His Majesty's Government of Nepal
Ministry of Physical Planning & Works
Department of Roads

WORKING PAPER

ROAD USER COSTS

MRCU- MAINTENANCE AND REHABILITATION
CO-ORDINATION UNIT

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NEPAL VEHICLE OPERATING COSTS, 2001

1. INTRODUCTION

In order to undertake a cost benefit analysis of road investment and road maintenance information on vehicle operating costs (VOC) are required. VOCs are an important component of road planning models such as HDM III and HDM-4. Major research studies on VOCs have been carried out over the last 25 years in order to establish how transport costs change with respect to road based parameters such as road roughness, curvature and gradient.

To use VOC models it is necessary, from time to time, to ensure the following:-

a) The proposed model is appropriate to the circumstances
b) Up-to-date input costs are used
c) Up-to-date vehicle utilisation and other parameters are used.

In the period 1992 to 1994, under the MRCU, a computer spreadsheet program for VOCs in Nepal was developed. It was subsequently updated in 1996. The program was designed to provide basic guidance to the Department of Roads and consultants on VOCs in Nepal. The relationships used in the program were based on the VOC research carried out in India by the Central Road Research Institute. Research has shown very wide variations in the nature of relationships, particularly relating to vehicle maintenance, between different countries. Because most of the trucks and buses used in Nepal were made by Tata in India and it was felt that the Indian research would be most appropriate for Nepal. Small scale surveys were undertaken and the results compared with models to test whether they were broadly appropriate. Some adjustments were made to relationships in order to obtain a good fit. In particular adjustments were made to the fuel consumption relationships in order to suit the conditions found in Nepal.

It has now been recognised that this type of calibration is crucial for the successful adoption of the road planning model HDM-4. Within in HDM-4 it is important to calibrate key relationships relating to both VOCs and road deterioration.

It should be recognised that general price inflation is not a key reason for updating VOC data. In undertaking a cost benefit analysis of a road project both road maintenance costs and VOCs are forecast for 20 years or more into the future. It is, or course, necessary for the prices used in calculating road investment, road maintenance and VOCs to relate to the same date. However, over time, the relationships between the price components will change (e.g. between fuel and vehicles), similarly over time, vehicle types and vehicle utilisation will also change and it for these reasons that up-dating exercise is necessary.

In July 2001 a consultant was appointed to up-date the Nepal VOC model. This task was undertaken by carrying out some small scale surveys of trucks and buses and by collecting a range of input prices relating vehicles, fuel taxation rates etc. The purpose of the surveys is to collect utilisation data and to help test the overall validity

of the models, particularly through estimating revenues and comparing with total operating costs**. The approach taken has been to check the validity and make adjustments to the VOC model on the basis of surveys of buses and trucks operating on good main road. It has not been possible to check the validity of the model in more extreme conditions of road roughness and gradient and curvature.**

For road planning purposes "economic" prices need to be used so vehicle operating costs need to be collected without taxation. Conventional financial prices are also required in order to test general financial viability. The spreadsheet model deals with both financial and economic VOCs separately.

2. TRUCK SURVEY RESULTS

A survey was carried out at Thankot on 12th of July in which 42 drivers going to Kathmandu were interviewed about their current trip, revenues, operating costs and utilisation. Key data collected and directly estimated is presented in Table 1.

Table 1: Truck Survey (12th July)

	Mean	Median
Vehicle Age	6 yrs	5 yrs
Trip Distance	370 km	300 km
Revenue per trip	8266 Rs	8000 Rs
Estimate of rounds trips/month	10	10
Annual distance travelled	83654 km	72000 km
Fuel consumption per km	0.30 lt/km	0.266 lt/km
Maintenance costs per month	11754 Rs	10000 Rs
Crew costs per month	7213 Rs	7375 Rs

The data confirmed that fuel, maintenance and crew costs was closely predicted by the 1994 MRCU VOC spreadsheet model using the Indian VOC relationships. However insufficient data was collected on tyre consumption and furthermore predicted revenues per km were estimated to be very close to direct operating costs leaving little margin for depreciation, interest charges and overheads. As a result a further series of in-depth interviews were carried out with truck drivers to assess their operating costs and revenues. Good estimates of oil and tyre consumption was collected together with more information on truck revenues.

