vehicle speeds of 50 - 60 km/h and there can be frequent sharp movements and swaying. These are associated with severe defects taking the form of frequent, deep and uneven depressions, patches and potholes.

Roughness IRI 11.0 - 12.0 m/km
Vehicle speeds generally have to be below 50 km/h because there are many deep depressions and severe disintegration.

In the following discussions of surface roughness and vehicle operating costs the above qualitative categorisation of pavement condition will be simplified as follows:

- IRI 3 m/km or less - good condition
- IRI 5 - 6 m/km - fair condition
- IRI 7 - 9 m/km - moderate to poor condition
- IRI 10 m/km or over - bad to very bad condition

Table 3.4 TOTAL VEHICLE OPERATING COSTS AT DIFFERENT ROAD SURFACE ROUGHNESS LEVELS

Country	Length of main road network (a) (km)	Vehicle-Km on the main road network (million)	Total Vehicle Operating Costs (US$ million) if average main road condition was: Good (IRI 3 m/km)	Fair (IRI 6 m/km)	Poor (IRI 9 m/km)	Very bad (IRI 12 m/km)
Armenia	3.147,8	1.970,0	309	354	404	461
Azerbaijan	4.689,0	4.496,0	967	1.095	1.236	1.392
Georgia	5.005,3	2.088,4	293	336	387	444
Kazakhstan	17.496,0	10.089,0	2.004	2.360	2.756	3.190
Kyrgyzstan	3.109,9	1.506,1	297	341	390	444
Tajikistan	1.785,2	620,6	147	166	188	212
Turkmenistan	7.682,6	3.545,4	841	972	1.112	1.263
Uzbekistan	21.825,0	10.466,7	2.635	3.009	3.418	3.862

Country	Percentage Increase in Vehicle Operating Costs compared with those on roads in good condition: Condition Fair (IRI 6 m/km)	Condition Poor (IRI 9 m/km)	Condition Very bad (IRI 12 m/km)
Armenia	14,5	31,0	49,4
Azerbaijan	13,2	27,8	43,9
Georgia	14,9	32,1	51,5
Kazakhstan	17,8	37,5	59,2
Kyrgyzstan	14,7	31,2	49,4
Tajikistan	13,3	28,2	44,6
Turkmenistan	15,5	32,2	50,1
Uzbekistan	14,2	29,7	46,6
ALL	15,2	32,0	50,4

Source: Consultant's estimates

TABLE 3.4: TOTAL VEHICLE OPERATING COSTS AT DIFFERENT ROAD SURFACE ROUGHNESS LEVELS

3.5.2 The Relationship Between Vehicle Operating Costs and Road Roughness

The World Bank's HDM-III model is a road simulation model and the vehicle operating cost sub model within it simulates the behaviour of vehicles in response to actual and predicted changes in road condition and surface roughness. The slightly simplified vehicle operating cost sub model (VOCM) used for this study presents the relationship between road roughness and vehicle operating costs in the form of the following two alternative formulations:

- VOC = a + b (IRI) + c (IRI^2)
- VOC = exp[a + b (IRI)]

where VOC = unit vehicle operating cost per kilometre
IRI = road surface roughness in metres per kilometre
a and b are parameters to be solved for each vehicle type

In practice, the first form of the simplified model has been found to give the better statistical relationship in the TRACECA countries and it has been adopted for use in this study.

On the basis of the inputs described earlier, vehicle operating cost estimates have been prepared for each of the six representative vehicle types in each TRACECA country. The detailed results are presented in Annex 3 Table A.3.5 . This shows the results from the model for each vehicle type in each country and the unit vehicle operating costs per kilometre at IRI 3 up to IRI 15 m/km. All operating costs are in US dollars.

The results can be summarised quite briefly. For each increase in road surface roughness of IRI 1 m/km unit vehicle operating costs rise by 5 - 7 percent for light vehicles and 2 - 5 percent for heavy vehicles. When allowance is made for the structure of traffic and the mix of vehicle kilometres in the TRACECA countries, each increase of IRI 1 m/km in surface roughness can be shown to result in an increase in total vehicle operating costs of 4 - 5 percent. Translating this into a comparison of vehicle operating costs on roads in good, fair, poor and bad condition, the overall average increase in operating costs compared with a road in good condition are as follows:

- Road in fair condition (IRI 6 m/km) - operating costs 15 percent higher
- Road in poor condition (IRI 9 m/km) - operating costs 32 percent higher
- Road in very bad condition (IRI 12 m/km) - operating costs 50 per cent higher

Total vehicle operating costs in each country have been estimated by multiplying the unit vehicle operating costs for each vehicle type by the total annual vehicle kilometres for the same vehicle types. The vehicle kilometre estimates for each country are described in Chapter 6. Total vehicle operating costs in each country at different roughness levels are shown in detail in Annex 3 Table A.3.6. The results are summarised in Table 3.4. In Kazakhstan, for example, an increase in average main road roughness levels from , say, IRI 5 m/km to IRI 6 m/km would result in an increase in annual vehicle operating costs on main inter urban roads of US$ 123 million at present traffic levels. This is US$ 52 million or 75 percent more than the country's total road budget in 1995. Examples from the other countries would show a similar picture.

Road surface roughness levels have been reported to be increasing at around 7 percent a year on the main roads in the TRACECA region and in some countries such as Armenia and Georgia it could be nearer 20 per cent. Assuming an annual rate of increase of 10 per cent in average main road network roughness it would take 7 years for average network condition to deteriorate from good (IRI 3 m/km) to fair (IRI 6 m/km) and a further 4 years for it to deteriorate to poor (IRI 9 m/km). At the much higher rates of deterioration reported in the Caucasus region the same developments would take 4 and 2 years respectively. In Armenia an increase in average main road network roughness from IRI 3 to IRI 6 m/km implies an increase in annual vehicle operating costs of US$ 45 million at present traffic levels and if roughness progression really is 20 percent a year, this loss would be incurred over only 4 years. A further increase in average roughness from IRI 6 m/km to IRI 9 m/km over two or three years would result in a further increase of US$ 50 million in vehicle operating costs at present traffic levels.

These operating costs magnitudes obviously have a potentially serious impact on costs elsewhere in the economy. They also provide a clue as to why appropriate road maintenance and rehabilitation designed to arrest road network roughness progression has such a high economic priority. Such maintenance and rehabilitation can be undertaken for costs which are very significantly less than the potential savings in vehicle operating costs which they can bring about. For this reason appropriate road maintenance and rehabilitation programmes have high economic rates of return which is another way of saying that they are of high economic priority.

3.6 Economic Significance of Vehicle Operating Costs

In the TRACECA countries as a group vehicle operating costs on the main inter urban road networks amount to not less than 14 percent of Gross Domestic Product (GDP) or 6 percent of GDP at purchasing power parity. The estimates of GDP are based on data from the World Bank and the European Bank for Reconstruction and Development (EBRD).

There are some variations about this average in the different countries, but only in Azerbaijan is it significantly different. The available data suggest that total inter urban main road vehicle operating costs in Azerbaijan could amount to more than 30 percent of GDP or 10 per cent of GDP at purchasing power parity. This ratio double the TRACECA region average and it seems unlikely to be correct. There are two possible explanations. The first is that the available estimates of Azerbaijan's GDP may be too low. The second is that the data on Azerbaijan traffic on which our estimates of vehicle kilometres and, hence, total vehicle operating costs are based may be significantly overstated. However, the degree of overstatement of traffic volumes would have to be very large indeed to explain such a high ratio of operating costs to GDP, and this to be inherently unlikely. Given the presently available data, an underestimate of GDP seems to be the more plausible explanation.

The ratios of total vehicle operating costs to GDP in the TRACECA countries are high enough for the economic significance of rising, or indeed falling, road roughness levels to be self evident. A comparison of total vehicle operating costs and GDP in each of the TRACECA countries is set out in Annex 3 Table A.3.7. Background economic data are presented in Table A.3.8.

3.7 Potential Significance of Passenger and Goods Delay Costs

The overwhelming importance of vehicle operating costs in road user costs has already been discussed briefly in Chapter 2. The main evidence for this is the work undertaken in the road feasibility studies in Azerbaijan and Kyrgyzstan undertaken respectively by Wilbur Smith and Associates and Carl Bro International a/s. In the Baku - Astara road study in Azerbaijan the consultants estimated vehicle operating costs and passenger delay costs. In Carl Bro International's study of the Bishkek - Osh road in Kyrgyzstan vehicle operating costs and the costs of delays to goods in transit were estimated.

The assessment of passenger delay costs involves the following steps:

- Estimating the average number of passengers per vehicle.

- Estimating the value of time for different categories of passengers which involves obtaining information on passenger occupations.

- Estimating what proportion of passenger time saved could be used productively. This is usually based on information on trip purposes derived from detailed roadside interview surveys of vehicle drivers and passengers.

The valuation of the cost of delays to goods in transit involves valuing the goods making up vehicle loads and the cost of time represented by an interest rate.

The information required for these valuations is very detailed which explains why estimates of the cost of delays to passengers and goods is only attempted in the context of detailed road feasibility studies. Experience from many road feasibility studies in low income countries throughout the world has shown that the economic value of passenger and goods time saved is usually a very small fraction of the value of vehicle operating costs. This is another reason why they are sometimes omitted from studies which are being undertaken under limited budgets and time constraints.

Using the methodology described above, the consultants undertaking the studies in Azerbaijan and Kyrgyzstan estimated the value of delays to passengers and goods in transit as follows:

- **Azerbaijan.** The valuation of passenger time was based on average wage rates and on this basis, and taking account of occupational categories, the time of car and bus passengers was estimated to be equivalent to US$ 0.51 and 0.35 per hour. However, it was assumes that only 30 percent of car passengers' and 20 percent of bus passengers' trips were for economically productive purposes and the real value of time saved was accordingly reduced to these proportions of the full time value. In effect the real hourly value of passenger time saved was US$ 0.15 for car passengers and US$ 0.07 for bus passengers. The average number of passengers per vehicle was assumed to be two for cars and thirty four for large buses. The value of delays to goods in transit was not estimated, presumably because it was assumed to be insignificant.

- In the **Kyrgyzstan** study passenger time values were also based on weekly wage rates and an undifferentiated hourly value of US$ 0.36 was initially estimated for passengers of all vehicle types. However, only 50 percent of passenger time saved was assumed to be potentially used productively and the real value of passenger time saved was, therefore, US$ 0.18. Average vehicle occupancy was assumed to 3.5 passengers per car, 6.5 passengers per utility vehicle and 32 passengers per bus.

- **Kyrgyzstan cargo delay costs.** The basis of the estimate was an assumption from origin-destination survey evidence that 10 percent of trucks were carrying perishable commodities, mainly fruit and vegetables, and 50 percent were carrying non-perishable goods. A representative value of US$ 200 per tonne was estimated for perishable cargoes, 0.5 percent of the cargo was assumed to be spoiled per day and an hourly interest rate of US$ 0.013 was calculated. The hourly cargo delay cost was accordingly estimated at US$ 0.01 per tonne of truck capacity and this translated into the following cargo delay costs by truck type:

-	2 axle truck	US$ 0.05 per hour
-	3 axle truck	US$ 0.10 per hour
-	>3 axle truck	US$ 0.15 per hour

In order to test the significance of passenger and goods time costs compared with vehicle operating costs in Azerbaijan and Kyrgyzstan we have entered assumed time values into the operating cost model for each country and rerun the model. In fact the passenger time value for Azerbaijan was rounded up to a uniform US$ 0.15 per hour for passengers on all vehicle types. Kyrgyzstan passenger time value was rounded up from US$ 0.18 per hour to US$ 0.20 per hour. The value of goods delay costs per hour were as set out above. The respective models for the two countries were then run and the results are summarises in Annex 3 Table A.3.9

In Azerbaijan annual passenger time costs only account for 3.9 per cent of the total of vehicle operating costs and passenger time costs. In Kyrgyzstan the proportion is 5.9 per cent. Cargo delay costs were only valued in the Kyrgyzstan study and they vary insignificant indeed. Compared to annual vehicle operating costs of US$ 324.1 million and passenger time costs of US$ 20.3 million, cargo delay costs amounted to only US$ 679,000 or 0.2 per cent of total road user costs. A number of tests for other TRACECA countries showed the same picture.

In view of the low prevailing income levels and the resulting very low economic time values in the TRACECA states their marginal contribution to road user costs in the inter urban road context hardly justifies the considerable effort required to quantify them. This conclusion would not, however, be necessarily valid in the urban road transport context.

4 ECONOMIC IMPACT OF ROAD MAINTENANCE

4.1 Introduction

The purpose of road maintenance is to make sure that a road does not fail before its design life. Successful road maintenance achieves this by reducing the road's rate of deterioration and, by slowing down the rate of surface roughness progression, it enables road user costs to be lower than they would otherwise have been. The overwhelming importance of road user costs in total road transport costs has already been demonstrated in Chapter 3 and anything which reduces these costs has a significant effect. The economic impact of a reduction in road user costs must, however, be assessed in relation to the costs of achieving it. In this respect, maintenance, which is a relatively low cost activity in comparison, for example, with new road construction, is highly desirable from the economic perspective as well as being good engineering practice. This is reflected in the high economic rates of return to maintenance programmes which are appropriate in scale and timing. In short, road maintenance is one of the most appropriate uses of scarce budgetary resources in the transport sector.

In the past the main problem with road maintenance in many low income countries had nothing to do with engineering or economics, but rather with image. Road maintenance was perceived to be a rather mundane activity with none of the political attractions of higher profile new construction projects. In Africa and Latin America this led to a neglect of road maintenance and a very high economic costs were subsequently incurred. The sharp contraction in highway budgets in the late 1970s and 1980s came about just as the effects of neglected maintenance were becoming highly visible. Attitudes toward highway maintenance have subsequently changed and this reflects both the new budgetary realities and the prompting of international donors such as the World Bank.

In the TRACECA countries highway maintenance has been inadequate in the 1990s and the effects are becoming evident in rising road surface roughness levels. This means that in the more serious cases rehabilitation is needed as well as maintenance. In the most serious cases the situation will have deteriorated to a point where the pavement may have to be completely reconstructed. The progression from routine and periodic maintenance to rehabilitation and reconstruction involves very large increases in the cost of roadworks. Inadequate allocations of funds to road maintenance have been a result of severe contractions in state budgetary resources and this in turn has reflected the economic crisis experienced by most of the TRACECA countries.

4.2 Road Maintenance, Road Condition and Road User Costs

The use of computerised models to simulate pavement behaviour has enabled the effects of different maintenance levels on road condition and road user costs to be predicted with greater precision in recent years. The development of the World Bank's HDM-III model and its use to analyse the economic implications of network deterioration in low income countries in the late 1980s did much to focus attention on the vital importance of appropriate maintenance. It has also been widely used to develop optimum maintenance and rehabilitation strategies for different road conditions with and without budget constraints.

