TECHNICAL MEMORANDUM

Cost Per Hour and Value of Time Calculations for Passenger Vehicles and Commercial Trucks for Use in the Urban Mobility Study

by
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Introduction

Value of time as commonly used in the context of calculating congestion cost is an estimate of the average differential cost of the extra travel time as a result of the congestion. For personal travel, value of time is the sum of the driver's perceived value of time plus the value of the extra fuel that is consumed in congested conditions. For commercial trucks, value of time is expressed as the wage rate of the driver plus the various operating cost components associated with the truck or tractor-trailer. The sum of these costs, multiplied by the hours of delay, result in the total congestion cost. In the case of personal travel, the value of time eventually accrues to the vehicle (value of time *x* average vehicle occupancy). For commercial vehicles, the value of time represents the operating cost to the truck owner. This memorandum summarizes the components of each cost estimate and the values used in the Texas Congestion Index and Urban Mobility Study (UMS) calculations.

Current Methodology for Passenger Vehicles

A speed choice model developed by Chui and McFarland (1986) of the Texas Transportation Institute (TTI) is used by the Texas Department of Transportation. The model derives its utility from the notion that speed is regarded as one of the most important factors in any traveler's choice. Travel time is directly related to the choice of speed that one chooses to travel. The first attempts to discern any relationship between speed and the value of travel time were by Mohring (1965, 1976). The speed choice model assumes that a rational driver chooses to drive at a speed which minimizes his or her total trip cost, i.e., a speed at which his or her marginal cost is equal to or less than the marginal benefit.

The travel characteristics in Texas during the development of the speed choice model included a relatively small number of toll roads and small percentage of people using mass transit systems in Texas. The model was developed to analyze the nature of traffic in Texas at that time. More or less the same conditions exist today with the exception of a significant increase in truck traffic in some border areas and the I-35 corridor as a result of the North American Free Trade Agreement. The model provides travel time value estimates that are in line with other models used by the other states. Daniels, Ellis, and Stockton (1999) provided the details of the values used by other states through a telephone survey. The results reported in their study are presented in Table 1.

Table 1. Value of Time Used by States

State	Automobiles (1997 $)
North Carolina	$8.70
New York	$9.00
Florida	$11.12
Georgia	$11.65
Texas	$11.97
Virginia	$11.97
California	$12.10
Pennsylvania	$12.20
Washington	$12.51
Ohio	$12.60
Mean	$11.26

Table 2 takes the $11.97 value of time shown for Texas in Table 1 and adjusts it for inflation by the Consumer Price Index back to 1982 as well as forward to 2006. Values of time for past and future years derived from the 1997 base year are as follows:

Table 2: Value of Passenger Car Time

Year	Value of Time
1982	$7.20
1983	$7.45
1984	$7.75
1985	$8.00
1986	$8.20
1987	$8.50
1988	$8.80
1989	$9.25
1990	$10.00
1991	$10.25
1992	$10.50
1993	$10.75
1994	$11.05
1995	$11.40
1996	$11.70
1997	$12.00
1998	$12.15
1999	$12.40
2000	$12.85
2001	$13.25
2002	$13.45
2003	$13.75
2004	$14.10
2005	$14.60
2006	$15.04

In summary, the Texas application of the Speed Choice Model produces a value of time estimated to be $15.04 for 2006 (derived from the $11.97 valued used in 1997 and adjusted for inflation) and appears to be in line with estimates produced by other states using different approaches.

Adjustments of Current Methodology for Passenger Vehicles

Given that the value used in the Urban Mobility Study (1) appears to be consistent with values used by other states, (2) the values used by other states were derived by independent methods, and (3) there is, at this point, no more recent research that contradicts these data, there does not appear to be any compelling reason to adjust the methodology used for calculating value of time for passenger vehicles.

Current Methodology for Commercial Vehicles

Commercial truck costs are calculated on a cost per mile basis in the Urban Mobility Study. The original base-year cost per mile value of $1.65 per mile used by TTI was obtained from the American Trucking Association in 1986. In subsequent years, the value was adjusted by an approximation of the general rate of inflation. The per mile value includes costs for depreciation, interest, general maintenance, tires, repairs, and other similar costs, but does not include the cost of fuel. The amount of fuel used per mile was then multiplied by the cost of fuel to determine the fuel cost per mile. Values used in the Urban Mobility Study are shown in Table 3 below.

