Estimating of Operating Costs for Intercity Vehicles in Mexico

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ABSTRACT

The objective of this research is to provide information on a simple procedure used to calculate vehicle operating costs for a typical vehicle used for commercial and private intercity transportation in Mexico. The procedure here described, takes into account the geometric alignment and pavement surface conditions and their effects on the vehicle operating costs. The work was developed at Instituto Mexicano del Transporte (IMT) in the year 2008.

The work here reported is based on the mathematical models developed by the World Bank and published in 1987, which gave origin to the software called Vehicle Operating Costs (VOC). Therefore, the software developed for this work (called VOCMEX) is an adaptation of the VOC. VOCMEX considers the technical characteristics of the vehicles running on Mexican roads as well as the models with the new mathematical expressions developed for the HDM-4 software.

From the use of the World Bank models through VOCMEX and the data update about technical characteristics of the vehicles, their prices and their components, a set of graphics is built. These graphics allow one to estimate the operating costs of seven types of vehicles

Keywords: Vehicle Operating Costs, VOC, VOCMEX, HDM, Design and Maintenance of Highways, World Bank, Mexico.

We want to include the job in the area: Computing Technologies.

The investigation is completed.

1. INTRODUCTION

The main idea of this paper is to present the study *Costos de Operación Base de los Vehículos Representativos del Transporte Interurbano 2008*[1] prepared at Instituto Mexicano del Transporte (IMT), whose purpose is to provide information about Transportation Sector of Mexico and a simple procedure for estimating vehicle operating costs representatives of the national intercity transit, taking account the geometric alignment and pavement surface conditions and their effects on the vehicle operating costs, for purposes of route planning and evaluation of projects on road conservation and construction.

This work arose basically as a response to the need for updating the Technical Publications 30, 202 and 282 (references 1, 3 and 4) of IMT, concerning the same theme, derived from the continuing requests for information from different areas of Secretaría de Comunicaciones y Transportes (SCT) as well as engineering consulting firms and state governments.

2. ROAD SURFACE CONDITIONS AND VEHICLE OPERATING COSTS

Data on the characteristics for seven types of vehicles (two articulated trucks with semi-trailer, an articulated truck with semi-trailer and trailer, a three-axle heavy truck, a two-axle medium truck, a foreign bus and a light vehicle) are presented. From those data, we obtained the respective Vehicle Operating Costs. All graphics -two for each vehicle- which related the effect of paved roads deterioration with operating costs and speeds for each type of vehicle are updated.

The graphs for the first type (Figure 1) related to the seven vehicle configurations, and three different types of terrain, flat, semi-mountainous and mountainous, the roughness of the running surface and the index of service with the vehicle operation costs. This is considered as 1, corresponding to the "basic vehicle operating costs", in a straight and flat length with new pavement, so that the costs associated with other conditions of roughness and horizontal and vertical alignment is expressed

[1] J. A. Arroyo, R. Aguerrebere and G. Torres, **Costos de operación base de los vehículos representativos del transporte interurbano 2008**, Publicación Técnica No. 316, Instituto Mexicano del Transporte, Sanfandila, Qro., 2008.

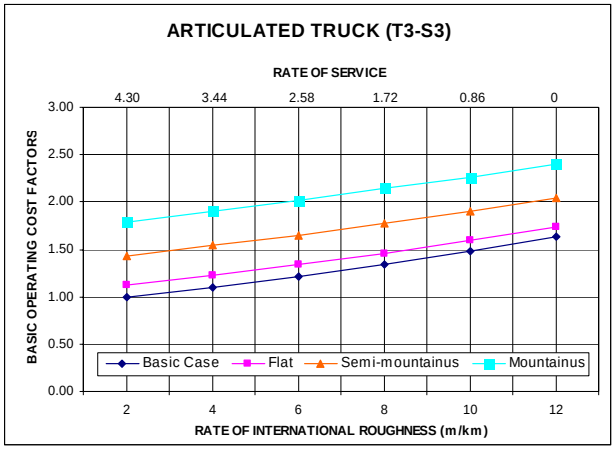
as a factor always greater than 1 (Basic Operating Cost Factors). In this way it is possible to eliminate the reference to a variable price.

Basic Operating Cost Factors of the vehicles can be valued in monetary units, knowing unit prices of different inputs, such as: the price of the vehicle, fuel, lubricants, tires and others.

The second set of graphs (Figure 2) shows, for three types of terrain previously mentioned above, the relationship between the roughness and the index of service with an operating speed.

For simple reasons, this article only shows the figures to Articulated Truck with semi-trailer (T3-S3).

Figure 1
Relationship between the road deterioration effect with vehicle operating costs



Source: Personal Elaboration.

Considering technological changes in vehicles, the data concerning the Maximum Power Speeds and Maximum Power Brake, which are required in the calculation of vehicle operating costs through the VOCMEX model that is based on the original version of the World Bank[2], were obtained through new mathematic expressions from recent research to applied for model HDM-4[3] due to the fact that achieved results were more consistent with observed results in practice.