Under the current TRACECA project all 8 recipient states are provided with hardware and software for a computerised data base and a pavement management system (PMS).The model used in this PMS to predict pavement deterioration and surface roughness progression is from the latest version of the World Bank's Highway Design and Maintenance Standards model (HDM-IV) which is currently being tested. The model basically takes account of existing pavement condition as measured by roughness (IRI in m/km), pavement age and strength, the incidence of rutting and cracking, cumulative pavement damage from axle loading and environmental factors represented by an environmental coefficient. The specification of the roughness prediction model is as follows:

$$IRI_t = 0.98 * e^{mt} * [RI_0 + 135 SNCK_4^{-5} * NE_t] + [0.143 * RDS_t] + [0.0068 * CRX_t] + [0.056 * PAT_t]$$

Where

$SNCK_4$	=	1 + SNC - 0.00004 * HS * CRX_t
RI_t	=	roughness at pavement age t, IRI in m/km
RI_0	=	initial roughness, IRI in m/km
NE_t	=	cumulative equivalent standard axle loads (ESAL) at age t, in million ESA/lane
t	=	pavement age since construction or rehabilitation in years
m	=	environmental coefficient
SNC	=	structural number modified for subgrade strength
HS	=	thickness of bound layers in mm
CRX_t	=	area of indexed cracking (%) at time t
RDS_t	=	standard deviation of rut depth in mm at time t
PAT_t	=	area of patching (%) at time t

The use of this and other pavement models in engineering and economic analysis of road maintenance and rehabilitation is needed to predict the progression of surface roughness with or without some form of treatment, and the reduction of roughness resulting from a treatment. Once the year by year roughness has been predicted, there is a direct link with road user costs via the type of models illustrated in Chapter 3.

The economic analysis of alternative maintenance and rehabilitation options takes the form of a discounted cash flow analysis over a defined period or life cycle. It is customary in this type of analysis to compare one or more defined alternatives with an option representing doing the minimum possible. The latter is sometimes called the "without situation" and the former the "with situation(s)". It is important to realise that over long appraisal or life cycle periods of 10 or more years doing the minimum in the "without situation" is very unlikely to mean doing nothing. Therefore, the occasional references to the "do nothing situation"which are encountered in some analyses are misleading and they should be avoided. The total engineering and road user costs under the two options are compared and the results are expressed in the form of different measures of economic feasibility or project worth. These include the Net Present Value (NPV) which is the sum of the discounted net benefits over the defined appraisal period, the NPV per kilometre, and the Internal Rate of Return (IRR), which is the discount rate at which costs and benefits are equated. The Benefit/Cost Ratio (B/C ratio) is also sometimes used, particularly when establishing priorities under budget constraint. The B/C ratio is the ratio of discounted benefits to discounted costs.

These measures indicate economic priority, although on technical grounds the NPV and B/C ratio are superior to the IRR for this purpose. The general decision rule is that the higher the NPV, B/C ratio and IRR, the higher the economic priority of the proposed expenditure. When choosing between a number of alternative maintenance strategies for a given combination of road condition and traffic, the strategy showing the highest NPV or NPV per kilometre is normally chosen. The IRR is not a particularly reliable measure for ranking alternatives in order of economic priority, but it is widely used, particularly by international donor organisations, because its use avoids the necessity of defining the appropriate discount rate to be used in different countries.

A detailed description of economic project appraisal methodologies is not required in a study such as this. The brief summary given above is designed to provide sufficient background explanation to facilitate understanding of the two illustrative examples of the economic effects of road maintenance which are set out in Tables 4.1 and 4.2.

These two examples are taken from the maintenance strategy analyses undertaken within the pavement management system currently being implemented by the Consultant in the TRACECA countries. In Table 4.1 the economic analysis compares the following alternative strategies for a specified road section:

- Undertake routine maintenance and patching only in a do minimum strategy.
- Provide an initial overlay, undertake routine maintenance and patching, and then provide a subsequent overlay at a defined roughness threshold level.

The table shows how roughness progresses under the alternative scenarios and how this affects the level of road user costs. The net economic benefits in each year are obtained by subtracting total transport costs under Strategy 1 from total transport costs under the minimum maintenance strategy (Strategy 0). The results of the discounted cash flow analysis show that Strategy 1 is economically highly desirable and preferable to the minimum maintenance strategy because the NPV at the indicated discount rates is positive. If the do minimum strategy had been the better one, the NPV would have been negative at the indicated discount rates and the IRR would have been below 10 or 15 percent. The analysis shows that spending US$ 788,086 more than required by the minimum maintenance alternative results in this instance in an undiscounted saving in total transport costs of US$ 2.5 million over the appraisal period.

The second example set out in Table 4.2 involves a similar comparison of a minimum maintenance strategy of routine maintenance and patching with a strategy involving deferred rehabilitation in addition to routine maintenance and patching. Roughness under the two alternatives is the same until Year 6 when the deferred rehabilitation takes place and there are, therefore, no saving in road user costs until Year 6. The result of this comparison shows that the strategy of deferred rehabilitation in this situation is of only marginal priority and its economic feasibility is dependent on what is defined as the appropriate discount rate. If the discount rate is only 10 percent, the deferred rehabilitation strategy is acceptable, but if it is 15 percent, the minimum maintenance strategy is preferable.

The analysis of optimum maintenance strategies involves repeating this type of analysis many times for alternative road expenditure options. In the pavement management system being implemented in the TRACECA countries an exhaustive list of options is compared for each road section, and only the 20 options showing the highest economic priority are stored in the computer database for future reference.

Traffic volumes obviously have an important effect on road pavements, but the precise nature of the effect is not always clearly understood. The inclusion of cumulative equivalent standard axles as an important variable in the model set out above gives an idea of the nature of the traffic effect. This is discussed more fully below.

Table 4.1 EXAMPLE OF THE ECONOMIC IMPACT OF MAINTENANCE AND REHABILITATION.

Road section length (km) = 7,00

Year		Traffic Loading		Pavement Roughness (IRI m/km)		Economic Costs (US$ '000)								
						Minimum Maintenance (Strategy 0)				Required Maintenance (Strategy 1)				Undiscounted
No.	Actual	Equivalent Standard Axles (ESALs million)	Cumulative ESALs (million)	Minimum Maintenance -Strategy 0	Required Maintenance -Strategy 1	Routine Maintenance Costs	Other Maintenance Costs	Vehicle Operating Costs	Total Transport Costs (A)	Routine Maintenance Costs	Other Maintenance Costs	Vehicle Operating Costs	Total Transport Costs (B)	Net Cah Flow (A)-(B)
0	1996	0,11	0,11	7,52	3,92	0,70	0,00	277,50	**278,20**	0,70	382,40	231,54	**613,94**	-335,74
1	1997	0,12	0,23	7,81	4,06	0,70	0,00	287,17	**287,87**	0,70	0,00	237,85	**238,55**	49,32
2	1998	0,12	0,35	8,12	4,21	0,70	0,00	297,43	**298,13**	0,70	0,00	244,40	**245,10**	53,03
3	1999	0,12	0,47	8,43	4,36	0,70	0,00	308,21	**308,91**	0,70	0,00	251,20	**251,90**	57,01
4	2000	0,12	0,59	7,76	4,52	0,70	0,00	319,56	**320,26**	0,70	0,00	258,26	**258,96**	61,30
5	2001	0,13	0,72	9,11	4,68	0,70	0,00	331,52	**332,22**	0,70	0,00	265,60	**266,30**	65,92
6	2002	0,13	0,85	9,46	4,86	0,70	0,00	354,24	**354,94**	0,70	0,00	281,41	**282,11**	72,83
7	2003	0,14	0,99	10,12	5,04	0,70	0,00	384,24	**384,94**	0,70	0,00	298,26	**298,96**	85,98
8	2004	0,14	1,13	10,51	5,24	0,70	0,00	411,23	**411,93**	0,70	0,00	316,22	**316,92**	95,01
9	2005	0,15	1,28	10,93	5,45	0,70	0,00	440,50	**441,20**	0,70	0,00	335,62	**336,32**	104,88
10	2006	0,16	1,44	11,35	5,67	0,70	0,00	472,20	**472,90**	0,70	0,00	356,34	**357,04**	115,86
11	2007	0,17	1,61	11,80	3,92	0,70	0,00	506,64	**507,34**	0,70	405,70	342,58	**748,99**	-241,65
12	2008	0,17	1,78	12,84	4,06	0,70	0,00	559,07	**559,77**	0,70	0,00	362,29	**362,99**	196,78
13	2009	0,18	1,96	13,33	4,21	0,70	0,00	600,78	**601,48**	0,70	0,00	383,23	**383,93**	217,55
14	2010	0,19	2,15	13,85	4,36	0,70	0,00	646,38	**647,08**	0,70	0,00	405,49	**406,19**	240,89
15	2011	0,20	2,35	14,40	4,52	0,70	0,00	696,31	**697,01**	0,70	0,00	429,18	**429,88**	267,14
16	2012	0,21	2,56	14,97	4,68	0,70	0,00	750,89	**751,59**	0,70	0,00	454,38	**455,08**	296,51
17	2013	0,22	2,78	15,58	4,86	0,70	0,00	810,74	**811,44**	0,70	0,00	481,48	**482,18**	329,26
18	2014	0,24	3,02	16,22	5,05	0,70	0,00	876,55	**877,25**	0,70	0,00	510,36	**511,06**	366,19
19	2015	0,25	3,27	16,92	5,25	0,70	0,00	950,15	**950,85**	0,70	0,00	541,16	**541,86**	408,99
Undiscounted Totals						14,00	0,00	#######	10.295,30	14,00	788,10	6.986,84	7.788,25	2.507,06
										Net Present Value (NPV) @ 10% discount rate				480,06
										Net Present Value (NPV) @ 15% discount rate				185,70
										Net Present Value (NPV) @ 21.94 % discount rate				0,00
										Internal Rate of Return (IRR %)				21,94
										NPV per Km @ 10% discount rate				68,58
										NPV per Km @ 15% discount rate				26,53
										NPV per Km @ 21.94 % discount rate				0,00

Source: Consultant's estimates

TABLE 4.1: EXAMPLE OF THE ECONOMIC IMPACT OF MAINTENANCE AND REHABILIATION

Table 4.2 EXAMPLE OF THE ECONOMIC IMPACT OF DEFERRED REHABILITATION.

Road section length (km) = 7,00						Economic Costs (US$'000)								
Year		Traffic Loading		Pavement Roughness (IRI m/km)		Minimum Maintenance (Strategy 0)				Required Maintenance (Strategy 1)				Undiscounted
No.	Actual	Equivalent Standard Axles (ESALs million)	Cumulative ESALs (million)	Minimum Maintenance -Strategy 0	Required Maintenance Strategy 1	Routine Maintenance Costs	Other Maintenance Costs	Vehicle Operating Costs	Total Transport Costs (A)	Routine Maintenance Costs	Other Maintenance Costs	Vehicle Operating Costs	Total Transport Costs (B)	Net Cah Flow (A)-(B)
0	1996	0,11	0,11	7,52	7,52	0,40	0,00	158,57	**158,97**	0,40	0,00	158,57	**158,97**	0,00
1	1997	0,12	0,23	7,81	7,81	0,40	0,00	164,10	**164,50**	0,40	0,00	164,10	**164,50**	0,00
2	1998	0,12	0,35	8,12	8,12	0,40	0,00	169,96	**170,36**	0,40	0,00	169,96	**170,36**	0,00
3	1999	0,12	0,47	8,43	8,43	0,40	0,00	176,12	**176,52**	0,40	0,00	176,12	**176,52**	0,00
4	2000	0,12	0,59	7,76	7,76	0,40	0,00	182,61	**183,01**	0,40	0,00	182,61	**183,01**	0,00
5	2001	0,13	0,72	9,11	9,11	0,40	0,00	189,44	**189,84**	0,40	0,00	189,44	**189,84**	0,00
6	2002	0,13	0,85	9,46	2,45	0,40	0,00	202,42	**202,82**	0,40	800,00	142,44	**942,84**	-740,02
7	2003	0,14	0,99	10,12	2,54	0,40	0,00	219,57	**219,97**	0,40	0,00	150,23	**150,63**	69,33
8	2004	0,14	1,13	10,51	2,63	0,40	0,00	234,99	**235,39**	0,40	0,00	158,47	**158,87**	76,52
9	2005	0,15	1,28	10,93	2,73	0,40	0,00	251,71	**252,11**	0,40	0,00	167,20	**167,60**	84,52
10	2006	0,16	1,44	11,35	2,83	0,40	0,00	269,83	**270,23**	0,40	0,00	176,44	**176,84**	93,39
11	2007	0,17	1,61	11,80	2,93	0,40	0,00	289,51	**289,91**	0,40	0,00	186,22	**186,62**	103,29
12	2008	0,17	1,78	12,84	3,05	0,40	0,00	319,47	**319,87**	0,40	0,00	196,69	**197,09**	122,78
13	2009	0,18	1,96	13,33	3,17	0,40	0,00	343,30	**343,70**	0,40	0,00	207,80	**208,20**	135,51
14	2010	0,19	2,15	13,85	3,30	0,40	0,00	369,36	**369,76**	0,40	0,00	219,58	**219,98**	149,78
15	2011	0,20	2,35	14,40	3,44	0,40	0,00	397,89	**398,29**	0,40	0,00	232,25	**232,65**	165,64
16	2012	0,21	2,56	14,97	3,59	0,40	0,00	429,08	**429,48**	0,40	0,00	245,72	**246,12**	183,36
17	2013	0,22	2,78	15,58	3,75	0,40	0,00	463,28	**463,68**	0,40	0,00	260,04	**260,44**	203,24
18	2014	0,24	3,02	16,22	3,91	0,40	0,00	500,89	**501,29**	0,40	0,00	275,34	**275,74**	225,55
19	2015	0,25	3,27	16,92	4,09	0,40	0,00	542,95	**543,35**	0,40	0,00	291,63	**292,03**	251,32
Undiscounted Totals						8,00	0,00	5.875,02	**5.883,02**	8,00	800,00	3.950,83	**4.758,83**	1.124,19
										Net Present Value (NPV) @ 10% discount rate				73,70
										Net Present Value (NPV) @ 15% discount rate				-33,49
										Net Present Value (NPV) @ 21.94 % discount rate				0,00
										Internal Rate of Return (IRR %)				12,82
										NPV per Km @ 10% discount rate				10,53
										NPV per Km @ 15% discount rate				-4,78
										NPV per Km @ 21.94 % discount rate				0,00

Source: Consultant's estimates

TABLE 4.2: EXAMPLE OF THE ECONOMIC IMPACT OF DEFERRED REHABILITATION

4.3 The Effect of Axle Loads on Road Pavements

Heavy vehicle traffic is a an important contributor to the deterioration of road pavements. This contribution to pavement damage over time is sometimes mistakenly attributed to gross vehicle weight, but this is only true under special circumstances. In general, the damage caused to road pavements by vehicles is a function of a complex combination of factors of which the weight on the vehicle axles is the best known and most easily measured. Damage to bridges and other road structures on the other hand is a function of gross vehicle weight, but it is damage to pavements which is the main item of interest in the context of this study.