The in-depth interviews revealed that tariffs during the "summer" months were usually (by about 22%) lower than during the "winter" months. In addition some drivers take advantage of the higher tariffs by operating more frequently. Furthermore there seems less scope now than previously to collect return trip loads. Overall return trips accounted for only 2% of total revenue on the Kathmandu run compared with previous estimates of about 5.5% that was found from studies in the early 1990s.

Data from the main truck survey and the in-depths interviews was converted to a per kilometre basis and compared with the 1994 VOC model predictions using current financial prices. Road data for the Kathmandu –Birgunj route was used in the analysis. The key road based parameters were: IRI: 5.21 m/km, curvature 189 degs per km and rise and fall 19m/km. The data is presented in Table 2.

The table shows that currently trucks are operating with revenues very close to operating costs. In fact many operators do not appear to be covering their long run standing costs. In both surveys drivers confirmed that they were well aware of very low margins between revenues and direct costs.

Table 2: Truck Operating Costs and Revenues on a per km basis

	Main Truck Survey N Rs/km	In-Depth Interviews N Rs / km	1994 VOC model N Rs /km
Fuel	7.959	7.766	7.813
Oil	-	0.336	0.626
Tyres	-	1.968	1.514
Maintenance	1.686	1.649	1.770
Crew	1.305	1.035	1.098
Total variable costs		12.754	12.821
Depreciation	-	-	1.512
Interest	-	-	1.010
Overheads	-	-	0.504
			15.847
Total operating costs	-	-	
Estimated revenues	13.28[1]	15.5[2]	

Notes
1. Without adjustment for greater revenues and utilisation in the six winter months
2. With adjustment for greater revenues and utilisation in the six winter months

On the basis of the data collected it was noted that oil consumption is lower than predicted while tyre wear is higher than predicted. ". In discussions it was found that oil consumption is relatively easy to estimate. As a result it is recommended that the Indian oil consumption relationship be multiplied by a factor of "0.54". Although tyre consumption is relatively difficult to estimate, because of the complication of the joint use of both new and remoulded tyres, however the difference between observed and predicted was thought to sufficient to justify a new correction factor. It recommended that tyre wear is multiplied by a factor of "1.37". Currently vehicles are using particularly cheap tyres and their wearing quality may now be poorer than before.

In the previous model fuel consumption was increased by 30% over the Indian model estimate to meet observed fuel consumption in Nepal. This was achieved by multiplying by a given factor. It is now proposed to achieve the same result by adding

a constant factor. This will have the effect of reduce total fuel consumption for more extreme conditions.

New VOC input prices and utilisation rates should be applied to the truck VOC relationships.

3. BUS SURVEY RESULTS

A bus survey was carried out at the main bus station in Kathmandu. In total 22 drivers were interviewed about their operations. Key survey data are presented in the table 3. below:

Table 3: Bus Survey

	Mean	Median
Vehicle Age	3 yrs	2 yrs
Trip Distance	425 km	436 km
Revenue per trip	9802 Rs	8862 Rs
Estimate of rounds trips/month	5.2	4.5
Annual distance travelled	52,407 km	38,016 km
Fuel consumption per km	0.438 lt/km	0.336 lt/km
Maintenance costs per month	11,550 Rs	9,250 Rs
Crew costs per month	14,053 Rs	14,400 Rs
Revenue per km	23.3	21.1

An estimate of variable bus operating costs is presented in Table 2. together with an estimate of operating costs derived from the 1994 MRCU vehicle operating cost model. As with the truck data the VOC model uses data for the Birgunj –Kathmandu route.

As can be seen bus operating revenues are in the order of being 50% higher than trucks on a per km basis. The bus survey found that the annual distance travelled was lower because buses spent a lot of time queuing at the bus terminal, often for several days at a time, waiting for their turn. The cost analysis suggests that revenues are comfortably above costs. There are a number of indications that buses are currently much more profitable than trucks. Crew wages are much higher and the fleet age appears younger. The low trip rate and extensive queuing indicates that there is an oversupply of buses.

Table 4: Bus Operating Costs and Revenues on a per km basis

	Bus Survey N Rs /km	VOC model N Rs / km
Fuel	8.809 (median)	6.836
Oil	-	0.626
Tyres	-	1.417
Maintenance	2.018 (median)	1.477
Crew	2.892 (median)	3.174
Direct costs		13.530
Depreciation	-	2.351
Interest	-	1.571
Overheads	-	1.151
Total Operating Costs		18.603
Revenue	21.1 to 23.3	

An exact comparison with the VOC model was not as easy to achieve, compared with the trucks, because of the more varied nature of the bus operations surveyed. Bus trip lengths were longer as many buses travelled on routes to west and east Nepal where road roughness is higher than on the main truck route to Birgunj. The higher, than predicted, maintenance and fuel costs may be explained, in part, by this difference in road conditions. The components that do not vary directly with travel (ie. Crew, depreciation, interest, overheads) are higher for buses than for trucks because of the lower levels of utilisation.