Table 3: Components of Cost per Mile Value as Developed for the UMS

Year	Cost Per Mile
1982	$1.50
1983	$1.55
1984	$1.55
1985	$1.60
1986	$1.65
1987	$1.65
1988	$1.75
1989	$1.85
1990	$1.95
1991	$2.05
1992	$2.15
1993	$2.25
1994	$2.35
1995	$2.45
1996	$2.55
1997	$2.65
1998	$2.75
1999	$2.85
2000	$2.95
2001	$3.05
2002	$3.15
2003	$3.20
2004	$3.25
2005	$3.30
2006	$3.35

Adjustments to Calculating Value of Time for Commercial Trucks

Two primary sources of data were identified for determining true road user costs for trucks for use as a check against values used in the Urban Mobility Study.

The first source is a report published by Transport Canada entitled *Operating Costs for Trucks 2000*. In that particular report, the data is segregated by Canadian provincial and U.S. regions. The U.S. South section of the report includes Texas data and, consequently, is the region used as a source of data in the Texas Congestion Index calculations produced in this memorandum. These data include trucks with a gross vehicle weight (GVW) more than 14,000 lbs. For the year 2000, the data in Table 4 indicates the cost for several different truck categories for the U.S. South region.

Table 4. Truck Category Costs for the Southern U.S.

Unit Type	Cargo	Annual Miles	Hourly Cost (incl. fuel) US$
5 axle semi-unit (van)	dry	50,000	$66.28
5 axle semi-unit (van)	dry	100,000	$55.89
5 axle semi-unit (van)	dry	150,000	$52.43
5 axle semi-unit (flat deck)	dry	50,000	$66.88
5 axle semi-unit (flat deck)	dry	100,000	$57.17
5 axle semi-unit (flat deck)	dry	150,000	$53.99
5 axle bulk liquid tanker	bulk	50,000	$65.93
5 axle bulk liquid tanker	bulk	100,000	$53.70
5 axle bulk liquid tanker	bulk	150,000	$49.62
5 axle bulk dry tanker	bulk	50,000	$68.67
5 axle bulk dry tanker	bulk	100,000	$55.11
5 axle bulk dry tanker	bulk	150,000	$50.58
2 axle straight truck (6-wheel)	dry	25,000	$71.09
2 axle straight truck (6-wheel)	dry	50,000	$65.25
2 axle straight truck (6-wheel)	dry	75,000	$63.30

The data in Table 4 above include costs from three main categories: tractor costs, trailer costs, and other costs. Tractor costs include driver wage, fuel, repairs, tires, depreciation, and licenses. Trailer costs include repairs, tires, depreciation, and licenses. Other costs include insurance, administration and interest.

To obtain a single weighted-average value of time to apply in calculations for the Urban Mobility Study, an estimate of the number of trucks that fall into each truck category was developed from data used as inputs from TTI's Air Quality Model. When those categories were reclassified to conform to the data categories from the Transport Canada study for which TTI has hourly costs, it was determined that 65 percent of the trucks fall into the 5-axle category and 35 percent of trucks fall into the 2-axle (6-wheel) category.

The truck cost data was then collapsed into the same two main categories by averaging the hourly rates from the table on the preceding page. The cost per hour figures for the lowest mileage category within each truck class were used. The average produced the following rates:

Cost per hour for trucks in the 5-axle category	$67
Cost per hour for trucks in the 2-axle (6-wheel) category	$71

Finally, these hourly rates were multiplied by the percentage distribution of trucks per category to produce a weighted average cost of per hour of $68 in 2000 US dollars.

The second source of data used to calculate a value of time for commercial vehicles is a report entitled *An Evaluation of Expenses per Ton-Mile, Expenses per Mile and Expenses per Ton for Major Commercial Carriers in Numerous Segments of For-Hire Trucking* produced by Transportation Technical Services, Inc. for the Federal Highway Administration Office of Freight Management and Operations. Data from this report indicates the following costs per mile for all commercial trucks for the following years.