The effects on pavements considered in this section concentrate on structural damage, which is the most important factor influencing effective pavement life. Other forms of damage, such as those to wearing courses, are not discussed further because they can be attributed to all types of vehicles.

The axle load has traditionally been treated as the sole damage factor since the research undertaken in the 1950s by the American Association of State Highway Officials (AASHTO). However international research undertaken over the last 20 years has demonstrated that the picture is more complex and that the following factors are also important:

- the type of axle, including the number of wheels and the type of tyres,
- the axle grouping - single, tandem and triple (tridem),
- The surface contact pressure of the tyres and
- the vehicle suspension system.

The precise effect and relative importance of these also varies according to whether the damaging potential being considered is to flexible or rigid pavements. The main problem with utilising the results of the more recent research is that it is extremely difficult in practice to obtain adequate data on all the above variables for each vehicle using a road. For this reason, the traditional AASHTO based research evidence continues to be used.

According to the AASHTO research the damage to flexible pavements from the passage of a single vehicle axle could be described by the following expression using the so-called "fourth power law":

- Equivalence Factor = [(Axle weight)/Reference axle weight)]^4

  Where

Equivalence factor	= pavement damage factor
Axle weight	= the weight of a single axle in tonnes
Reference axle weight	= a single axle weight of 8.16 tonnes

Occasionally a reference axle of 10 tonnes is also used. The exponent used is commonly in the range 4.0 - 4.3. In more sophisticated formulations different exponents are sometimes used to express the potential damage to different layers in flexible pavements. In the case of semi rigid or rigid pavements the exponent used can be between 8 and 12. The "fourth power law" suggests that the damage to flexible pavements increases extremely rapidly with single axle loads above the reference axle weight.

The damage to flexible pavements caused by a given load on tandem axles is less than the damage caused by the same load on two single axles. Similarly, the damage caused by a load on a tridem (triple) axles is even less than the equivalent load carried on three single axles. The AASHTO research and the more recent research carried out in a number of member countries of the Organisation for Economic Co-operation and Development (OECD) indicate that the damage to flexible pavements attributable to tandem axles is just over 60 percent of the damage caused by the same load on two single axles. In the case of tridem axles the equivalent damage is 45 percent of the damage which would be caused by the same load on three single axles. The national axle loading regulations in various OECD countries take these damage ratios into account. These ratios embody a high, if necessary, degree of simplification because the damaging effect is also a function of the way the load is distributed over the axles and whether single or double tyres are used. In most of the discussion in this section twin wheeled axles are assumed. The difference in damaging power between single, tandem and tridem axles also grows rapidly with rising load weight. This is the obvious reason why only the heavier trucks have tandem or tridem axles.

The grouping and type of tyres also influences potential damage to pavements. For example, wide base tyres do about 92 percent of the damage of normal single tyres and twin tyres only do around 77 percent of single tyre damage. Finally, there are also differences in the pavement damaging potential of different types of vehicle suspension systems. Modern suspension systems are thought to have only 95 percent of the pavement damaging potential of traditional suspension systems.

The simplified methodology for calculating the potential pavement damaging impact of different axle grouping and characteristics shown below provides a very useful basis for assessing the impact of different types of vehicles. In practice, conventional axle load surveys are seldom able to provide the amount of information required for this level of pavement damage evaluation. It is important nevertheless to have a clear idea of the pavement damage potential of different types of heavy vehicle because it has an important bearing on road user charges for heavy vehicles and on national axle loading regulations.

The total pavement damaging power of different types of heavy vehicle can be summarised in the following simplified model:

$$PD = [(AL_1/AL_0) * k_1 * k_2 * k_3]^a$$

where AL_1 = load on the axle or axle grouping
Al_0 = the reference axle load

k_1 (type of grouping)	single axle	=	1.0
	tandem axle	=	0.6
	tridem axle	=	0.45
k_2 (type of tyres)	twin tyres	=	1.0
	wide base tyres	=	1.2
	single tyres	=	1.3
k_3 (type of suspension)	traditional	=	1.0
	improved	=	0.95

a is the exponent

Based on the use of this model, the OECD in its report "The Impacts of Heavy Freight Vehicles" evaluated the pavement damaging potential of different types of trucks and the findings are discussed briefly below.

4.4 The Effects of Different Types of Trucks on Pavements

Any reasonably rigorous assessment of the pavement damage attributable to different types of heavy goods vehicles has to take payload into account. While it is interesting to know the absolute pavement damage factors for different vehicle types, it is even more interesting to have information on these damage factors in relation to payload tonnes. Assuming that a given annual tonnage has to be transported over a road network, it is important from a vehicle licencing perspective to know what types of heavy goods vehicles would transport that tonnage at minimum damage to the pavements. With this knowledge it should be possible to use the vehicle licencing system to encourage vehicles with axle configurations which do least pavement damage in relation to load capacity.

The results of analyses carried by the OECD are summarised in Table 4.3. These show that gross vehicle weight is not necessarily a very good guide to the pavement, as opposed to bridge, damaging potential. The damage factors for different types of goods vehicles with different axle configurations is a much better guide, but the most valid basis for considering pavement damaging potential by heavy goods vehicles is in relation to payload capacity. The estimated damage factors per payload tonne of capacity show that large articulated trucks are usually less harmful to pavements than smaller rigid single axle trucks. The results in the table assume correct loading and the greater pavement damaging potential of 2 axle rigid trucks increases when overloading is taken into account. These results reflect the respective damaging potential of single, tandem and tridem axles discussed earlier.

None of the systems of heavy goods vehicle licencing encountered in the TRACECA countries appears to take these factors into account. In the longer term considerable gains in economic efficiency would result from reforming the structure of heavy vehicle licences to take pavement damage factors per tonne of payload capacity into account.

4.5 Vehicles and Pavement Damage in the TRACECA Countries

Axle load surveys had been undertaken by the Consultant in Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Turkmenistan and Uzbekistan. The results of these surveys show that most heavy goods vehicles manufactured in the C.I.S are smaller and have lighter axle loads than the equivalent non - C.I.S vehicles traversing the TRACECA road networks. The overall level of axle loading is very low by international standards, but it can be expected to increase in line with international experience in the medium to long term. The contribution of vehicle axle loading to pavement damage in the TRACECA countries has been much smaller than it would have been if international vehicle damage factors and incidence of vehicle overloading had been experienced.

The overall results of the axle loading surveys in six TRACECA countries are set out in Annex 4 Tables A.4.1 and A.4.2. The overall pavement damage factors for heavy goods vehicles in Table A.4.2 are low, but they still overstate the pavement damaging potential of the different vehicle types because they are estimated on a single axle basis. In other words, no reduction is made for vehicles with tandem or tridem axles because this information was not recorded. It should also be noted that the large samples of heavy vehicles weighed at each location included empty vehicles and vehicles with low load factors. The samples were, therefore, representative of the heavy vehicle flows. The average damage factors using an exponent of four from all the surveys were as follows:

Large Buses	All = 1.50	
2 axle trucks	All = 0.11	non-C.I.S = 4.87
3 axle trucks	All = 0.24	non-C.I.S = 1.27
4 axle trucks	All = 0.83	non-C.I.S = 1.92
5 axle trucks	All = 0.45	non-C.I.S = 1.31

The corresponding damage factors using a 10 tonne reference axle are lower.

Estimates of damage factors per payload tonne have also been estimated in Annex 4 Table A.4.4 assuming payload to be around 60 percent of gross vehicle weight, an 8.16 tonne reference axle and an exponent of 4. The resulting damage factors per payload tonne are summarised below:

2 axle trucks	All	= 0.02 per payload tonne
	Non C.I.S	= 0.67 per payload tonne
3 axle trucks	All	= 0.03 per payload tonne
	Non C.I.S	= 0.11 per payload tonne
4 axle trucks	All	= 0.06 per payload tonne
	Non C.I.S	= 0.12 per payload tonne
5 axle trucks	All	= 0.03 per payload tonne
	Non C.I.S	= 0.08 per payload tonne

It should be remembered that these are overestimated to the extent that no adjustment to damage factors has been made for tandem and tridem axles. The damage factors per payload tonne are clearly significantly higher for non C.I.S vehicles than for C.I.S vehicles and this reflects higher load factors as might be expected from commercial operators of the more expensive international trucks. The relationship between the damage factors and damage factors per payload tonne between non C.I.S two axle trucks and multi axle trucks is similar to the OECD examples. The two axle truck fleets of C.I.S manufacture are dominated by trucks which are small by international standards and their damage factors and damage factors per payload tonne are very low both in comparison with international 2 axle trucks and in relation to multi axle trucks of C.I.S manufacture.

A revival of economic activity in the TRACECA countries could be expected to be accompanied by a significant increase in trucking activity and growing load factors. A greater use of larger articulated trucks of non C.I.S origin can also be expected. In the medium to long term it can be expected that damage factors for heavy goods vehicles in the TRACECA countries will move into line with internationally accepted norms and the implications of this for pavement maintenance and rehabilitation need to be recognised.

It will have been noticed that no mention has been made of passenger cars and other light vehicles in the above discussion. The reason for this is that they make very little contribution to pavement damage. The pavement damage factor for a typical passenger car of around 1.6 tonnes is only about 0.0001 and for a small pickup or minibus it might be of the order of 0.0015 to 0.002. A car, therefore causes only one thousandth of the pavement damage of an average 2 axle truck of C.I.S manufacture. For light utility vehicles the proportion is 1 - 2 percent. Even allowing for the much greater number of light vehicles on the roads, the total pavement damage attributable to them is negligible.

Table 4.3 PAVEMENT DAMAGING POTENTIAL OF DIFFERENT TYPES OF CORRECTLY LOADED TRUCK

Truck Type	Axle Configuration	No.of Axles	Gross Vehicle Weight (tonnes)	Payload (tonnes)	Pavement Damage Factors		
					Per Vehicle	Per GVW tonne	Per Payload tonne
Rigid 2 axle	S-S	2	14	9	**1,35**	0,10	**0,15**
Rigid 3 axle	S-T	3	22	14	**1,22**	0,06	**0,09**
Rigid 2 axle truck + 2 axle drawbar trailer	S-S / S-S	4	37	24	**3,36**	0,09	**0,14**
Rigid 2 axle truck + 3 axle drawbar trailer	S-S / S-T	5	45	29	**3,22**	0,07	**0,11**
Rigid 3 axle truck + 3 axle drawbar trailer	S-T / S-T	6	54	34	**3,06**	0,06	**0,09**
Articulated 2 axle tractor + 2 axle semi trailer	S-S / T	4	34	21	**2,23**	0,07	**0,11**
Articulated 3 axle tractor + 2 axle semi trailer	S-T / T	5	42	26	**2,08**	0,05	**0,08**
Articulated 3 axle tractor + 3 axle semi trailer	S-T / TR	6	50	31	**2,17**	0,04	**0,07**

Note: The estimated damage factors take account of the reduced pavement damaging effect of tandem and triple axles.
S = single axle T = tandem axle TR = triple (tridem) axle
Source: Organisation for Economic Co-operation and Development (OECD) - "Impacts of Heavy Freight Vehicles"

TABLE 4.3 PAVEMENT DAMAGING POTENTIAL OF DIFFERENT TYPES OF CORRECTLY LOADED TRUCK

5 THE FINANCING OF ROADWORKS

5.1 General

The financing of roadworks in most of the TRACECA states is nominally through a road fund set up by government. In Armenia, however, there is no road fund and financing of roads from the general government budget. In practice, the lack of financial independence of most of the road funds means that financing of roadworks operates in much the same way as if it were from the general government budget.

The main direct charges on road users are in the form of taxes on automotive fuels, vehicle licences and registration taxes, transit taxes on foreign (non-C.I.S) vehicles and taxes on vehicle acquisition. Nearly all these charges are at levels which are very low by international standards. Other taxes used for financing roadworks include turnover and - or profits taxes on enterprises linked functionally or locationally with the highway networks. In the economic climate experienced by most TRACECA states in recent years profits taxes are unlikely to have been a major contributor to highway budgets. In most cases these taxes and charges are at levels which are very low by international standards. In part this reflects a traditional philosophy of road financing inherited from the past, and it is also the result of a failure to make adequate adjustments in taxes and charges to take account of inflation. The overall effect has been a declining real financial contribution from road user charges to the road sectors. This has been accompanied by an irresistible downward pressure on general government budgets as a result of the economic depression of the 1990s.

5.2 Road Funds

5.2.1 Introduction

Road funds have been established in most of the TRACECA states since 1991. None of them can be said to possess the degree of financial and operational independence which the World Bank, for example, regards as critical to their success. In practice, most of the TRACECA road funds appear to operate as an extension of the central government's tax collection machinery. They have little effective control over how much of the money which they collect from the road sector is used in the road sector. A possible exception to this could be Uzbekistan where it is claimed that lessons learned from the problems of other road funds have been incorporated in the design of its own fund. The following sections briefly summarise the main features of road funds in individual TRACECA countries.

5.2.2 Azerbaijan

The Road Fund Law setting up Azerbaijan's road fund was passed in November 1994, but the fund effectively started operations in mid 1994.. Before the establishment of the road fund the financing of roadworks was from the State Budget. The fund is supposed to collect revenue from road user charges and highway related taxes and to pass this revenue on to the Ministry of Finance. These charges include an automotive fuel sales tax, a road use tax on enterprises, a vehicle sales tax, vehicle ownership taxes and a transit tax on non - C.I.S foreign vehicles. The potential revenue from this transit tax is significantly reduced by the fact that Iranian vehicles, which constitute the majority of foreign vehicles, are exempted from paying it.

Fifteen percent of the revenue from the fuel tax is supposed to be passed onto the fund by the State Fuel Committee, but this has not happened so far. The Ministry of Finance decides the annual budget to be allocated to Azeravtoyol, the state highway organisation, so highway financing is still effectively from the State Budget.

In the second half of 1994 the road fund collected the equivalent of US$ 10 million. This increased to US$ 27.9 million in 1995. The road fund's estimated revenue collection for 1996 is equivalent to US 79.8 million, but as of August 1996 the predicted budget allocation for roadworks by the Ministry of Finance was no more than US$ 10.4 million of which approximately 80 percent was for state highways.

5.2.3 Georgia

The law establishing Georgia's road fund was passed in September 1995. The law sets out the basis of the fund, its main purpose, the provision of financial resources for it and the use of those resources. The main charges and taxes contributing to the fund's revenues include a sales tax on automotive fuel, a road use tax on enterprises, taxes on vehicle ownership, a tax on the location of public utility facilities within road rights of way, contributions from lotteries and traffic fines, and a transit tax on foreign vehicles entering Georgia and on Georgian vehicles carrying foreign export cargoes.