In Nepal the Tata trucks and buses are based on a very similar vehicle type and it is to be expected that the model relationships used should be fairly similar because the vehicle and the component parts are very similar and have similar prices. However differences in operating costs can arise not only from the different road conditions but from the different driving behaviour and different vehicle loading. Buses tend to drive faster while trucks are much more heavily loaded.

Overall it was felt that there was insufficient basis to change the bus VOC relationships. However it is recommended that the changes relating to oil consumption and tyres for trucks should also be applied to buses. New utilisation rates and VOC prices should also be applied.

4. OUTSTANDING ISSUES

It should be recognised that considerable uncertainty still exists on the nature of VOC relationships in Nepal. This is particularly the case for how VOCs behave on rougher roads and roads with more extreme gradient and curvature. If possible research should be carried out to check how fuel consumption, tyre wear and maintenance costs vary away from the main road network. The Indian VOC relationships show

much greater sensitivity of fuel consumption to road roughness than other models including HDM4.

It is also recommended that research is carried out to check passenger values of time. There are now relatively simple methods using stated preference techniques to do this.

5. A SURVEY OF INPUT PRICES

The following data was collected from a variety of sources including vehicle dealers, mechanics ,tyre distributors the national insurance company.

Vehicles

	With tax	**Without tax**
Tata Truck		
SE 1613 chassis	1197000	910266
Body	235000	210762
Total	1432000	1121028
Tata Truck		
LPT 1613 chassis	1260000	958175
Body	235000	210762
Total	1495000	1168937
Small Truck LP 709E	992000	754372
Tata Bus LP1512	1157000	847619
Body	375000	336322
Total	1532000	1183941
Small bus LP407	836,000	551815
Body	200,000	179372
Total	1,036,000	731187
Utility Tata Sumo	1836000	1396198
Toyota Lancruiser Prado	2738344	1964554
Nissan Pickup	1730000	1252000
Maruti Gypsy utility	1336500	1016350
Maruti car	831600	632395
Nissan sunny	1344250	950000
Toyota Echo	1051065	756000

Tyres

Truck / Bus Tyre	India	15000	10950
	Nepal	11000	9821
Truck remould		3000	2679

Mini Truck	Nepal	6000	5357
Mini Bus	Nepal	3700	3304
Small Car	Chinese	1000	727
Small Car	Malay/Indonesia	3000	2182
Remould		450	402
Pickup	Chinese	1450	1054
	Malay/Indonesia	4500	3273

Fuel

Petrol ltr	46	30.76
Diesel ltr	26.5	21.26

Lubricants	Truck/bus	ltr	150	98.7
	Car	ltr	250	164.5

Insurance

Annual premium:

Truck value 1000,000	15925
Truck value 2,000,000	28425
Bus 40 seats value 1,000,000	18660
Pick-up value 1,000,000	14390
Maruti Car value 800,000	16205

Annual Vehicle Tax	Petrol	Diesel
Truck /Bus	11,500	12,700
Minitruck/ bus	7,400	8,700
Car under 1300 cc	6,500	10,000
1300-2000 cc	8,500	13,750
2100-2900 cc	10,000	17,500
3000-4000 cc	12,300	23,000

Maintenance Labour

Different garage charge rates: 107 Rs/hr , 375 Rs/hr , 108 Rs/hr , 230 Rs/hr

Earnings:

Senior Mechanic	3500 Rs/ month	truck wayside garage
Helper / mechanic	2000 Rs/month	truck wayside garage
	---	
average	2750 Rs/ month i.e. per hour = 19.6 Rs/hr	

6. RECOMMENDED VEHICLE OPERATING COST INPUT VALUES

It is now standard practise to subtract tyre costs from the new vehicle prices to be applied in VOC models on the basis that tyre costs are modelled separately. However in view of the fact that manufacturers buy tyres at a much lower cost than general public, that tyre distribution costs are much lower and that tyre consumption formulae do not take into account the associated interest costs it is recommended that only half of the tyre costs are subtracted.