Table 5. Commercial Truck Cost Per Mile Developed for the Federal Highway Administration, Office of Freight Management and Operations

Year	Commercial Truck Cost Per Mile
1982	$1.79
1983	$1.76
1984	$1.80
1985	$1.86
1986	$1.83
1987	$1.78
1988	$1.78
1989	$1.74
1990	$1.76
1991	$1.72
1992	$1.69
1993	$1.68
1994	$1.66
1995	$1.65
1996	$1.65
1997	$1.66
1998	$1.65
1999	$1.70
2000	$1.78

Note: Costs per mile for 2002-2004 are estimates based on trends seen in 2000.

Calculating Cost on a Value of Time Basis vs. a Cost Per Mile Basis

In previous editions of the Urban Mobility Study, commercial truck costs were calculated on a cost per mile basis. The original base-year cost per mile value (1982) used by TTI was obtained from the American Trucking Association. In subsequent years, the value was adjusted by $0.05 per year to approximate increases resulting from inflation. The cost per mile value includes depreciation, interest, general maintenance, tires, repairs, and other similar costs, but does not include fuel. The amount of fuel used per mile was then multiplied by the cost of fuel to determine the fuel cost per mile that was in turn added to the cost per mile value.

In this memorandum, several updates have been made. First, a "new" cost per mile figure was developed using the actually consumer price index for the years 1982 through 2003. Beginning in 2004 the Producer Price Index for general freight trucking is used it adjust operating costs. Second, diesel fuel prices have been updated using data from the Energy Information Administration. Third, revised fuel cost per mile values were calculated using the new cost per mile and fuel price values. (See Table 6 and accompanying notes.)

Table 6: Components of Cost Per Mile Value as Developed for the UMS

Year	"Old" Cost Cost Per Mile[1]	"New" Cost Per Mile[2]	"Old" Fuel Price Per Gallon[3]	"New" Fuel Price Per Gallon (diesel)[4]	"Old" Fuel Cost per Mile[5]	"New" Fuel Cost per Mile[6]	"Old" Total Cost Per Mile (w/ fuel)	"New" Total Cost Per Mile (w/ fuel)
1982	$1.50	$1.50	$1.33	$1.33	$0.072	$0.242	$1.57	$1.74
1983	$1.55	$1.54	$1.28	$1.28	$0.070	$0.229	$1.57	$1.76
1984	$1.55	$1.60	$1.27	$1.27	$0.069	$0.223	$1.62	$1.83
1985	$1.60	$1.65	$1.28	$1.28	$0.070	$0.221	$1.67	$1.87
1986	$1.65	$1.58	$0.95	$0.95	$0.052	$0.164	$1.70	$1.75
1987	$1.65	$1.63	$1.03	$1.03	$0.056	$0.175	$1.71	$1.80
1988	$1.75	$1.68	$1.02	$1.02	$0.056	$0.170	$1.81	$1.85
1989	$1.85	$1.76	$1.11	$1.11	$0.061	$0.182	$1.91	$1.95
1990	$1.95	$1.86	$1.10	$1.10	$0.060	$0.183	$2.01	$2.05
1991	$2.05	$1.91	$1.13	$1.13	$0.062	$0.188	$2.11	$2.10
1992	$2.15	$1.96	$1.17	$1.17	$0.064	$0.195	$2.21	$2.15
1993	$2.25	$2.02	$1.14	$1.14	$0.062	$0.187	$2.31	$2.20
1994	$2.35	$2.08	$1.06	$1.14	$0.058	$0.187	$2.41	$2.26
1995	$2.45	$2.15	$1.16	$1.11	$0.063	$0.182	$2.51	$2.33
1996	$2.55	$2.21	$1.27	$1.24	$0.070	$0.199	$2.62	$2.41
1997	$2.65	$2.23	$1.24	$1.20	$0.068	$0.187	$2.72	$2.42
1998	$2.75	$2.19	$1.13	$1.04	$0.062	$0.171	$2.81	$2.36
1999	$2.85	$2.23	$1.24	$1.12	$0.068	$0.187	$2.92	$2.42
2000	$2.95	$2.37	$1.51	$1.49	$0.083	$0.257	$3.03	$2.63
2001	$3.05	$2.39	$1.61	$1.40	$0.088	$0.237	$3.14	$2.62
2002	$3.15	$2.36	$1.45	$1.32	$0.080	$0.227	$3.23	$2.59
2003	$3.25	$2.44	$1.50	$1.51	$0.083	$0.225	$3.33	$2.66
2004	$3.35	$2.52	$1.80	$1.81	$0.099	$0.270	$3.45	$2.79
2005	$3.40	$2.69	$2.40	$2.40	$0.132	$0.359	$3.52	$3.05
2006	$3.45	$2.80	$2.71	$2.71	$0.149	$0.404	$3.59	$3.20

Notes:

[1] Cost per mile was increased by $0.05 per year to estimate increased costs associated with inflation.