In the first seven months of 1996 the proceeds from road user charges and taxes amounted to the equivalent of US$ 9.46 million. Of this, just over 40 percent came from transit taxes on foreign vehicles, 29 percent from road use taxes on enterprises, 25 percent from vehicle ownership taxes and only 4.1 percent from taxes on fuel. Indications from the first half of 1996 are that expenditure on roadworks was running at around 60 percent of the total proceeds from the fund.

5.2.4 Kazakhstan

Up to 1992 expenditure on roads in Kazakhstan was financed from the National Budget. In December 1991 two categories of road funds were established by government decree, the National Road Fund for national road maintenance and development and the Regional (Oblast) Road Funds for local road maintenance and development. Road fund revenue was originally designed to come from the proceeds of a road use tax on enterprises, a purchase tax on vehicles, a vehicle ownership tax based on vehicle horse power, a tax on petroleum products and vehicle tyres, a tax on the income of transport companies and a transit tax on foreign vehicles entering Kazakhstan.

The structure of road use taxes and user charges was modified in 1994, but the new arrangements were rescinded in the second half of 1995. As of mid 1996 a number of road funding arrangements were under consideration by the

Government. In general, Kazakhstan's experience with operating a road fund has not been satisfactory.

Road fund revenue dropped from the equivalent of US$ 185 million in 1993 to US$ 92 million and US$ 100 million respectively in 1994 and 1995. The latest available information on the main sources of road fund revenue only relate to 1993 when road use taxes accounted for 47 percent and taxes on fuel and vehicle tyres contributed a further 36 percent of the total. In 1993 road fund revenue and expenditure on roads were almost in balance. Since then, however, expenditure on roads has been only 50 percent of road fund revenue in 1994 and 70 percent in 1995. The balance has presumably gone into the Government's general tax revenues.

5.2.5 Kyrgyzstan

The establishment of a road fund has been under consideration for the past two years, but as of May 1996 the necessary legislation had not been passed.

5.2.6 Tadjikistan

Tadjikistan has a road fund responsible for collecting road user charge revenue, but details on the operation of the fund are not available.

5.2.7 Turkmenistan

Turkmenistan's road fund was only established in 1995 and it became operational at the beginning of 1996. Its objectives were the financing of requirements for the maintenance, rehabilitation and development of State roads. The fund's financial resources were originally intended to come from the excise duty on automotive fuels, transit charges on foreign vehicles and the annual vehicle registration tax. Subsequently, the abolition of special government departmental or agency accounts meant that the road fund could not be operated as a financially independent entity. A further blow to the fund's resources was the removal of the proceeds of the excise tax on automotive fuels from its control. The fund's managing authority is Turkmenautellari.

The estimated financial resources of the fund in 1996 are the equivalent of US$ 17 million to US$ 20 million depending on whether official or commercial exchange rates are used, This represents a significant increase on the US$ 7 million made available for roads out of the state budget for in 1995.

5.2.8 Uzbekistan

Uzbekistan originally established a road fund in 1993. It has been mainly financed out of taxes on enterprises and institutions at the state, oblast (regional) and rayon (district) level, taxes on vehicle ownership and transit taxes on foreign vehicles entering the country. The fund is responsible for financing all roadworks, but its resources do not include a tax on automotive fuel. The only part of the country levying a tax on fuel is the Semi Autonomous Republic of

Karakalpakistan where a 7 percent fuel tax is in force.The road fund is administered by Uzavtoyul, the state highway organisation.

The amount of fund revenue raised at just over the equivalent of US$ 100 million may be insufficient, but Uzbekistan appears to be one of he few TRACECA countries with a road fund where a significant part of fund revenue is not appropriated by the finance ministry for non - road uses.

5.3 Road User Charges and Road Related Taxes

5.3.1 General

In the following sections the details of road user charges and road related taxes in individual TRACECA countries are briefly summarised. The information on these charges was collected during visits to the various countries in the course of the Project.

5.3.2 Armenia

Armenia is in the process of introducing a new road tax and draft legislation was supposed to have been presented to Parliament in September 1996. The present structure of charges and taxes is similar to those in force in most of the other TRACECA countries and the most distinguishing feature of the new Armenian proposals will be the much greater reliance to be placed on the proceeds from a fuel tax.

The main features of the proposed new road tax are as follows:

- The 2 percent tax on the revenues of enterprises involved in vehicle operation and the 0.43 percent tax on the incomes of all other enterprises will be replaced by a fuel levy.
- The levy or tax on petrol and diesel will be at the rate of 12 percent.

The Ministry of Finance estimates that the new fuel tax will raise just over the equivalent of US$ 7 million in a full year and the stated intention is that this will be specifically assigned to road expenditure. This would be an advance on the road budgets of US$ 1.65 million in 1994 and US$ 4.15 million in 1995. It should be noted, however, that only one third of the 1995 road budget allocation had been paid out as of June 1996. The predicted 1996 fuel tax yield will also be required to cover a local counterpart contribution of around US$ 864,000 to an International Development Association (IDA) credit.

5.3.3 Azerbaijan

The existing road taxes and road user charges comprise the following:

- A 0.5 percent tax on the turnover of road vehicle operating companies and a 0.3 percent tax on the turnover of trading companies and certain other types of company.

- A 2 percent vehicle sales tax.

- A vehicle ownership tax levied on the basis of a complicated formula involving the multiplication of a percentage of the minimum wage rate by vehicle horse power. For private cars the relevant percentage is 2 and for other vehicles it is 5.

- International transit tax on foreign vehicles entering the country, but specifically exempted from this tax are Iranian vehicles which make up the largest group of foreign (non C.I.S) vehicles. The following transit tax rates have been in force in 1996:

  - **Cars** - US$ 15 per entry

  - **Buses** - from US$ 30 per entry for buses of 12 passenger capacity to US$ 100 for buses with a capacity of more than 30 passengers.

  - **Trucks** attract a transit tax of from US$ 100 (less than 10 tonnes) to US$ 180 for trucks of more than 24 tonnes. It is not clear whether the truck tonnage refers to payload capacity or gross vehicle weight. There are additional weight related transit charges based on truck weight. These range from US$ 0.15 per kilometre for trucks weighing 37 - 41 tonnes to US$ 1.8 per kilometre for trucks weighing more than 81 tonnes.

    In the absence of vehicle weighing equipment at each border post it is not clear how the truck weight assessments for transit tax purposes is made or how the relevant number of kilometres for charging is calculated. In addition to transit charges on vehicles, there are transit charges on vehicle loads. These range from US$ 100 per load for a “not very dangerous“ load to US$ 400 per load for a “very dangerous“ load.

  - A petrol sales tax of from US$ 3.07 - 3.74 per tonne, depending on octane level, and a tax on automotive diesel of US$ 2.20 per tonne. There is also a retail sales tax on automotive fuels of 15 percent.

Azerbaijan has a system of complex road taxes and user charges, but in the absence of information on the relative contribution of the different charges to total road fund revenue it is difficult to judge their effectiveness as a source of revenue. What is beyond dispute is that total revenue raised from road users is insufficient and the proportion passed on as road budgets is even more inadequate.

5.3.4 Georgia

A tax for the use of public roads is levied on the profits and - or turnover of specified enterprises. There is a 2 percent profits tax on enterprises operating passenger transport services. Municipal buses are exempt. The profit tax rate is 0.5 percent for banking organisations and 0.1 percent for other business organisations. Trading enterprises must also pay a 0.1 per cent tax on their turnover. Enterprises located within 50 metres of a public road in densely settled areas and within 100 metres in less densely populated areas have to pay double the above tax rates. Organisations selling automotive fuels also have to pay a fuel tax, and their liability to pay profit taxes is reduced in line with their liability to pay the fuel tax. The fuel tax is in the form of a value added tax of 5 percent.

There is a vehicle ownership tax based on engine capacity. The rates for different vehicle types is as follows:

Cars- US$ 0.20 per horse power

Buses-from US$ 0.50 per horse power for vehicles with less than 13 seats to US$ 2.00 per horse power for vehicles with more than 30 seats.

Trucks from US$ 1.00 per horse power for vehicles of less than 11 tonnes to US$ 3.00 per horse power for vehicles of more than 40 tonnes.

The annual registration - ownership tax has to be paid before the annual safety check and when a vehicle is re-registered on change of ownership.

A transit tax is levied on foreign vehicles entering Georgia and on owners of Georgian vehicles loaded with foreign cargoes for re-export abroad. The transit tax rates levied on entry into Georgia are as follows:

Cars	US$ 20.00
Buses (less than 13 seats)	US$ 40.00
Buses (13 - 29 seats)	US$ 80.00
Buses (30 or more seats)	US$ 130.00
Trucks (less than 11 tonne payload capacity)	US$ 130.00
Trucks (11 - 20 tonne payload capacity)	US$ 160.00
Trucks (21 - 39 tonne payload capacity)	US$ 220.00
Trucks (40 or more tonnes payload capacity)	US$ 300.00

Payment of this tax can be made in US dollars or in other currencies.

Finally, there are taxes on public utility facilities located within State road right of way and on roadside advertising hoardings. The utility tax is levied at the rate of the equivalent of US$ 0.10 per linear metre of facility within the right of way. The tax rate on roadside advertising hoardings ranges from the equivalent of US$ 20 per square metre of hoarding on national roads to US$ 15 per square metre on intra state (republican) roads and US$ 5 per square metre on local roads.

The State Tax Office is responsible for raising these taxes and road user charges and for the accounting and financial contrive of the road fund.

5.3.5 Kazakhstan

Under the 1994 restructuring of road financing the main road taxes and user charges were as follows:

- Special road tax of 1.0 percent of turnover levied on all enterprises. The proceeds were split in the proportions 30 per cent for national roads and 70 percent for Oblast funds.

- A tax of 1.0 percent on vehicle purchases with the proceeds going to Oblast funds.

- An annual transport tax linked to vehicle size.

- A value added tax on fuel, lubricants and tyres the proceeds being destined for the Oblasts.

- A levy of 2.0 per cent on transporters' turnover with the revenue going to national roads.

As mentioned earlier, these arrangements were rescinded during the second half of 1995 and alternative financing arrangements are still being considered by the Government.

5.3.6 Kyrgyzstan

In recent years road related taxes and road user charges have comprised the following:

- an annual road tax of 0.8 percent of turnover levied on most enterprises. Trading companies and privatised or small scale agricultural enterprises pay at the rate of 0.08 per cent of turnover.

- a levy of 2 percent on the turnover of all transport companies, which has now become a voluntary contribution

- an excise tax on petrol of the equivalent of US$ 4.1 per tonne. A similar tax on diesel was abolished in 1995

- a vehicle registration tax of 5 percent of the vehicle's value on transfer of ownership

- an annual vehicle licence tax of approximately US$ 0.90 per horse power of engine capacity for trucks and US$ 0.02 per horsepower on cars

- A 10 percent import levy on imported cars from outside the C.I.S.

Revenue from these sources goes into the Government's central budget and it is not specifically allocated to the Ministry of Transport for expenditure on roads.

A draft of a Republican Road Fund Law was prepared by the Ministry of Transport as part of the Automobile Road Act which has been under consideration by the Ministry of Finance since early 1995. The objective of this would be to establish a dedicated road fund which would legally tie specified sources of revenue to expenditure on roads. Under the draft proposals there would be 13 different sources of revenue, either existing or newly proposed. Proposed new charges and taxes would include the following:

- a value added tax on fuels and tyres

- licencing fees for transport activities

- duties on heavy axles and large vehicles

- toll fees for selected roads and tunnels
- a transit tax on foreign vehicles entering Kyrgyzstan

As of May 1996 the Ministry of Transport was attempting to add supplementary proposals focusing on existing taxes and charges. Revenue from taxes paid by vehicle owners amounted to around US$ 5.4 million in 1994. Revenue from automotive fuel taxes might have contributed a further US$ 0.8 million. These revenues are clearly inadequate in relation to expenditure requirements, but total Government revenue in 1994 only amounted to the equivalent of US$ 181.8 million.

5.3.7 Turkmenistan

The main road user charges in force in Turkmenistan include transport licence fees, taxes for vehicle inspection , vehicle registration fees, fuel tax, import duties on vehicles and transit fees for international (non - C.I.S) vehicles. The main features of current charges and taxes are as follows:

- **Road transport licence fees**. These have been applicable to international road transport enterprises since May 1996. Before then they were also applied to domestic transport enterprises, but at a much lower rate. Foreign freight carriers now pay monthly fees at the following rates per vehicle:

  - Trucks with a carrying capacity of less than 10 tonnes US$ 20
  - Trucks with carrying capacity of 10 - 20 tonnes US$ 50
  - Truck with carrying capacity of more than 20 tonnes US$ 100

- **Annual vehicle inspection fees** are collected by the Police Department of the Ministry of the Interior. The fee for Turkmen vehicle owners is the equivalent of US$ 0.12 per vehicle and for foreign owners the fee is US$ 4.00 per vehicle. It is not immediately apparent why inspection of foreign owned vehicles should be thirty three times more expensive than for domestic vehicle owners.

- **Vehicle registration fees** in the form of fees for vehicle licence plates are the equivalent of US$ 7.50 for Turkmen and US$ 100.00 for foreign owners.

- **Duties on passenger vehicles imported** from outside the C.I.S and Iran are levied at the rate of 10 percent of the vehicle's declared import value which cannot be less than US$ 1,000. There are also additional Customs charges of 0.2 percent to cover the administrative paperwork.

- **Transit charges on international vehicles** entering Turkmenistan are as follows:
  - Trucks of less than 10 tonnes carrying capacity US$ 50
  - Trucks of 10 to 20 tonne carrying capacity US$ 100
  - Trucks of more than 20 tonnes carrying capacity US$ 150

  Passenger vehicles attract the following transit charges:
  Cars US$ 30

Buses with less than 20 seats	US$ 25
Buses with 13 to 30 seats	US$ 50
Buses with more than 30 seats	US$ 100

In 1995 vehicles from the C.I.S countries (except Azerbaijan, Georgia and Ukraine) and from Afghanistan, Iran and Turkey were exempt and if this is still the case, the potential revenue yiel from this charge seems rather limited.

- **Excise tax on motor fuels** are at the rate of 55 percent and 60 per cent of the respective ex refinery prices of petrol and diesel. In October 1996 these were the equivalent of US$ 0.047 - 0.052 per litre for petrol and 0.038 per litre for diesel. Even allowing for distribution costs, the economic opportunity cost of Turkmen refined automotive fuels is probably nearer US$ 0.30 per litre. The above percentage rates seem to be quite high, but the ex refinery prices on which the tax is based are so extraordinarily low by international standards that this results in a very low duty in practice.