	With Tax	Without
Tax		
Truck LPT 1613	1,495,000	1,168,937
Less tyre correction (3 tyres)	- 33,000	- 29,463
	1,462,000	1,139,474
Mini Truck LP709	992,000	754,372
Less tyre correction (3 tyres)	- 18,000	- 16,071
-	974,000	
738,301		
Bus LP1512	1,532,000	1,183,941
Less tyre correction (3 tyres)	- 33,000	- 29,463
	1,499,000	1,154,478
Minibus LP407	1,036,000	731,187
Less tyre correction (3 tyres)	- 11,100	- 9,900
	1,024,900	721,287
Utility: composite of three vehicles:		
Nissan Pickup	1,730,000	1,252,000
Maruti Gypsy	1,336,500	1,016,350
Toyota Landcruiser Prado	2,700,000	1,934,554
Average	1,924,948	1,400,851
Less tyre correction (2 tyres)	-5950	- 4328
	1,928,998	1,406,523
Car : Composite of three vehicles:		
Maruti	831,600	632,395
Nissan sunny	1,344,250	950,000
Toyota echo	1,051,065	756,000

Average	1,075,638	779,465
Less tyre correction (2 tyres)	-4000	-2909
	1,071,638	776,556
Tyres: Large Bus /Truck (Nepalese)	11,000	8,030
Mini Truck	6,000	5,354
Mini Bus	3,700	3,304
Utility Composite of		
Chinese	1,450	1,054
Malay/Indonesian	4,500	3,273
average	2,975	2,164
Car:	1000	727
Fuel &Lubricant Costs:		
Petrol	46	30.76
Diesel	26.5	21.26
Lubricating Oil	175	115.15
Crew Costs month		
Truck	7,375	7,375
Mini truck	6,225	6,225
(less half of one assistant at 2300)		
Bus	14,053	14,053
Mini bus	11,053	11,053
(less one conductor at 3000)		
Utility	4,500	4,500
(one driver plus allowances est)		
Car	2,250	2,250
(half of driver plus allowances est.)		
Maintenance Labour:	20 Rs/ Hr	20 Rs/Hr

Overhead and Insurance Costs:

Say: 2% of new taxed value + insurance + annual tax for buses
1% of new taxed value + insurance + annual tax for other vehicles

		With Tax	Without tax
Large Truck	1%	14,530	14,530
	Insurance	15,925	15,925
	Tax	12,700	
		43,155	30,455
Mini Truck	1%	9,500	9,500
	Insurance(est)	10,000	10,000
	Tax	8,700	
		28,200	19,500
Large Bus	2%	29,800	29,800
	Insurance	18,660	18,660
	Tax	12,700	
		61,160	48,460
Mini Bus	2%	19,880	19,880
	Insurance(est)	12,000	12,000
	Tax	8,700	
		40,580	31,880
Utility	1%	19,290	19,290
	Insurance	14,390	14,390
	Tax	11,125	
		44,805	33,680
Car	1%	10,716	10,716
	Insurance	16,205	16,205
	Tax	6,500	
		33,421	26,921

Value of time

Av income per month - say 37$ or 2590 Rs
At 160 hrs per month = 16.2 Rs /hr
Value of time at one third wage rate = 5.3 Rs/hr

Utilisation Rates

Passengers (in addition to driver and conductors etc):

Truck	1.5
Mini Truck	0.5
Bus	35
Mini Bus	25
Utility	2.5
Car	2.5

Utilisation	Distance per year	Hours worked per year
Large truck	83,650	2800
Mini truck (0.8 of large truck)	66,920	2240
Large Bus	52,400	1650
Mini Bus (0.8 of large bus)	41,920	1320
Utility	30,000	750
Car	20,000	500

Weight and Power to weight

	Power to Weight	weight
Truck	8.6	13
Mini Truck	12.7	7
Bus	12.5	9
Mini Bus	17.8	5
Utility	-	2
Car	-	-

7. RECOMMENDED VEHICLE OPERATING COST EQUATIONS

In view of the fact that Nepal uses Indian trucks and buses and the close similarities between the two countries it is recommended that Indian VOC model relationships should be the basis of a VOC model for Nepal. In the following Section a set of recommended VOC relationships are identified for Nepal. The key relationships have been developed from the following reports:

A Chesher & R Harrison: HDM Vehicle Operating Costs Evidence From Developing Countries The World Bank 1987, Washington DC.