[2] From 1982 to 2003 costs are increased by the Consumer Price Index. Beginning in 2004 annual costs are increased by the Producer Price Index for general freight trucking. (2004 is the first year PPI data is available for general freight trucking.)

[3, 4] Beginning in 1994 the nationwide average annual cost of diesel fuel published by the Energy Information Administration is used to calculate fuel cost.

[5] Average fuel economy was estimated to be approximately 18 miles per gallon.

[6] Average fuel economy is the that value published by the Energy Information Administration in Annual Energy Review 2006.

Including fuel in the revised TTI cost per mile value allows a direct comparison between the values used in the Urban Mobility Study and those calculated by the Federal Highway Administration, Office of Freight Management and Operations and obtained from the truck operator's data. The result of that comparison is shown in Table 7.

Table 7: Comparison of UMS and FHWA Cost Per Mile Value (Including Fuel in the UMS Cost)

Year	TTI Cost Per Mile Value	FHWA Cost Per Mile Value
1982	$1.74	$1.79
1983	$1.76	$1.76
1984	$1.83	$1.80
1985	$1.87	$1.86
1986	$1.75	$1.83
1987	$1.80	$1.78
1988	$1.85	$1.78
1989	$1.95	$1.74
1990	$2.05	$1.76
1991	$2.10	$1.76
1992	$2.15	$1.72
1993	$2.20	$1.69
1994	$2.26	$1.68
1995	$2.33	$1.66
1996	$2.41	$1.65
1997	$2.42	$1.65
1998	$2.36	$1.66
1999	$2.42	$1.65
2000	$2.63	$1.70
2001	$2.62	$1.67
2002	$2.59	$1.65
2003	$2.66	$1.71
2004	$2.79	$1.79
2005	$3.05	$1.96
2006	$3.20	$2.05

Note: Source for the FHWA data from 1982 through 2000 is derived from Expenses per Mile for the Motor Carrier Industry: 1990 through 2000 and Forecasts through 2005 published by the Federal Highway Administration, Office of Freight Management and Operations.

It should be noted that what is presented here as FHWA data in Table 7 for the years 2001 through 2006 are estimates. The FHWA report *Expenses per Mile for the Motor Carrier Industry: 1990 through 2000 and Forecasts through 2005* notes, "Diesel fuel prices, more than any other single factor, trigger the immediacy of motor carrier rate swings. The actual 8-cent per mile increase in motor carrier expenses from 1999 to 2000 was principally the result of diesel fuel rising from $1.20 a gallon to an average of $1.50 per gallon in 2000." This ratio between fuel price and operating costs was used to develop the estimated values for 2001 through 2006.

By taking the cost per mile calculations and multiplying them by the average peak period speed (i.e., congested speed) weighted by vehicle miles traveled, it is then possible to derive a value of time as expressed on a per-hour basis. Here, as in Table 7, values for some variables were updated. Most notably "new" weighted average speeds were calculated as a part of the urban mobility report process. The results of these calculations are shown in the last two columns of Table 8.