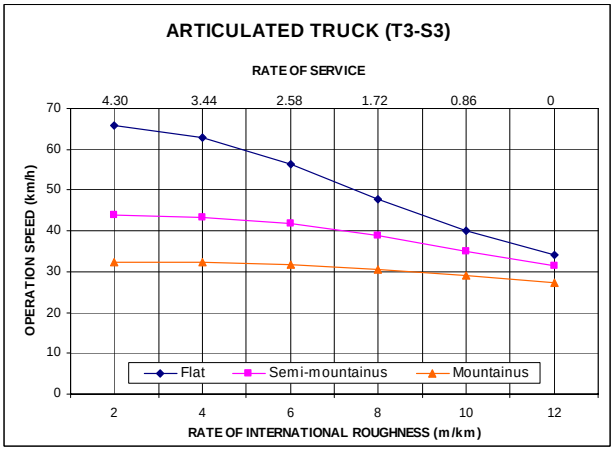
Finally, this work is supplemented by three appendices:

Appendix A provides technical information for each one of vehicles considered in the study. Appendix B displays real information on speeds, consumption and yields of fuel for some vehicle combinations, used to validate intermediate results achieved by the model and, finally, Appendix C provides information related with freight cost for some journeys of companies engaged in cargo transportation, which was used to validate the achieved final results.

[2] T. Watanatada, A. M. Dhareshwar and P. R. Rezende, **Vehicle Speeds and Operating Costs, Models for Road Planning and Management**, The World Bank, 1987.

[3] C. R. Bennett and W. D. O. Paterson, **Documentation of HDM-4, Version 1.0, International Study of Highway Development and Management Tools (ISOHDM)**, United Kingdom, 2000.

Figure 2
Relationship between the road deterioration effect with vehicle operating speeds



Source: Personal Elaboration.

The illustrative example of this work was also updated in order to show the magnitude of the vehicle operation costs, conditioned by the alignments and the roughness, compared with maintenance costs during the useful life of a road. The illustrative example is show below.

3. VEHICLE OPERATING COSTS VS ROAD MAINTENANCE COSTS

Consider the roads Acayucan-Salina Cruz and Mazatlán-Tepic with traffic volumes and vehicle composition graduated in 2008, the stations are listed in Table 1.

Table 1
Traffic Volumes and Vehicle Composition

ROAD	AADT	A	B	C	STATION
Acayucan-Salina Cruz	4,363	66%	5%	29%	Palomares
Mazatlán-Tepic	7,856	71%	9%	20%	Acaponeta

AADT: Annual Average Daily Traffic; A: Light vehicles; B: Foreign buses; C: Trucks.
Source: Personal Elaboration.

In both cases the road topography is substantially flat. Suppose now that, at three different times, the road surface condition of the sections corresponds to the Index of Service (IS) and Index of International Roughness (IIR) that are listed in Table 2.

The Classification “A” of the vehicle composition corresponds to the Light vehicles in the graphics, Foreign buses to the “B” and the “C” is considered 25% of Articulated trucks and 75% of three and two-axle trucks, represented in the graphics for the Articulated Truck with semi-trailer (T3-S3) and Two-axle medium truck (C2), respectively.

Table 2
Index of Service (IS) and Index of International Roughness (IIR)

Road surface condition	IS	IIR
Very good	4.30	2.0
Regular	3.44	4.0
Bad	2.58	6.0

Source: Personal Elaboration.

Table 3 presents the Basic Operating Cost Factors, obtained from the graphs of the first type of each vehicle (Figure 1).

Table 3
Basic Operating Cost Factors
Terrain substantially flat

Vehicle type	Road surface condition		
	Very good	Regular	Bad
Light vehicle	1.04	1.10	1.18
Foreign bus	1.09	1.15	1.21
Two-axle medium truck	1.10	1.27	1.43
Articulated truck with semi-trailer	1.12	1.23	1.34

Source: Personal Elaboration.

It is very important (Table 3) to note that the percentage increase experienced by vehicles in the operating cost to transit on roads deteriorated progressively, is significantly higher in heavy trucks compared with light vehicles. For example, in the case of the articulated truck increased passing of a very good road surface condition to one regular is 11%, raising its basic operating cost by 22% when driving on a bad road. In the case of a light vehicle, the overhead is 6% if you drive in a regular way and from 14% to use a road in poor condition.

Operating costs per type of vehicle (Table 4) are obtained by multiplying the cost factors listed in Table 3 for the basic operating costs. Consequently, there was a strong influence on the magnitude of the basic operating cost, given that cost overruns are higher in the case of the articulated truck compared with the two-axle medium truck, even when the increase expressed as a percentage is higher in the last vehicle.

It is remarkable the foreign bus case, although it is the one who in percentage recorded the lowest increases in monetary value is second in importance.