- **Annual tax on road vehicles.** This is based on a specified multiple of the minimum wage and in US dollar equivalent terms the tax rates are approximately as follows:

Cars	US$ 10
Buses (depending on seating capacity)	US$ 40 - 100
Rigid trucks (depending on capacity)	US$ 100 - 1,000
Road tractors (depending on horse power)	US$ 150 - 400
Semi trailer (depending on load capacity)	US$ 50 - 250

Until the beginning of 1996 revenues from some of the above taxes went into special Ministry of Road Transport accounts at the Bank of Turkmenistan. However, all special accounts were abolished in January 1996 and these revenues now go into the State Budget. Revenues from vehicle inspection are allocated to the special Road Traffic Safety Fund which comes under the jurisdiction of the Ministry of the Interior. Revenues from transit charges are supposed to be directly allocated to the Road Fund administered by Turkmenautoellari, but there is some doubt as to whether the full hard currency receipts are being transferred to the fund.

5.3.8 Uzbekistan

Uzbekistan has the traditional mix of road taxes on enterprises, taxes on vehicle purchase and ownership and a transit tax on foreign vehicles. Except in Karakalpakistan there is no automotive fuel tax.

The profits tax on enterprises operating road vehicles is levied at the rate of 2.0 percent. The purchases tax on vehicles is at 5.0 percent for cars and 10 per cent for buses and trucks. The transit tax on foreign (non-C.I.S) vehicles entering the country has been fixed at US$ 150.0, but this figure appears to have been arrived at arbitrarily and not based on rigorous analysis.

5.4 Road Budgets and Expenditure on Roads

The traumatic economic conditions experienced by most of the TRACECA countries since 1991 have been reflected in severely constrained government budgets and sharply reduced levels of expenditure on roads. Consequently, expenditure levels on roads appear to be low both by historical standards and by the standards of other countries of similar income levels.

The available evidence on expenditure on roads, total central government expenditure and Gross Domestic Product which is set out in Table 5.1 has to be treated with considerable caution because of the uncertain quality of the data, but it does indicate a fairly consistent pattern. All the countries except Turkmenistan and Uzbekistan are spending significantly less per kilometre on their state road networks than was being spent in the mid 1980s. In Azerbaijan, Kazakhstan, Kyrgyzstan and Tadjikistan the prevailing levels of expenditure on state roads are less than half of the levels between 1983 and 1985. In Armenia it is just over half.

Expenditure on roads appears to lie within the range 0.2 - 1.9 per cent of total central government expenditure in 1995/1996. In Tadjikistan, however, it appears to be only 0.2 per cent. For the TRACECA countries, excluding Tadjikistan, expenditure on roads is 0.16 - 0.35 per cent of Gross Domestic Product. Once again, Tadjikistan is well below the range at only 0.05 percent of GDP.

Historical and international comparisons are only interesting up to a point. The main interest in any analysis of expenditure levels on roads is how they compare with required expenditure levels. This is the subject of the next chapter.

Table 5.1 TRACECA COUNTRIES - EXPENDITURE ON ROADS 1983/85 - 1995/96

Country	Period	State Road Network Length			Average Annual Budget / Expenditure on Roads				Expenditure on roads as % of:	
		Inter State (km)	Intra-State (Republic) (km)	Total	Total (US$ million)	Per Km of: Inter State roads (a) (US$)	Intra State roads (US$)	Combined inter- and intra state roads (d) (US$)	central government expenditure (1995-96)	GDP (1995)
Armenia	1983-85	1.281	1.907	3.188	12,20	5.547	2.697	3.827		
	1995-96	1.629	1.579	3.208	6,60	4.052		2.058	0,90	0,24
Azerbaijan	1983-85	1.698	4.330	6.028	26,70	8.894	2.677	4.429		
	1995-96	1.409	3.280	4.689	10,40	7.381		2.218	1,20	0,35
Georgia	1983-85	1.610	3.843	5.453	5,10	1.724	604	935		
	1995-96	946	4.059	5.005	4,83	5.106		965	1,90	0,25
Kazakhstan	1983-85	13.032	32.009	45.041	51,33	1.616	946	1.140		
	1995-96	6.132	11.364	17.496	25,80	4.207		1.475	0,80	0,16
Kyrgyzstan	1983-85	2.849	6.310	9.159	13,80	2.627	843	1.507		
	1995-96	748	2.363	3.110	5,20	6.956		1.672	0,70	0,21
Tajikistan	1983-85	1.310	2.787	4.097	6,04	1.728	1.354	1.474		
	1995-96	1.089	696	1.785	0,90	826		504	0,20	0,05
Turkmenistan	1983-85	1.740	5.329	7.069	4,97	1.785	350	703		
(b)	1995-96	1.720	3.748	5.468	10,00	5.815		1.829	2,00	0,20
Uzbekistan	1983-85	1.656	15.313	16.969	42,11	5.612	989	2.482		
	1995-96	1.393	20.432	21.825	62,73	14.917	2.053	2.874	0,80	0,30

Note: (a) In 1983-1985 this is based on actual allocations. In 1995-1996 it isonly based on actula allocations in Kazakhstan and Uzbekistan. Elsewhere is is the per km expenditure if the inter state roads absorbed the whole budget.
(b) Total government expenditure is underestimated and expenditure on roads as a percentage of it is , therefore, overstated.

Source: Consultant's estimates based on data obtained in each country.
Government expenditure data from EBRD and GDP data from EBRD and the World Bank.

TABLE 5.1: TRACECA COUNTRIES - EXPENDITURE ON ROADS 1983/85 - 1995/96

6 ROAD USE COSTS AND EXPENDITURE

6.1 General

In this chapter estimates are presented of the total costs of using the inter state and intra state road networks in each of the TRACECA countries. These costs are undiscounted life cycle costs presented on an average annual basis. The road use costs are then compared with the budget - expenditure levels in each country as presented in the last chapter and the excess of required maintenance and rehabilitation expenditure over existing expenditure levels shows the scale of the financing gap, if any.

At this early stage it is important to distinguish clearly between **road use costs** and **road user costs.** Road user costs were discussed at some length in Chapter 3 where they were defined as including the following categories of costs incurred by road users:

- Vehicle operating costs
- Passenger delay costs
- The costs of delays to goods in transit.

Accident costs to road users are also included in road user costs, but they have not been quantified in this study in the absence of adequate data.

Road use costs are the other main component of total road transport costs, namely the costs of building, maintaining and managing or administering roads. These costs include the costs of routine annual maintenance, periodic maintenance and rehabilitation, which are usually incurred by the highway agency or department, and the administrative, policing and other costs incurred by other agencies or government departments.

Although the potential importance of environmental costs in total transport costs is acknowledged, especially where new addition to road infrastructure is involved, they are not discussed further in this study which is mainly concerned with road maintenance and rehabilitation in an inter urban context.

The cost of maintaining and rehabilitating road networks is a function of their initial characteristics and condition, the levels and characteristics of traffic using them, factors associated with the road's physical environment, and the unit costs of roadworks. A rigorous assessment of future road network maintenance and rehabilitation requirements should normally be based on detailed information by road section on road condition, pavement roughness, pavement strength and a number of other engineering factors likely to affect future pavement life and the nature and costs of future roadworks. The assessment would also include detailed analysis of present and future traffic by vehicle type and axle loading and an analysis of road user costs at different road pavement roughness levels. Predictions also have to be made of future pavement performance and pavement surface roughness based on an assessment of the expected impact of traffic.

The most rigorous basis for estimating future road network maintenance and rehabilitation requirements would be an engineering and economic analysis of alternative treatment strategies on a section by section basis. This is the type of approach envisaged in the use of the computerised pavement management system being demonstrated in each country as part of this Project. The nature and cost of all the section level strategies would be brought together to create a network level road expenditure programme over time and the total costs of this would be calculated on a year by year basis. This approach is very demanding of resources and as a minimum it needs to be based on a detailed highway database of the type which is not yet available in the TRACECA countries at the network level. In summary this is the future aim of the current project which can be seen as the first, the important step for the implementation of the PMS.

A slightly simpler approach, which is still fairly demanding of highway data, involves describing the network in a matrix of hypothetical representative sections combining defined road and traffic characteristics. Optimum maintenance and rehabilitation strategies would be developed for each of these representative road sections on the basis of engineering and economic cost benefit analyses, probably using a computerised model of some sort. In this optimisation analysis different potential, initial and subsequent road expenditure plans would be compared with a “do minimum” scenario in a discounted cash flow analysis and the plan or strategy showing the highest economic Net Present Value (NPV), NPV per kilometre or Benefit -Cost Ratio would be selected. The optimum strategy for each section would be the one minimising total discounted life cycle transport costs in which, it will be remembered, road user costs are the main component.The optimum strategy and the implied road agency expenditure programme over time for each section would be set out and the road costs for all sections would be added up to form an overall expenditure programme from which the average annual road expenditure requirements for the network would be ascertained.

It is important to be clear about the role of road user costs in this process. Road user costs are a vital component of the optimum strategy analysis because they are the largest component of total transport costs associated with each scenario being compared. However, once the optimum maintenance and rehabilitation strategy for each section has been found on the basis of engineering and economic cost benefit analysis, the focus of attention moves to road or road use costs. These are the future highway agency costs which will dictate road expenditure requirements and , hopefully, budgets.

The approach to the estimation of road use costs described later in this chapter is of necessity a highly simplified version of the representative section approach described above. The road use cost analysis has had to be based mainly on readily available data in the highway departments in each country. An exception to this is vehicle axle load data which was collected in a series of special surveys conducted by the Consultant. With the possible exception of Kazakhstan, none of the TRACECA countries has a highway database capable of sustaining the above type of analysis. The detailed databases created for the pilot road sections selected for the introduction and training of the pavement management system under the Project covered approximately 30 kilometres of main road in each country. These sections were not though for and also are too short to form a representative sample of pavement characteristics suitable for extrapolation to the network level. However, all socalled TRACECA roads (marked as ROAD CORRIDOR on the TRACECA Map) were inspected and data recorded for road surface condition category/class with relation to IRI (roughness).

Table 6.1 PAVEMENT STRENGTH INDICATORS IN SELECTED C.I.S COUNTRIES

Country		Modified Structural Number (SNC) by Design Standard Assumed in Road Use Cost Analyses				
		I	II	III	IV	V
Armenia (a)		4,5	4,0	2,6	2,6	2,4
Armenia (b)		7,5	4,8	4,0	3,0	2,3
Azerbaijan		4,9	4,0	3,8	3,5	2,9
Georgia		5,0	4,2	3,5	3,2	2,6
Kazakhstan		4,6	4,0	3,0	2,4	2,0
Kyrgyz Republic		4,6	3,9	3,0	2,8	1,5
Tajikistan		4,6	3,9	3,0	2,8	1,5
Uzbekistan		4,7	4,0	3,0	2,5	2,0
Country		**Estimates of Structural Numbers By design Category made in other studies**				
		I	II	III	IV	V
Carl Bro International a/s Kyrgyz Republic (Bishkek - Osh Road)	612		3,9	3,6	2,8	
TecnEcon - The Armenia Highway Survey"						
CowiConsult and TecnEcon "Road and Road Transport St4dy in Russia, Ukraine, Kazakhstan and Belarus"						
Russia - Moscow area	1454,0	6,2	6,8	4,6		1,9
Russia - St Petersburg area	850,0	4,2	5,1	4,6	3,9	2,3
Russia - Samara area	476	5,6	4,6	4,2	3,2	2
Russia - Tjumen area	235		3,8	4,1	3,6	
Russia - Irkutsk area	592			4,4		
Kazakhstan - 2 areas (a)	962	4,6	4,2	3,2	2,8	2,3
Ukraine - 2 areas	1.190	4,2	2,3	1,4		
10 tonne design:						
Normal layer coefficients		8,0	7,0			
Reduced layer coefficients		6,5	5,5			
6 tonne design:						
Normal layer coefficients		5,0	4,5	4,0	3,0	2,0
Reduced layer coefficients		4,0	3,5	3,0	2,5	

Note: (a) Assumed from design standards
(b) Based on benkelman beam survey results.

Sources: Consultant's estimate.
CowiConsult and TecnEcon - "Roads and Road Transport Study" (Russia, Ukraine, Kazakhstan and Belarus) - for EBRD, 1992
Carl Bro International a/s - Road (Bishkek-Osh) Rehabilitation Project - for Asian Development Bank (1995)

TABLE 6.1: PAVEMENT STRENGTH INDICATORS IN SELECTED C.I.S COUNTRIES

The methodology used for estimating road use costs is based on a short cut approach suggested by the World Bank and this is described in greater detail below. However, even this short cut approach requires the following network level information:

- representative daily traffic levels by vehicle type
- axle loading by vehicle type
- pavement strength

The next section sets out the estimates of the above traffic and pavement strength inputs for each country and the process by which they were obtained.

6.2 The Characteristics and Utilisation of the Main Road Networks

6.2.1. Characteristics of the Main Road Networks

The highway institutions and agencies in the TRACECA countries have more or less readily available road inventory information on road geometrics and pavement type, visual road condition survey information and information on the design standard to which individual road sections were built. Except in Armenia and Kazakhstan, there is very little information on pavement strength as measured by Benkelman Beam surveys and virtually no pavement roughness survey data. In general, more and better information is available for the inter state roads than for the intra state or old republican roads. The lack of information on the characteristics of district and local roads precluded their inclusion in the road use cost study, even though they form the largest part of each country's public road network.

The World Bank's short cut approach to road use cost analysis being adopted for this study uses information on pavement strength (modified structural number) as a proxy for pavement characteristic and condition. The absence of pavement strength data in most TRACECA countries is, therefore, a potential obstacle to this form of analysis. Information on road design standards is, however, widely available and this provides the somewhat imperfect guide to potential pavement strength which has had to be used in this study. The main features of the geometric and pavement design standards used in the C.I.S are shown in Annex 6 Table A.6.2. There are, however, differences in pavement design details from country to country. reflecting the differences in geography and climate.

The structural numbers for different pavement design categories shown in Annex 6 Table A.6.2 are based on normal pavement layer coefficients for road construction in the West. However, there are reasons to believe that layer coefficients for roads built in the former Soviet Union can be considerably lower. The reason for this is that roadworks often deviated from the design standards in their implementation. The use of poorer than specified quality materials, variations in sub base thickness and low compaction levels have been three of the more common examples mentioned by highway engineers in the TRACECA and other C.I.S countries. In the "Roads and RoadsTransport Study of Russia, Ukraine, Kazakhstan and Belarus" carried out by CowiConsult and TecnEcon for the EBRD in 1992 it was suggested that a general reduction in theoretical layer coefficients of, around, 20 percent was warranted when assessing pavement strength from the design standards. According to the AASHTO Guide for Design of Pavement Structures, this corresponds to a reduction of E-module by 20 percent or CBR values by 30 percent for unbound materials. Our assumptions about road design standards and pavement strength are based on the above suggestion that a 20 percent reduction in the layer coefficients should be made.