Table 8: Conversion of Cost Per Mile Value to a Cost Per Hour (Value of Time)

Year	"Old" UMS Cost Per Mile	"New" UMS Cost Per Mile	FHWA Cost Per Mile	"Old" Weighted Average Speed	"New" Weighted Average Speed	UMS Per Hour	"New" UMS Per Hour	Suggested UMS Cost Per Hour
1982	$1.57	$1.74	$1.79	38.3877	42.0956	$66.09	$73.32	$75.35
1983	$1.62	$1.76	$1.76	38.4469	42.0778	$68.17	$74.23	$74.06
1984	$1.62	$1.83	$1.80	38.5311	41.9117	$67.90	$76.55	$75.44
1985	$1.60	$1.87	$1.86	38.3437	41.5060	$66.41	$77.45	$77.20
1986	$1.65	$1.75	$1.83	38.5558	41.0955	$67.81	$71.74	$75.20
1987	$1.65	$1.80	$1.78	38.2874	40.7446	$67.23	$73.52	$72.53
1988	$1.75	$1.85	$1.78	37.9579	40.1477	$70.26	$74.31	$71.46
1989	$1.85	$1.95	$1.74	37.7265	39.8770	$73.77	$77.62	$69.39
1990	$1.95	$2.05	$1.76	37.8839	39.6802	$77.38	$81.21	$69.84
1991	$2.05	$2.10	$1.76	38.0758	39.6773	$81.34	$83.43	$69.83
1992	$2.15	$2.15	$1.72	38.0977	39.5558	$85.04	$85.09	$68.04
1993	$2.25	$2.20	$1.69	37.9253	39.5530	$88.99	$87.15	$66.84
1994	$2.35	$2.26	$1.68	38.0931	39.4562	$92.72	$89.32	$66.29
1995	$2.45	$2.33	$1.66	37.9966	39.0823	$95.75	$91.18	$64.88
1996	$2.55	$2.41	$1.65	37.8842	38.7766	$98.88	$93.47	$63.98
1997	$2.65	$2.42	$1.65	37.8120	38.5289	$102.10	$93.19	$63.57
1998	$2.75	$2.36	$1.66	37.7785	38.3652	$105.50	$90.57	$63.69
1999	$2.85	$2.42	$1.65	37.6570	38.0210	$108.36	$92.00	$62.73
2000	$2.95	$2.63	$1.70	37.6726	37.8132	$111.55	$99.36	$64.28
2001	$3.05	$2.62	*$1.67*	37.6747	37.5965	$114.67	$98.64	$62.79
2002	$3.15	$2.59	*$1.65*	37.5642	37.3092	$117.52	$96.70	$61.56
2003	$3.25	$2.66	*$1.71*	37.5500	37.1681	$120.80	$98.95	$63.56
2004	$3.35	$2.79	*$1.79*	37.5400	36.8239	$123.36	$102.82	$65.91
2005	$3.40	$3.05	*$1.96*	37.5300	36.5496	$124.27	$111.39	$71.64
2006	$3.45	$3.20	*$2.05*	37.5200	36.5195	$125.99	$116.90	$74.86

Note: Values for "FHWA Cost Per Mile" are estimated by the author based off of increases in diesel fuel prices as outlined in this memorandum on page 8.

Summary

It is believed that that the cost per mile values developed by the Federal Highway Administration Office of Freight Management and Operations for 1982 and 2000 and by the author for 2001 and 2006 (then multiplied by peak period speed) are a more reliable statistic for use in the Urban Mobility Study than the "inflation adjusted" cost per mile figure previously used in the UMS.

One obvious question is why did the two costs per mile values begin to differ over time as shown in Table 7? The answer may well, in part, be due to the fact that the deregulation of the trucking industry in the 1980s served to significantly increase the competitive environment in which trucking companies operate. To whatever degree there were "excess" profits in the industry prior to deregulation, that "excess" has disappeared. Further, whatever increased labor, insurance and benefit costs the industry has experienced have been moderated by decreases in computer and information processing costs as well as communication and tracking costs. Further, there was (through 2006) little price increase pressure from equipment prices, tire and parts costs, or tax and regulatory costs. Almost all cost increases were a function of diesel fuel prices.

As a result, for purposes of Urban Mobility Study calculations, the following unit values are suggested for use to calculating the cost of congestion in 2006:

- Passenger vehicle occupant value of time: $15.05 per hour
- Passenger vehicle fuel cost: $2.62 per gallon
- Truck operations cost: $74.86 per hour

The consumer price index (CPI) will be used to update the time values for personal travel and the average fuel cost will be obtained each year and incorporated in to the commercial vehicle cost per hour calculation. Periodic review of the literature and an economic analysis will be conducted to maintain the best estimates possible. Additional cost elements may be added and the analysis can be expanded to include other cost effects.

Sources:

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