T Watanatada et al. The Highway Design and Maintenance Standards Model Volume 1. Description of the HDM III Model, The World Bank 1987, Washington DC.

Central Road Research Institute: Road User Cost Study In India, Final Report. CRRI, 1982, New Delhi

The treatment of capital costs, crew and overheads is based on the approach used in the TRL road planning model RTIM3. Cars are assumed to drive a constant distance per year irrespective of speed. Other vehicles are assumed to increase the utilisation with speed by assuming constant working hours per year (including loading, unloading, refuelling etc). Expected working life is also assumed to be constant. To correctly calculate costs per kilometre with changes in vehicle speeds it is necessary to estimate and include in these calculations non-travelling working time per trip.

In the fuel consumption equations an adjustment factor of 1.5 (rather than the figure of 1.15 mentioned earlier) has been included.

Suggested modifications compared with 1994

The following modifications are suggested for incorporation into the Nepal VOC model

a) Vehicle capital costs have been modified by the subtraction of half the value of tyres (on the road)
b) The cars and utility tyre consumption has been modified so that now the relationship reaches a plateau with increasing roughness. In the previous model tyre consumption reached a maximum and declined even to give negative values for very high roughness values.
c) The interest charge formula has been improved to produce a more accurate result. Although interest is a monetary phenomena the equivalent of interest charges are required when discounting in a economic context.
d) For trucks and buses oil consumption has been reduced by the multiplication of a factor of “0.54”
e) Tyre consumption has been increased by multiplying by a factor of “1.34”.
f) Fuel consumption has been modified by multiplying the basic equation by 1.15 (the original recommended factor) and including an additional constant factor.

Definitions of variables:

ACREW = annual crew costs per year
AKM = annual distance travelled (km)
AWH = annual working time (driving hours + non driving hours (including loading, unloading, refuelling etc) (hours)
C = average degrees of curvature (o/km)
CKM = average cumulative distance travelled (per 1000 km)
CREWC = crew costs per 1000 vehicle km
DEP = depreciation (per 1000 vehicle km)
F = average fall (m/km)
FL = fuel consumption (lt/1000km)
FLd = fuel consumption down gradient (lt/1000km)
FLu = fuel consumption up gradient (lt/1000km)
GVW = Gross vehicle weight (ton)
I = rate of interest
IC = interest cost per 1000 vehicle km
LH = maintenance labour (hours per 1000 vehicle km)
LIFE = expected vehicle service life (yrs)
OC = lubricants consumption (lt/1000 km
PASSC = passenger time value per 1000 vehicle km
PAX = passengers per vehicle
PC = maintenance parts consumption costs
PTV = passenger time value per hour
PWR = Power to weight ratio (hp/ton)
R = average rise (m/km)
RF = average rise plus fall (m/km)
RG = road roughness, measured with the bump integrator(BI) (mm/km)
RL = round trip distance (km)
S = average speed (km/h)
Sd = speed down gradient (km/h)
Su = average speed up gradient (km/h)
TC = tyre consumption (number per 1000 vehicle km)
TN= Non travelling time per round trip
VP = new vehicle price less tyre adjustment
W = average pavement width (m)

The VOC Equations

CUMULATIVE DISTANCE TRAVELLED
CKM = AKM * LIFE * 0.5 * 0.001

SPEED

$$\text{Round trip journey speed } S = \frac{2}{\frac{1}{Su} + \frac{1}{Sd}}$$

Where Su and Sd are as follows:

Passenger Cars and Utilities
Su = max[20; 60.6 + 1.046 W - 0.192 RF - 0.0078 C - 0.0036 RG]
Sd = max[20; 60.6 + 1.046 W - 0.184 RF - 0.0078 C - 0.0036 RG]

Trucks
Su = max[15; 47.3 + 1.056 W - 0.269 RF - 0.0099 C - 0.0019 RG]
Su = max[15; 47.3 + 1.056 W - 0.265 RF - 0.0099 C - 0.0019 RG]

Buses
Su = max[15; 55 + 0.609 W - 0.301 RF - 0.0077 C - 0.0022 RG]
Sd = max[15; 55 + 0.609 W - 0.228 RF - 0.0077 C - 0.0022 RG]

Single direction truck
S = max[15; 47.3 + 1.056 W - 0.269 R - 0.265 F - 0.0099 C - 0.0019 RG]