Table 4
Vehicle Operating Costs
(US dollars/veh-km)[4]

Vehicle type	Road surface condition		
	Very good	Regular	Bad
Light vehicle	0.30	0.31	0.34
Foreign bus	0.94	0.98	1.04
Two-axle medium truck	0.50	0.58	0.65
Articulated truck with semi-trailer	1.17	1.29	1.40

Source: Personal Elaboration.

Table 5 shows the cost per kilometer than the all vehicles owners assume to pass through the section Acayucan-Salina Cruz during a year, on the basis of AADT (4,363 vehicles) and their vehicle composition shown at the beginning of this example.

Table 5
Acayucan-Salina Cruz
Operating Costs for Annual Transit
(Thousands of dollars/km)

Vehicle type	Road surface condition		
	Very good	Regular	Bad
Light vehicle	313.04	331.40	355.56
Foreign bus	74.40	78.26	82.13
Two-axle medium truck	174.88	200.00	224.15
Articulated truck with semi-trailer	135.27	148.79	162.32
Annual Transit	**697.59**	**758.45**	**824.16**

Source: Personal Elaboration.

When the road is in very good surface condition, the annual costs per kilometer to the users are 697,590 US dollars; sixty thousand eight hundred and sixty US dollars if the surface condition is regular, and sixty-five thousand seven hundred and ten US dollars extra if it is bad. It is noteworthy that the excess of costs per kilometer are considerable compared to making an effective conservation action with useful life of several years for the same length.

In the case of Mazatlán-Tepic, considering the AADT (7,856 vehicles) and vehicle composition shown previously, operating costs per kilometer of all vehicles that running in this road in a year are shown in Table 6. When the road is in very good surface condition, operating costs are 1.39 million dollars. If the surface keeps a steady condition, costs increase 107,260 US dollars more per kilometer. When the road surface condition is poor, such costs increase by 228.030 US dollars per kilometer over the road is in very good condition. In this case, also cost overruns cover, no doubt, the cost of effective conservation designed for an extended period.

Table 6
Mazatlán-Tepic
Operating Costs for Annual Transit
(Thousands of dollars/km)

Vehicle type	Road surface condition		
	Very good	Regular	Bad
Light vehicle	685.02	724.64	777.78
Foreign bus	273.43	286.96	301.45
Two-axle medium truck	244.44	280.19	314.98
Articulated truck with semi-trailer	190.34	208.70	227.05
Annual Transit	**1,393.23**	**1,500.49**	**1,621.26**

Source: Personal Elaboration.

Table 7 shows that operating cost overruns nearly double in the road of Mazatlán-Tepic relative to that of Acayucan-Salina Cruz are due to 80% more annual traffic and greater absolute presence of heavy vehicles.

To get an idea of the cost overruns that has a road in poor condition respecting to another that is in good conditions, it can be said that a section of 100 km of the road Acayucan-Salina Cruz, costs 12'657, 000 additional US dollars each year on the normal operation cost. On the road Mazatlán-Tepic, a section of the same length in poor condition, would give the country an extra operation cost approximately of 22'803, 000 US dollars per annum.

[4] 1 US dollar=10.35 Mexican pesos (April, 2008).

Table 7
Annual Operating Cost Overruns/Km
(Thousands of dollars and Percentage)

ROAD	Very Good-Regular		Regular-Bad	
	Thousands of dollars	%	Thousands of dollars	%
Acayucan-Salina Cruz	60.86	8.72	65.71	8.66
Mazatlán-Tepic	107.26	7.70	120.77	8.05

Source: Personal Elaboration.

4. LESSON LEARNED

The results of this work have been very good and useful, because they were obtained with real information that validates them. Although, it will be always important to develop more complete studies and learn more about the practical use of vehicles by transportation companies.

5. CONCLUSIONS AND COMMENTS

In general terms is better apply maintenance actions that ensure long periods of the road in good conditions due to the cost will be recovered quickly for the country by reducing vehicle operating costs and travel times.

In terms of initial design and construction, results convenient spend more on construction of roads to spend less on the initial investment and with these decisions to avoid falling into money savings poorly understood, because in the first case it guaranteed to have stables structure and resilient pavements and therefore , more durable roads, with less disruption to traffic for maintenance and, consequently, safer and cheaper cumulatively for the users and the country in general. While in the second case, although the initial investment is reduce, such economy is causing a significant increase in the maintenance costs of the infrastructure and, therefore, an increase in the operating costs for users of the same infrastructure during all useful life of the road.

There will be cases, no doubt, in which the conclusion is not favorable to realize a higher initial investment in construction or maintenance. Recovery or justification for it, by reducing operating costs can vary significantly and do not even occur in the all useful life period of the road. It will depend of its traffic volumes (AADT), its composition, its annual growth rate, how fast the roads are deteriorate and the magnitude of the investment amounts involved in repair or reinforcement it.

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