The assumptions used in this study about pavement strength for roads of different design standards are summarised in Table 6.1. This table also shows estimates which have been made in a number of other studies in recent years in the C.I.S. In Armenia there are two alternative pavement strength assumptions. The first is based on design standards as in the other countries, and the second is based on the results of a benkelman beam survey carried out in 1995. The results of our statistical analysis of the results of this survey are presented in Annex 6 Table A.6.3. The deflections recorded in the survey were converted to Modified Structural Number using a formula recommended in the World Bank's documentation of its HDM-III model.The survey was extensive and the sample of over 2,500 observations was very large . It was, therefore, hoped that the results could form the basis of a more rigorous approach to linking pavement strength to design standards in the TRACECA countries. In practice, however, we have some reservations about the data largely arising from the high degree of uniformity of deflection levels recorded across large lengths of road and different design standards. This may have been the result of the equipment used or its calibration. In the case of Armenia, therefore, the road use cost analysis described later in this chapter is undertaken on the basis of the alternative assumptions about pavement strength shown in Table A.6.3. Deflection surveys have also been undertaken in Kazakhstan in recent years, but the results were only available in the form of a qualitative summary. No alternative pavement strength estimates based on deflection survey results could, therefore, be made.

The length of inter state and intra state roads falling within the five different design categories in each country are shown in Annex 6 Table A.6.1 In each country this summary has been based on an analysis of the detailed section by section road data made available by the respective highway institutions. For certain countries the quality of data available for the intra state network was of variable coverage and in these cases it has been necessary to make assumptions about applicable design categories based on the distribution over the rest of the intra state network. In the case of Azerbaijan it should be noted that the intra state road network defined for this study does not include roads in the occupied territories. There is no up to date information on these roads.

6.2.2 Utilisation of the Main Road Networks

The analysis of traffic levels on the main road networks has largely been based on the results of routine classified traffic surveys undertaken by the respective highway institutes. Most TRACECA countries inherited efficient traffic counting and analysis procedures for inter urban main roads, but subsequent budget cuts have had a significant adverse effect on the coverage of traffic counting programmes in certain countries. Inter state roads are covered in greater detail than are the intra state roads in most countries and for this reason the traffic estimates for inter state roads are more reliable than those for the intra state network.

The traffic estimates for intra state roads in Tadjikistan, Uzbekistan, Armenia, and Georgia are considered to be less reliable than those for the other countries. In Georgia the traffic counting programme virtually ceased between 1991 and 1995 and the counts undertaken within the last eighteen months have concentrated on selected inter state roads. Even now, the traffic survey coverage of Georgia's inter state road network is inadequate and the Consultant carried out supplementary classified volume counts on three inter state roads. The estimates of traffic on Georgia's intra state road network are based on the results of the extensive routine surveys undertaken in the period before 1990, in particular between 1986 and 1990. The average traffic levels indicated in these surveys have then been significantly reduced in accordance with the observed reduction in traffic on inter state roads where recent data made possible a comparison of 1986-1990 and 1995-1996 traffic levels. In Armenia an excellent traffic counting programme has been established, but it is focused on the inter state road network. The only information on intra state road traffic levels is from traffic counts undertaken on roads which were inter state roads but which have recently been classified as intra state roads. Some of the traffic data collected as part of the 1994 "Armenia Highway Survey" comes under this category.

Where traffic data on the intra state networks were inadequate estimates have been based on analysis of traffic levels by road design category on inter state roads and on the original traffic levels inherent in the design category. The traffic thresholds for each design category are as follows:

- Design Standard category I. — Average daily traffic (ADT) over 7,000
- Design Standard category II — ADT 3,000 - 7,000
- Design Standard category III — ADT 1,000 - <3,000
- Design Standard category IV — ADT 100 - <1,000
- Design Standard category V — ADT < 100

The significant reductions in traffic which have taken place in most TRACECA countries since 1990/1991 may well have nullified a large part of the traffic growth which took place in 1970s and 1980s after the roads were constructed. For this reason, the traffic ranges in the design standard categories may well offer a better guide to current traffic ranges on the intra state roads than would have been the case in a continuous traffic growth environment.

The vehicle classification system used in routine traffic counts in all TRACECA countries except Armenia has a vehicle weight based classification for goods vehicles.In this system trucks are, with some local variations, classified as follows:

- trucks of less than 3 tonnes
- trucks of 3 - <5 tonnes
- trucks of 5 - 8 tonnes
- trucks of over 8 tonnes

An axle based truck classification system is more commonly used internationally and is required for use in the World Bank's HDM-III model. In this study and in the PMS programme system provided to each of the recipient states under the current Project the following vehicle classification system has been used for traffic and axle load inputs. Armenia has also adopted a similar axle based vehicle classification system since traffic surveys were undertaken for the "Armenia Highway Survey" in 1994.

- Passenger cars, jeeps etc.
- Utility vehicles (minibuses, pickups and small vans)
- Large buses
- axle trucks
- axle trucks or truck-trailer combinations
- trucks or truck-trailer combinations of more than 3 axles

The Consultant carried out a large number of moving observer counts on different types of road in each country. Classified volume counts of buses and trucks were carried out as part of the axle load surveys undertaken in Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Turkmenistan and Uzbekistan. Additional comprehensive classified volume counts were also carried out in Georgia. The results of all these counts were used to convert the results of the official routine counts to the above axle based classification.

The estimates of traffic by road design class were based on detailed analysis of the combined road section and traffic count data. The results of this analysis for each country are presented in Annex 6 Table A.6.4. The overall utilisation of each country's inter state and intra state networks in terms of vehicle kilometres by vehicle type is presented in Table 6.2 below. In the TRACECA region as a whole cars account for just over half the inter urban vehicle kilometres and light utility vehicles make up a further 9 per cent of the total. Large buses account for just under 4 per cent and trucks for just under one third.

Overall, approximately 45 percent of inter urban vehicle kilometres are on inter state roads and 55 per cent are on intra state roads. However, this overall picture is heavily influenced by the very large intra state road networks in Kazakhstan and Uzbekistan. In the other TRACECA countries the inter state networks carry a significantly larger share of total inter urban vehicle kilometres than the intra state networks.

The distribution of equivalent standard axle (ESAL) kilometres shows a very different picture of the potentially damaging impact of vehicles in terms of network utilisation.The summary of ESAL kilometres which is presented in Table 6.3 shows a very different pattern between vehicle types as might be expected from the discussion of pavement damage from axles in Chapter 4. Light vehicles contribute less than 0.2 percent of total ESAL kilometres on inter urban main roads in the TRACECA countries. Large buses account for 32 percent of total ESAL kilometres and trucks account for just over 67 percent. The overall distribution of ESAL kilometres between inter state and intra state roads is once again heavily influenced by Kazakhstan and Uzbekistan in showing inter state roads carrying only 39 per cent of the total. In most countries the inter state network carries between two thirds and three quarters of inter urban ESAL kilometres. Detailed estimates of ESAL kilometres by road design standard on inter state and intra state road networks in each country are presented in Annex 6 Table A.6.5.

Table 6.2 TRACECA COUNTRIES - VEHICLE KILOMETRES BY MAIN ROAD CATEGORY AND VEHICLE TYPE 1996

Country	Road Class	Road Length (km)	Vehicle Kilometres (million)						
			Car	Utility	Bus	Truck 2-axle	Truck 3-axle	Truck > 3-axle	TOTAL
Armenia	Inter State	1.569,1	1.057,7	129,8	90,1	117,3	108,2	23,5	1.526,6
	Intra State (Rep.)	1.578,7	289,2	46,5	16,8	45,2	36,2	9,5	443,4
	Total Main	**3.147,8**	**1.346,9**	**176,3**	**106,9**	**162,5**	**144,4**	**33,0**	**1.970,0**
		% total	68,4	8,9	5,4	8,2	7,3	1,7	100,0
Azerbaijan	Inter State	1.409,0	1.272,8	279,2	143,5	521,1	109,0	159,3	2.484,9
	Intra State (Rep.)	3.280,0	694,5	325,9	133,1	542,6	151,7	164,2	2.012,0
	Total Main	**4.689,0**	**1.967,3**	**605,1**	**276,6**	**1.063,7**	**260,7**	**323,5**	**4.496,9**
		% total	43,7	13,5	6,2	23,7	5,8	7,2	100,0
Georgia	Inter State	946,0	1.202,4	58,4	113,3	68,1	64,4	26,8	1.533,4
	Intra State (Rep.)	4.059,3	436,1	20,0	35,7	26,8	24,2	12,2	555,0
	Total Main	**5.005,3**	**1.638,5**	**78,4**	**149,0**	**94,9**	**88,6**	**39,0**	**2.088,4**
		% total	78,5	3,8	7,1	4,5	4,2	1,9	100,0
Kazakhstan	Inter State	6.132,0	2.594,0	194,0	45,0	811,0	486,0	93,0	4.223,0
	Intra State (Rep.)	11.364,0	3.715,0	322,0	64,0	986,0	549,0	230,0	5.866,0
	Total Main	**17.496,0**	**6.309,0**	**516,0**	**109,0**	**1.797,0**	**1.035,0**	**323,0**	**10.089,0**
		% total	62,5	5,1	1,1	17,8	10,3	3,2	100,0
Kyrgyz Rep.	Inter State	747,6	423,6	51,8	30,0	103,0	54,6	25,7	688,7
	Intra State (Rep.)	2.362,3	460,9	83,5	43,6	156,0	37,7	35,7	817,4
	Total Main	**3.109,9**	**884,5**	**135,3**	**73,6**	**259,0**	**92,3**	**61,4**	**1.506,1**
		% total	58,7	9,0	4,9	17,2	6,1	4,1	100,0
Tajikistan	Inter State	1.089,1	337,4	27,8	20,5	92,4	50,5	16,5	545,1
	Intra State (Rep.)	696,1	43,2	6,4	2,5	13,5	6,2	3,7	75,5
	Total Main	**1.785,2**	**380,6**	**34,2**	**23,0**	**105,9**	**56,7**	**20,2**	**620,6**
		% total	61,3	5,5	3,7	17,1	9,1	3,3	100,0
Turkmenistan	Inter State	1.211,6	761,3	119,1	162,2	532,6	64,2	149,9	1.789,3
	Intra State (Rep.)	6.471,0	741,4	201,9	49,3	190,8	98,6	474,1	1.756,1
	Total Main	**7.682,6**	**1.502,7**	**321,0**	**211,5**	**723,4**	**162,8**	**624,0**	**3.545,4**
		% total	42,4	9,1	6,0	20,4	4,6	17,6	100,0
Uzbekistan	Inter State	1.393,0	1.416,6	430,5	116,0	852,4	137,6	119,4	3.072,5
	Intra State (Rep.)	20.432,0	2.777,6	727,0	254,5	2.517,1	699,9	580,7	7.556,8
	Total Main	**21.825,0**	**4.194,2**	**1.157,5**	**370,5**	**3.369,5**	**837,5**	**700,1**	**10.629,3**
		% total	39,5	10,9	3,5	31,7	7,9	6,6	100,0

Note: Main roads are defined as the inter state (magistrale) and intra state (republican) road networks.

Source: Consultant's estimates based on the national authorities' road and traffic data.

TABLE 6.2 TRACECA COUNTRIES - VEHICLE KILOMETRES BY MAIN ROAD CATEGORY AND VEHICLE TYPE 1996

Table 6.3 TRACECA COUNTRIES - ESAL KILOMETRES BY MAIN ROAD CATEGORY AND VEHICLE TYPE

Country	Road Class	Road Length (km)	ESAL Kilometres (million) Car	Utility	Bus	Truck 2-axle	Truck 3-axle	Truck > 3-axle	TOTAL
Armenia	Inter State	1.569,1	0,11	0,18	57,19	18,96	44,06	8,36	128,86
	Intra State (Rep.	1.578,7	0,03	0,07	10,69	7,30	14,75	3,36	36,20
	Total Main	**3.147,8**	**0,14**	**0,25**	**67,88**	**26,26**	**58,81**	**11,72**	**165,06**
		% total	0,08	0,15	41,12	15,91	35,63	7,10	100,00
Azerbaijan	Inter State	1.409,0	0,13	0,39	177,10	66,29	19,53	53,92	317,36
	Intra State (Rep.	3.280,0	0,07	0,46	164,29	69,02	27,19	55,56	316,59
	Total Main	**4.689,0**	**0,20**	**0,85**	**341,39**	**135,31**	**46,72**	**109,48**	**633,95**
		% total	0,03	0,13	53,85	21,34	7,37	17,27	100,00
Georgia	Inter State	946,0	0,12	0,08	226,66	6,64	32,22	30,29	296,01
	Intra State (Rep.	4.059,3	0,04	0,03	71,38	2,61	12,09	13,78	99,93
	Total Main	**5.005,3**	**0,16**	**0,11**	**298,04**	**9,25**	**44,31**	**44,07**	**395,94**
		% total	0,04	0,03	75,27	2,34	11,19	11,13	100,00
Kazakhstan	Inter State	6.132,0	0,26	0,27	11,09	36,72	88,08	19,98	156,40
	Intra State (Rep.	11.364,0	0,37	0,45	16,00	44,66	99,60	49,58	210,66
	Total Main	**17.496,0**	**0,63**	**0,72**	**27,09**	**81,38**	**187,68**	**69,56**	**367,07**
		% total	0,17	0,20	7,38	22,17	51,13	18,95	100,00
Kyrgyz Rep.	Inter State	747,6	0,04	0,07	4,97	7,07	9,10	16,26	37,51
	Intra State (Rep.	2.362,3	0,05	0,12	7,24	10,70	6,28	22,59	46,98
	Total Main	**3.109,9**	**0,09**	**0,19**	**12,21**	**17,77**	**15,38**	**38,85**	**84,49**
		% total	0,11	0,22	14,45	21,03	18,20	45,98	100,00
Tajikistan	Inter State	1.089,1	0,03	0,04	2,38	6,34	8,41	10,43	27,63
	Intra State (Rep.	696,1	0,01	0,01	0,29	0,93	1,03	2,33	4,60
	Total Main	**1.785,2**	**0,04**	**0,05**	**2,67**	**7,27**	**9,44**	**12,76**	**32,23**
		% total	0,12	0,16	8,28	22,56	29,29	39,59	100,00
Uzbekistan	Inter State	1.393,0	0,14	0,60	127,61	164,52	25,86	120,77	439,50
	Intra State (Rep.	20.432,0	0,27	1,01	274,39	476,78	128,24	581,31	1.462,00
	Total Main	**21.825,0**	**0,41**	**1,61**	**402,00**	**641,30**	**154,10**	**702,08**	**1.901,50**
		% total	0,0	0,1	21,1	33,7	8,1	36,9	100,0

Note: Main roads are defined as the inter state (magistrale) and intra state (republican) road networks.
Source: Consultant's estimates based on the national authorities' road and traffic data.