FUEL

Passenger Cars
FLu = 1.15[49.8 + (319/Su) + 0.0035(Su)^2 + 0.0019 RG + 0.942 RF] + 26
FLd = 1.15[49.8 + (319/Sd) + 0.0035(Sd)^2 + 0.0019 RG - 0.677 RF] +26

Utilities
FLu = 1.15[-30.8 + (2260/Su) + 0.0242(Su)^2 + 0.0012 RG + 1.278 RF] + 29
FLd = 1.15[-30.8 + (2260/Sd) + 0.0242(Sd)^2 + 0.0012 RG - 0.565 RF] +29

Large Trucks and Buses
FLu = 1.15[85.1 + (3900/Su) + 0.0207(Su)^2 + 0.0012 RG
+ 3.328 RF - 4.59 min(PWR;30)] +65

FLu = 1.15[85.1 + (3900/Sd) + 0.0207(Sd)^2 + 0.0012 RG
- 1.777 RF - 4.59 min(PWR;30)] +65

Single Direction Large Trucks
FL = 1.5[85.1 + (3900/S) + 0.0207(S)^2 + 0.0012 RG + 3.328 R
- 1.777 F - 4.59 min(PWR;30)] + 65

Mini Trucks and Buses

FLu = 1.15[85.1 + (3900/Su) + 0.0207(Su)^2 + 0.0012 RG
+ 3.328 RF - 4.59 min(PWR;30)] +56

FLu = 1.15[85.1 + (3900/Sd) + 0.0207(Sd)^2 + 0.0012 RG
- 1.777 RF - 4.59 min(PWR;30)] +56

OIL AND LUBRICANTS

Passenger cars and Utilities

OC = 1.55 + 0.000211 RG

Buses and Trucks

OC = 0.54*(3.07 + 0.000211 RG)

MAINTENANCE PARTS

Parts consumption costs are expressed in terms of the new vehicle price per million vehicle kms.

Passenger cars and Utilities

PC/VP = (42 exp(0.000169 RG))/64.8

Trucks

PC/VP =(exp(0.488 + 0.000143 RG + 3.483/W +0.0531 GVW)* (CKM)^0.34)/100

Buses

PC/VP =(exp(1.252 + 0.0000526 RG + 0.000282 C + 0.00675 RF + 2/W)
*(CKM)^0.358)/100

MAINTENANCE LABOUR

Passenger cars

LH = 1.799 (64.8 PC/VP)^0.584

Utilities

LH = 4.42 (64.8 PC/VP)^0.445

Trucks

LH = 1.296 exp(0.000025 RG)*(100 PC/VP)^0.654

Buses

LH = 2.625 exp(0.0000426 RG)*(100 PC/VP)^0.473

TYRES

Passenger cars and Utilities

TC = 1.37* 0.727 [4000/(Max(6000;(60020 - 5.86 RG + 0.005)]

Trucks

TC = 1.37* 0.727[6000/Max((2000;(23500 – 0.609 RG – 117.5 RF – 8.49 C + 2410 W)+0.009]

Buses

TC = 1.37* 0.727[6000/Max((2000;(36100- 0.00434 CKM – 1.126 RG - 241 RF – 10.54 C + 1044 W)+0.0132]

DEPRECIATION

Passenger cars

DEP = (1000 VP)/(AKM*LIFE)

Utilities , Trucks, Buses

DEP = (1000 VP/(AWH*LIFE)) *((1/S)+(TN/RL))

INTEREST

Passenger cars

$$IC = \frac{1000VP*\left[1-\left(\frac{1}{LIFE}\sum_{1-LIFE}\frac{1}{I}\right)\right]}{AWH*AKM*\sum_{1-LIFE}\frac{1}{I}}$$

For Utilities, Trucks, and buses

$$IC = \frac{1000VP*\left[1-\left(\frac{1}{LIFE}\sum_{1-LIFE}\frac{1}{I}\right)\right]}{AWH*\sum_{1-LIFE}\frac{1}{I}}\left[\left(\frac{1}{S}\right)+\left(\frac{TN}{RL}\right)\right]$$

CREW

Passenger cars

CREWC = 1000 ACREW /AKM

Utilities, Trucks, Buses

CREWC = (1000 ACREW/AWH)*((1/S) + (TN/RL))

PASSENGER TIME

Passenger cars, Utilities, Trucks, Buses

PASSC = (1000 PAX * PTV)/S