TABLE 6.3 TRACECA COUNTRIES - ESAL KILOMETRES BY MAIN ROAD CATEGORY AND VEHICLE TYPE

6.3 Indicative Estimates of Road Use Costs

6.3.1 General

The estimated cost of using road networks in each country should be a basic input into any discussion about highway financing and road user charging policy. Without a realistic estimate of road use costs, decisions about road budgets are made in a vacuum and any cost recovery policy lacks a credible foundation. Road use costs are defined in this study as the average annual costs of maintaining, rehabilitating and managing road networks over a life cycle of several years. It will be noticed that the cost of adding to the road networks by building new roads is not included in this definition which is basically limited to recurrent costs . The cost of new roads should be considered separately under a capital investment cost heading, However, new roads start incurring recurrent costs as soon as maintenance commences. These recurrent costs should obviously be included in our definition of road use costs. In practice, very few new roads are being built in the TRACECA countries.

Road use costs can be divided into fixed and variable costs. Variable costs comprise that portion of costs which is dependent on traffic and loading. In the long run most road costs are variable to some degree, but it is usual practice to include as a minimum the costs of policing and administration and interest on loans in fixed road costs. There are also portions of routine and periodic maintenance and rehabilitation which are considered to be fixed . It is important to be able to distinguish between fixed and variable road use costs because the distribution between the two has a significant influence on the optimum structure of road user charges. The allocation of road costs between fixed and variable elements usually requires rather detailed research and can be time consuming which was not part of this study, and therefore the division of road costs between fixed and variable elements has been based on the results of analyses carried out by and for the World Bank in many low income countries.

6.3.2 Methodology Used for Estimating Road Use Costs

6.3.2.1 World Bank Short Cut Analysis of Road Use Costs

The approach to estimating road use costs adopted in this study is based on a short cut methodology suggested by the World Bank. This methodology is based on a series of analyses of optimum maintenance strategies using the Highway Design and Maintenance Standards model (HDM-III) and data from a wide range of road studies in low income countries. In the analysis optimum maintenance strategies and the associated life cycle average annual road use costs were developed for a range of combinations of traffic, pavement strength and pavement loading. This range of combinations can be considered as a three dimensional matrix made of cells comprising different combinations of traffic, pavement strength and traffic loading. The optimum maintenance strategy for each combination, or cell in the matrix, involves routine maintenance plus the application of periodic thick or thin overlays at pavement roughness thresholds defined as optimum on the basis of extensive analysis using HDM-III. It also includes reconstruction where relevant.The average annual road use costs associated with each optimum maintenance and rehabilitation strategy are then recorded. The results of the World Bank analysis are set out in Table 6.4.

Table 6.4 AVERAGE ANNUAL ROAD USE COSTS UNDER OPTIMUM MAINTENANCE STRATEGIES

Pavement Strength (Modified Structural Number)	Average annual daily traffic (AADT)	ESA per Lane per Year (million)	Optimum Strategy		Road UseCosts (US$ per km per year)				
			Treatment overlay thickness (mm)	Intervention roughness threshhold (m/km)	Non-traffic related (fixed) costs	Traffic related (variable) costs			Total Road Use Costs
						Vehicle related	Axle loading related	Sub Total	
Moderate traffic loading with normal truck composition									
8	10.000	1,740	80	3,0	3.806	3.216	636	3.852	7.658
8	6.000	1,000	80	3,0	3.155	3.217	432	3.649	6.804
8	3.000	0,260	80	3,0	2.955	2.647	578	3.225	6.180
5	10.000	1,740	80	3,0	3.921	3.365	2.667	6.032	9.953
5	6.000	1,000	80	3,0	3.270	3.038	1.734	4.772	8.042
5	3.000	0,260	40	3,5	3.211	2.391	640	3.031	6.242
5	1.000	0,053	80	7,0	3.062	145	317	462	3.524
5	300	0,014	80	7,0	2.562	128	249	377	2.939
3	3.000	0,260	40	3,5	3.212	2.648	2.128	4.776	7.988
3	1.000	0,053	80	5,0	3.062	379	1.563	1.942	5.004
3	300	0,014	80	7,0	2.562	206	336	542	3.104
2	3.000	0,260	80	3,5	3.272	3.323	2.963	6.286	9.558
2	1.000	0,053	40	4,0	3.122	1.336	1.517	2.853	5.975
2	300	0,014	80	7,0	2.622	290	648	938	3.560
Light traffic loading with normal truck composition									
8	6.000	0,500	80	3,0	3.155	3.217	214	3.431	6.586
5	3.000	0,130	80	3,5	3.211	2.391	605	2.996	6.207
3	1.000	0,025	80	5,0	3.062	379	1.309	1.688	4.750
2	300	0,013	80	7,0	2.622	290	468	758	3.380

Source: World Bank - "Management and Financing of Roads" 1995.

TABLE 6.4 AVERAGE ANNUAL ROAD USE COSTS UNDER OPTIMUM MAINTENANCE STRATEGIES

The pavement strength levels considered range from strong pavements with a modified structural number (SNC) of 8 to weak pavements with an SNC of 2. Average daily traffic ranges from 10,000 to 300 vehicles and traffic loading ranges from 1.74 million to 13,000 equivalent standard axles per lane per year were taken for use in the analysis. Analyses were undertaken under alternative assumptions about traffic composition, notably the proportion of trucks in the total. For the purpose of this study the moderate and light traffic loading assumption with normal (20 percent) truck composition was taken to be the most appropriate in view of the low axle loading recorded in the axle surveys carried out in the TRACECA countries.

In its analysis the World Bank distinguishes between fixed and variable road use costs. The distinction is based on the results of many international studies and, for recurrent maintenance and rehabilitation costs, on the results of HDM-III analysis. In this analysis the results of the model runs with predicted traffic were compared with runs where no traffic data was input. The results of the no traffic runs showed the non traffic related or fixed cost components of recurrent costs . All policing and road administration costs were taken as fixed costs and the order of magnitude of these items was based on the results from several international studies.

The road user costs used in the World Bank's HDM-III based maintenance strategy analyses were derived from a range of international studies and relationship between road user costs and pavement roughness would have been derived from the model. Predicted traffic growth rates used in the analysis are not specified by the World Bank, but they would presumably also be based on a wide range of international experience.

The economic and financial unit costs used in the World Bank analyses were also based on extensive international evidence. Economic costs were used in the strategy analyses. The unit costs on which the Bank's road use cost analysis was based were as follows:

Treatment	Economic cost (US$/km)	Financial cost (US$/km)
Routine maintenance	1,450 + 0.43 (AADT)	1,700 + 0.5 (AADT)
Reseal	19,400	22,400
Thin overlay (40mm)	47,600	56,000
Thick overlay (80mm)	76,200	90,000
Reconstruction (+2 SNC)	238,000	280,000

There are considerable variations in and uncertainties about the unit costs of roadworks in the C.I.S countries and this largely reflects local price distortions. The results of a comparison of unit costs of different roadworks used in a number of studies sponsored by international donors in recent years are set out in Annex 6 Table A.6.7. There is little discernible pattern in these costs and considerable uncertainty about realistic unit costs in the TRACECA countries. In view if this it was decided to use the unit costs in the World Bank's analysis and not to attempt to modify them to take account of possible local price factors.

It is not possible without a considerable amount of research to determine to what extent the results of the World Bank analyses would overstate or understate road use costs when applied to the TRACECA countries. To the extent that unit costs within the TRACECA region are below international levels in low income countries, the results would tend to overstate these costs, but there is little persuasive evidence either way. There is a tendency to overstate the loading related road use costs because the vehicle damage factors used in the Bank's maintenance strategy analyses are higher than present damage factors in the TRACECA region. However, there may also be a tendency to understate costs in those parts of the TRACECA region subject to severe winter weather because the HDM-III was not specifically designed to simulate pavement behaviour under extreme freeze-thaw conditions. On balance, the assumption in this study is that the road use costs predicted in the Bank's analyses for different combinations of pavement strength, traffic and loading are of the right order of magnitude.

6.3.2.2 Adaptation of the World Bank's Road Use Cost Estimates

The results of the short cut method of road use cost analysis suggested by the World Bank have been adapted for use in this study. The following main inputs for the analysis for each country have been prepared as described earlier in this chapter:

- Average daily traffic by vehicle type and road design category
- Vehicle kilometres by vehicle type and road design category
- ESAL kilometres and ESA per lane per year by road design category
- Pavement strength as measured by modified structural number for each road design category.

A series of regression analyses has been undertaken on the results of the World Bank analysis shown in Table 6.4 to permit interpolation between the values indicated for pavement strength, traffic and loading. The results of these regression analyses have been used to estimate fixed and variable road use costs resulting from the insertion of the estimated input values for each country. The results of this process are presented in Annex 6 Table A.6.6. The analysis has been run separately for inter state roads and intra state roads.

The regression models used for estimating fixed and variable road use cost values are as follows:

$$FC = 2{,}716.7 - SNC(51.7) + AADT(0.54) - 3{,}459.7(ESALY)$$
Adjusted R^2= 0.88

$$AADTVC = -414.2 - SNC(39.1) + AADT(2.8) - 20{,}385.9(ESALY)$$
Adjusted R^2 = 0.83

$$TOTALVC = 995.3 - SNC(431.4) + AADT(4.46) - 32201.7(ESALY)$$
Adjusted R^2 = 0.85

where:

FC	=	Fixed costs
AADTVC	=	Traffic related variable costs
TOTALVC	=	Total variable costs
SNC	=	modified structural number
AADT	=	average daily traffic
ESALY	=	equivalent standard axle per lane per year

The loading related variable costs were calculated by subtracting traffic related variable costs from total variable costs.

6.3.3 Estimated Annual Road Use Costs

The results of the estimates of average annual road use costs are summarised in Table 6.5. The detailed results for each country are presented in Annex Table A.6.6. It is emphasised that given the nature of the data on which they are based, particularly the pavement strength assumptions, the resulting estimates must be regarded as indicative rather than definitive.

These estimates understate total road use costs in each country because they do not include most urban , district and local roads. It is felt that even for the inter state and intra state road networks these costs should be considered to be conservative for a number of reasons. In the first place, the present situation with regard to the comparable light axle loading in TRACECA countries may change if there is a switch over time to the use of heavier trucks and if vehicle overloading becomes more common in line with international experience. Both of these factors would increase pavement damage costs and are likely to be an increasingly common feature of the road transport sector when sustained economic recovery starts to take place. Secondly, these road use costs do not include bridge costs, except in Turkmenistan where they were estimated to amount to around 9 percent of potential road use costs.

During the course of field visits to the TRACECA countries the engineers in the respective highway institutions were asked for their estimates of realistic road costs in the absence of a budget constraint. In most cases these estimates were significantly higher than the annual road use costs estimated in this study. With the exception of Kazakhstan, however, local estimates tended to include a significant amount of heavy reconstruction and new road construction even though only estimates for maintenance and rehabilitation was requested. Similarly, the local estimates may have been inflated by the inclusion of non state roads and by representing backlog maintenance needs rather than long term average annual requirements.

The situation in Kazakhstan is different. In early 1996, a World Bank mission assisted by Kazdornii carried out an analysis of the maintenance and rehabilitation requirements of the paved part of the state road network comprising 15,881 kilometres using HDM-III. The data for the analysis was supplied by Kazdornii. The results of this analysis indicated that annual expenditure of US$ 400 million (US$ 25,000 per kilometre) would be required to achieve a significant overall improvement in the condition of the paved state road network. A marginal improvement in overall network condition would require annual expenditure of US$ 200 million (US$ 12,600 per kilometre) and the expenditure of only US$ 100 million (US$ 6,300) would result in further deterioration in overall network condition. Our road use cost estimates for Kazakhstan suggest annual expenditure requirements of US$ 162 million for a 17,496 kilometre network and this suggests that with this level of expenditure network condition would be more or less static at its present standard. One possible reason for the differences is that the unit costs used in the World Bank mission's analysis were higher than those used in our study which are based on the unit costs used by the World Bank in its short cut methodology. The World Bank mission did express some doubts about the reliability of the unit cost and traffic data on which the HDM-III analyses were based and these uncertainties may account for the high resulting estimates of expenditure requirements.

In general, the indicative annual road use cost estimates presented in this study are unlikely to be overestimates. They do, however, represent a vary substantial increase over current expenditure levels. The summary presented in Table 6.5 shows that average road expenditure levels in 1995/1996 ranged from 43 percent of annual road use costs in Uzbekistan to only 9 percent in Tadjikistan. The overall average for the TRACECA countries was 24 percent. Expressed differently, the current **annual short fall** in expenditure on the inter state and intra state roads is of the following orders of magnitude:

- Armenia US$ 23.9 million (US$ 7,600 per kilometre)
- Azerbaijan US$ 49.0 million (US$ 10.450 per kilometre)
- Georgia US$ 27.9 million (US$ 5,600 per kilometre)
- Kazakhstan US$ 135.8 million (US$ 7,800 per kilometre)
- Kyrgyzstan US$ 21.4 million (US$ 6,900 per kilometre)
- Tadjikistan US$ 9.5 million (US$ 5,325 per kilometre)
- Turkmenistan US$ 55.1 million (US$ 7,200 per kilometre)
- Uzbekistan US$ 82.5 million (US$ 3,800 per kilometre)

Without the sharp decline in road traffic which has taken place in most TRACECA countries in the 1990s the present condition of the main road networks would have been significantly worse than it is today. Unfortunately constraints on government budgets have been so severe in most of the countries that the decline in expenditure on road maintenance and rehabilitation has been much greater than the decline in network utilisation. A continuation of present expenditure levels will, therefore, undoubtedly result in accelerating deterioration in the overall conditions of what in most countries is the nation's most important single category of infrastructure asset. Rising road surface roughness will cause sharp rises in road user costs, as shown in Chapter 3, and this will impact significantly on the broader structure of costs in the respective economies.

There is, therefore, an urgent need to focus attention on the problem of how to finance the required levels of expenditure on the maintenance and rehabilitation of the road networks. Modern ideas on road user charging policy are particularly relevant in this context and these and the potential for financing road expenditure from restructured road user charges are discussed in the next Chapter.

Table 6.5 TRACECA COUNTRIES - ROAD USE COSTS AND CURRENT EXPENDITURE LEVELS ON ROADS

Country	Main Road Network			Average Expenditure 1995/1996 (US$ million)	Annual Road Use Costs (US$ million)			Annual Road Use Costs (US$ / Km)			1995/1996 Expenditure as % of Road Use Costs
	Intra State (km)	Inter State (km)	Total (km)		Inter State	Intra State	Total	Inter State	Intra State	Total	
Armenia (a)	1.569	1.579	3.148	6,7	21,6	9,0	30,6	13.766	5.701	9.721	22
Azerbaijan	1.409	3.280	4.689	10,4	31,3	28,1	59,4	22.214	8.567	12.668	18
Georgia	946	4.059	5.005	5,1	17,9	15,1	33,0	18.922	3.720	6.593	15
Kazakhstan	6.132	11.364	17.496	25,8	68,6	93,0	161,6	11.187	8.184	9.236	16
Kyrgyz Republic	748	2.362	3.110	5,2	10,4	16,2	26,6	13.911	6.858	8.553	20
Tajikistan	1.089	696	1.785	0,9	6,2	4,2	10,4	5.693	6.034	5.826	9
Turkmenistan	1.212	6.471	7.683	10,0			65,1			8.474	15
Uzbekistan	1.393	20.432	21.825	62,7	39,1	106,1	145,2	28.069	5.193	6.653	43
	14.497	50.243	64.741	126,8			531,9	14.632	6.205	8.216	24

Note: (a) Based on assumed pavement strength. If the pavement strength estimates based on the deflection survey results are used, total road use costs would be US$ 29.8 million a year, of which inter state roads would account for US$ 20.9 million.

Source: Consultant's estimates

TABLE 6.5 TRACECA COUNTRIES - ROAD USE COSTS AND CURRENT EXPENDITURE LEVELS ON ROADS

7 ROAD USER CHARGES AND COST RECOVERY

7.1 Basic Principles

The present system of financing roads in the TRACECA countries is inadequate and in the absence of radical reform, the situation seems unlikely to improve. It would be unwise to expect that ultimately economic recovery will enable adequate allocations to be made out of general taxation to fully cover the costs of road use. Even in the richest countries increasing constraints on highway budgets have become common.

The present problems of road financing in the TRACECA states are by no means unique to those countries. They have been experienced in equally, if not more severe forms in the lower income countries of Africa and Latin America. Attempts by governments and international donors to solve the road financing problems in these regions in the 1980s and early 1990s led to the emergence of a number of stark conclusions which stimulated the adoption of more radical approaches. The starting point was a critical evaluation of two convictions underlying the traditional approach to road financing. These were:

- Roads are public goods which must necessarily be provided free of charge by the state because the mobility they provide is thought to be a citizen's basic right.

- The best way to provide and maintain roads is through the public administration.

In this respect roads have differed from other modes of transport, such as railways, ports and shipping, and from most public utilities, such as gas and electricity, where payment for use of the facility or service has long been readily accepted. The special treatment of roads may have been the result of the difficulty experienced in developing fair and efficient charging mechanisms for road use. The result was the preferential treatment of road users in comparison with users of other transport modes. Toll roads and the adoption of road funds with access to specially earmarked taxes are an exception to traditional public financing of roads out of general taxation. However, tolling is only practicable in certain clearly defined circumstances and properly functioning road funds are the exception rather than the rule.

The traditional provision of roads as a service perceived to be free is often defended on equity grounds, particularly in the states which are in the process of transition. However, road users are by no means the poorest members of society and they are almost certainly being subsidised by poorer members of society . Failure to charge for road use also means that most road users are unaware of the total road use costs which their travel is causing. This means that they make more trips than if they have to pay charges reflecting realistic road use cost information. They are only aware of their perceived costs of which the most immediately visible is usually the cost of fuel. When road charges are set to cover road use costs, road users have a more rational basis for deciding whether to make the marginal trip. Failure to charge adequately for road use has two linked and undesirable effects.

- More trips are made and road utilisation is greater than would otherwise be the case. This has adverse resource consumption and environmental impacts.

- The resulting higher traffic levels give rise to higher road maintenance costs, which place increased pressure on the state budget. These extra demands on the state budget are the direct consequence of encouraging road use by charging too little for it.

The approach to highway financing which has gained much wider international acceptance in recent years is based on the idea that road user charging systems should be designed to achieve the following objectives:

- to ensure that the revenues required to provide and maintain public roads is raised from road users, including foreign road users, rather than from the general tax payer;

- to price the use of public roads so as to improve economic efficiency in transport by removing price distortions and to charge road users in accordance with their use of road facilities;

- to promote equity between different categories of road users by ensuring, for example, that charges on vehicle operators are related to the road maintenance costs for which they are responsible;

- to establish a link between supply and demand for road infrastructure;

- to increase transparency in the road funding process so that road users can see what funds are being raised from which categories of users and for what purpose and

- to provide for fair competition between road and other transport modes by ensuring that road transport users pay for their use of road infrastructure.

In short, road user charging policy with the above objectives should be designed to maximize net economic benefits by setting charges at a level at least equal to the cost of resources consumed by the use of the road network. These costs, which are sometimes called short run marginal costs, are of two types. The first type covers the cost of damage done to road pavements by the passage of vehicles and include the variable costs of managing and maintaining the network. The second type comprise the costs imposed by road users on other road users and others. These include congestion costs and "external" costs arising, for example, from noise and atmospheric pollution. However, charges only set to cover short run marginal costs would still result in under funding because they would not meet the fixed costs of road use which, as we have seen, are a significant proportion of total road use costs. A road user charging system designed to achieve full recovery of road use costs will, therefore, need to comprise two major elements, a charge or group of charges designed to cover variable or traffic related costs, and additional charges designed to cover fixed road use costs.

Although congestion and external costs are undoubtedly of potential significance, they are not yet of great importance in the TRACECA countries where there is virtually no congestion on the inter urban road networks and relatively little congestion even in the major urban centres. The data on which this study's analyses are based relate to the inter urban state roads and the problem of congestion costs in urban centres must be considered to lie outside the scope of the present work. However, the structure of road user charges discussed below can readily accommodate charges related to congestion and external costs should it be decided to include these at a later date.

7.2 An Appropriate Structure of Road User Charges

The system of road user charges outlined in this section is designed to cover the fixed and variable costs of road use in the TRACECA countries. The estimated fixed and variable road use costs on the interurban state road networks in each country were presented in Chapter 6. Before describing the different types of charges and their appropriate levels it is important to be clear about what these charges mean. **The levels at which the recommended road user charges have been set in this study are based on the assumption that all the revenues from these charges go into the road system to cover road use costs.** To the extent that the governments wish to obtain a contribution towards general tax revenue from road user charges, the charges would have to be set at a correspondingly higher level. In most of the TRACECA countries some part of existing fuel taxes and other road user charges are used to finance a portion, however small, of road use costs. The recommended charges should, therefore be seen as additional to that portion of existing charges which is not used to cover road use costs.

The recommended structure of road user charges comprises charges designed to cover variable road use costs and fixed costs by means of a quasi two part tariff. The variable costs arise from traffic and vehicle loading and the proportion of costs attributable to each has already been estimated in Chapter 6. The first part of the two part tariff is based on a fuel levy designed to cover total variable road use costs. The fuel levy will not on its own be sufficient to ensure that different categories of vehicles contribute their fair share to road cost recovery. Heavy vehicles impose much higher loading costs on the road network than light vehicles and these loading costs have to be reflected in the second part of the two part tariff.

The fuel levy required to cover variable road use costs is expressed per litre of automotive fuel. Total variable costs are , therefore, divided by total automotive fuel consumption in litres to obtain the fuel levy per litre. In this study no distinction is made between petrol and diesel, but a refinement of the fuel levy to differentiate between the two would be perfectly practicable given the relevant breakdown of consumption between the two.The estimated fuel consumption per vehicle kilometre is based on the analysis of vehicle operating costs described in Chapter 3 and unit consumption by representative vehicle type is then multiplied by the estimated annual vehicle kilometres for each category of vehicles to obtain total fuel consumption on inter urban state roads. This should be less than total automotive fuel consumption to the extent that it excludes consumption on urban, district and local roads.

The second part of the two part road tariff has to cover fixed costs plus an amount to ensure that heavy vehicles are making their full contribution to the variable road use costs for which they are responsible. The application of the fuel levy on its own will not be sufficient to cover all the load related costs imposed by heavy goods vehicles and the adjustment in the second part of the tariff is intended to make good this shortfall in heavy vehicle contributions. The second part of the quasi two part tariff usually comprises one or more of the following types of charges:

- Vehicle licences
- Weight and distance related charges, especially for foreign goods vehicles.

Both of these types of charges are in use in the TRACECA countries, but they are not making an adequate contribution towards cost recovery. Vehicle licence fees are too low and although the unit transit charges for international vehicles are not usually too low, the number of exemptions from them rather reduces their revenue earning potential. In some countries vehicles from C.I.S countries and from neighbouring countries contributing more than 90 per cent of international (non C.I.S) vehicle movements are exempt from paying transit charges as a result of inter-governmental agreements.

Detailed recommendations on road user charges in the second part of the quasi two part tariff are beyond the scope of this study, partly because the appropriate information on vehicle registrations is not readily available at the required level of detail. Vehicle registration data in the TRACECA countries is usually collected by the traffic police departments of the ministries of the interior, and there is a tendency to treat this information as confidential. The result is that obtaining the information can be time consuming and, even when it is made available, it is in excessively aggregated form. Information on the vehicle fleet is one of the most basic items of transport planning information and it should be readily available as a matter of course.

The analysis of appropriate transit charges for international vehicle needs to be based on a detailed analysis of the movements of international vehicles within each country so that reliable estimates of international vehicle kilometres and international equivalent standard axle (ESAL) kilometres by vehicle type can be calculated. Transit charges on international vehicles should be based on international ESAL kilometres. Information on axle loads of international vehicles has been collected, but detailed origin destination survey is beyond the resources of this study and until this information is also available, there will be no adequate basis for estimating appropriate international transit charges. There is also a need to clarify the whole position on exemptions from these charges. For those TRACECA countries where a very large proportion of international vehicles are from countries which are exempt from the transit charges, decisions have to be made about how long the exemptions are to continue. If they are to be regarded as fixed by international obligations, then it is doubtful if international transit charges are a potentially useful source of road use cost recovery.

In this study the recommendations on the appropriate level of vehicle licences required to cover fixed costs and to ensure that heavy vehicles make an adequate contribution to cost recovery fees must be regarded as very approximate. They are also higher than they would be if international transit charges were taken into account. It is regarded as more important for this study to show what the appropriate structure of road user charges should be rather than to attempt to make highly detailed recommendations on the basis of insufficient information.

7.3 Road User Charges Required for Cost Recovery

A simplified computer spreadsheet model for estimating the components of the quasi two part tariff needed to cover road use costs has been set up for each country. The fixed and variable annual road use costs for each country were estimated in Chapter 6 and these are the starting point for the user charge analysis. The model is simplified because, as explained above, it does not distinguish between petrol and diesel in the fuel levy, it does not include international transit charges, and it does not attempt to make detailed calculations of vehicle licence fees, but rather to indicate what order of magnitude they should be. The allocation of variable road use costs between different categories of vehicles is based on annual vehicle kilometres for the traffic or vehicle related portion and ESAL kilometres for the axle or loading related portion. The results of the simplified model for each country are set out in Annex 7 Table A.7.1 and the method of calculating the individual components is explained below.

Fuel Levy. The fuel levy is required to cover total annual variable road use costs and it is calculated by setting the levy per litre at a rate which, when multiplied by annual automotive fuel consumption in litres, will just cover total variable costs. In this study total automotive fuel consumption has been derived from the vehicle operating cost analyses and estimates of annual vehicle kilometres. If official estimates of total automotive fuel consumption were used, these would be greater than the study estimates because they should also reflect vehicle usage on urban, district and local roads. In practice it is not usually possible to match the fuel levy to total variable road use costs with absolute precision without going to an impossibly small fraction of a currency unit.

A closer look at variable road use costs shows that heavy vehicles account for a very high proportion of the axle or load related portion . The axle or load related part can be calculated for individual vehicle types by dividing total axle related variable cost by annual ESAL kilometres and multiplying the result by the ESAL per vehicle. When the proceeds of the fuel levy for different vehicle types are subtracted from the total variable costs attributable to those vehicle types it is quite common for heavy vehicles to be shown as not covering their fair share of variable costs. In Table A.7.1 this is indicated by the minus signs against individual heavy vehicle categories in the "Variable Cost minus Fuel Levy" columns. This has to be adjusted for in the second half of the quasi two part tariff, particularly when establishing annual licence fee levels for the heavier vehicle categories.

Vehicle Licence Fees. The annual fixed costs of road use have to be covered by a combination of licence fees, international transit charges and, possibly other charges. In this context it is worth noting that duties on imports of automotive vehicles and tyres could be included, but the revenues from such charges are normally incorporated into general tax revenue. In this simplified model, it is assumed that fixed costs plus or minus any small balance remaining from fuel levy revenue need to be covered by vehicle licence revenue. The levels of annual licence fees for the different categories of vehicles have been arrived at by a process of trial and error. However, the underlying principle is based on a capacity to pay concept. For buses this means taking account of passenger carrying capacity and for heavy goods vehicles payload capacity. If international transit charges were included, the amount to be covered by licence fees would be correspondingly lower.

The fuel levies and indicative vehicle licence fees resulting from the analyses in Annex 7 Table A.7.1 are summarised in Table 7.1 below. It has to be emphasised that these estimates assume that all the proceeds go towards full road use cost recovery. If governments were to insist on diverting a portion of the revenue from these user charges to non road uses, the fuel levies and indicative licence levels would have to be correspondingly higher to achieve full cost recovery. Conversely, if some of the revenue required for variable cost recovery is already obtained from existing fuel taxes, the required increase in fuel taxes would be equal to the fuel levy minus the portion of existing fuel tax earmarked for road expenditure. Similarly, if some portion of fixed road use costs were to be covered by transit charges on international vehicles, the indicated annual vehicle licence fees could be lower.

A note of caution is also in order with regard to the fuel levies. The estimated levies per litre have been based on automotive fuel consumption on the inter urban state road networks. If these levies per litre were to be multiplied by official estimates of total fuel consumption based on fuel sales and import data reflecting total road usage, the total revenue would cover variable road use costs on inter urban roads plus an unspecified portion of variable costs on the urban, district and local road networks. Alternatively, if total variable costs were divided by total officially estimated automotive fuel consumption, the fuel levy per litre would be lower than indicated, but the revenue would only cover variable costs on inter urban state roads. While the latter alternative may be politically more attractive, the former is probably the more desirable option pending the preparation of the necessary estimates of road use costs on the urban, district and local road networks.

Table 7.1 INDICATIVE FUEL LEVIES AND ANNUAL VEHICLE LICENCE FEES REQUIRED FOR FULL COST RECOVERY

Country	Required Fuel Levy (US cents per litre)	Indicative Annual Licence Fees Per Vehicle (US $)					
		Cars	Utility Vehicles	Large Buses	Trucks 2 axle	Trucks 3 axle	Trucks > 3 axle
Armenia	5,6	10	15	30	50	100	200
Azerbaijan	3,6	15	20	50	125	205	290
Georgia	5,3	10	13	50	80	140	215
Kazakhstan	4,9	10	15	48	80	115	220
Kyrgyz Republic	5,5	25	45	90	115	200	305
Tajikistan	5,0	(a)	(a)	(a)	(a)	(a)	(a)
Turkmenistan (b)	8,0	5-10	5-10	15-20	120-150	150-200	460-650
Uzbekistan	1,4	10	15	40	100	160	205

Note : (a) Impossible to calculate in the absence of vehicle fleet data.
(b) Licence fees are presented as a range because there are alternative official estimates of the number of licenced vehicles.

Source: Consultant's estimate

TABLE 7.1: INDICATIVE FUEL LEVIES AND ANNUAL VEHICLE LICENCE FEES REQUIRED FOR FULL COST RECOVERY