

**EFFECT OF VEHICLE TYPE ON THE CAPACITY OF
SIGNALIZED INTERSECTIONS:
The Case of Light-Duty Trucks**

by

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ABSTRACT

This work analyzes the impacts of different light-duty trucks (LDTs) on the capacity of signalized intersections. Data were collected at two intersections in Austin, Texas, and regression analysis generated estimates of mean headways associated with various categories of LDTs, as well as passenger cars. Using the estimated headways Passenger Car Equivalents (PCEs) were calculated, and these suggest that the impacts of light-duty trucks should be given special consideration when analyzing the capacity of signalized intersections. For example, a single large sport-utility vehicle in through traffic is equivalent to 1.41 passenger cars; and a van is equivalent to 1.34. Such long headways reduce intersection capacity and increase urban congestion.

KEYWORDS

Headways, passenger car equivalent (PCE), light-duty truck, capacity, signalized intersection.

INTRODUCTION

Under ideal geometric and operational conditions, the *Highway Capacity Manual* (HCM 1998) estimates a lane's saturation flow rate (also known as its "ideal" flow rate) to be 1,900 *passenger cars* per hour of green time per lane (pcphgpl). Adjustments are made for conditions that do not conform to the HCM's definition of ideal. For example, there is a reduction in capacity due to the presence of heavy vehicles, because of their greater length and lower performance capabilities relative to passenger cars. This effect is formally recognized in the HCM, and the saturation flow rate is adjusted accordingly. However, only heavy/medium-duty trucks, buses, and recreational vehicles are treated as heavy vehicles. All light-duty trucks (LDTs) – a class made up of sport-utility vehicles (SUVs), pickups, and vans with gross vehicle weight ratings (GVWR) under 8,500 pounds – are assumed to fall in the passenger-car category. No adjustment is made to reflect the effect of their varying presence in the traffic stream, even though these vehicles average almost ten percent longer (based on 1997 LDT sales) and are becoming more and more common.

The percentage of light-duty trucks among *new* vehicle registrations in 1997 reached 44.0% – much more than the 2.7% corresponding to heavy/medium-duty trucks registered (Wards, 1998). The percentage of registered passenger cars in the U.S. is just above 60%, but this figure is falling, given trends in vehicle purchases towards LDTs. So even if an LDT does not impact traffic to the degree that a heavy truck does, LDTs are much more common, and their effect on roadway capacity merits our consideration.

In order to predict how LDTs affect overall intersection capacity, this research effort estimates headway differences in saturated flow among passenger cars and light-duty trucks traveling through a level, signalized intersection.

LITERATURE REVIEW:

Much research has been conducted to understand the effects of different vehicle types on the capacity of signalized intersections. For example, Webster and Cobbe (1966) estimated a passenger-car equivalency (PCE) value of 1.75 for heavy and medium goods vehicles. And Miller (1968) obtained a PCE estimate of 1.85 by measuring the additional time required by such trucks to cross an intersection.

By defining a “saturated” vehicle as one that came to a complete stop or near stop in the queue before proceeding and by measuring the lagging headway of these vehicles as they crossed the stop-line, Branston and van Zuylen (1978) obtained a heavy-vehicle PCE value of 1.74. Later, applying regression analysis to through-traffic data at a level intersection, Branston (1979) estimated PCEs to be 1.35 and 1.68 for medium and heavy trucks, respectively. Steuart and Shin (1978) studied the effect of small cars on the capacity of signalized intersections and found that vehicle size and preceding-vehicle type have a significant effect on headways. Sosin (1980) determined the delay for vehicles arriving at an intersection based on the difference needed for a single car to travel through the intersection from some point before the stop-line to some point after the stop-line and the time to travel the same distance at normal running speeds. His results suggest that single-unit trucks and tractor-trailers have PCE values of 1.6 and 2.8, respectively. Overall, these reported research results are in general in concurrence with – but somewhat lower than – the current HCM’s recommended heavy-vehicle PCE of 2.0.

The ideal saturation flow rate is usually taken to be 1,900 passenger cars (which, as mentioned, includes LDTs) per hour of green time per lane for signalized intersections (HCM 1998). The capacity reduction due to the introduction of heavy vehicles (defined to be any vehicle having more than four tires) is realized in the *Highway Capacity Manual* by multiplying this ideal flow rate by a heavy vehicle adjustment factor calculated from the following equation:

$$f_{HV} = \frac{1}{[1 + P_T (PCE_T - 1)]} \dots \dots \dots (1)$$

where

f_{HV} = heavy vehicle adjustment factor

P_T = percent heavy vehicles

PCE_T = heavy-vehicle's passenger car equivalent

Before developing a model for different LDT PCEs, it is interesting to note that the Canadian Capacity Guide for signalized intersection (Teply 1985) relies on the results of a least-squares optimization procedure for its PCE values for various vehicle types, and these suggest PCE values of 1.00 for vans and pickups, 1.5 for a single-unit trucks, 2.5 for a combination trucks, and 3.5 for large trucks if heavily loaded. Additionally, Tsao and Chu (1995) analyzed data from two intersections in Taiwan and concluded that the average headways of passenger cars and heavy vehicles are independent of the type of vehicle immediately ahead. Their results also suggested that different adjustment factors should be used for heavy vehicles in through versus left-turn traffic. As described in the following sections, our models' specifications allow one to test several of these conclusions.

MODEL DEVELOPMENT

Three major factors influencing headways are reported in the literature and were considered here in developing a model to capture effects of vehicle type on intersection capacity. These are vehicle length, vehicle performance capabilities, and driver behavior.

Intuitively, as a vehicle's length increases, it requires more time to cross an intersection, *ceteris paribus*. Research by Kockelman (1998) indicates that length contributes negatively to highway flows. She analyzed different third-order-polynomial models of flow versus density

interacted with other explanatory variables, and the elasticity of flow with respect to average vehicle length was estimated to be -17.4% . The average sales-weighted length of new vans and pickups is about 14% more than that of new passenger cars, while the average new sport-utility-vehicle length is about equal to that of the average car (Wards, 1998). However, there is large variability in the lengths of sport-utility vehicles: Chrysler's Jeep Wrangler is just 148 inches long – while GM's Suburban is 220 inches in length; such variety suggests that a sub-classification of these vehicles by length might be appropriate. Our models' specifications considers this possibility explicitly.

In terms of vehicle performance, acceleration characteristics are likely to be highly correlated with horsepower-to-curb weight ratios. For new vehicle sales in 1997, these ratios for SUVs and pickups are about 10% less than that of cars, and almost 20% less in the case of vans. Thus, LDTs starting on green near the stop bar of an intersection are expected to add to lost time, making less effective use of green time and adding to congestion and delays. Our models' specifications allow us to investigate this.

Finally, this research examines the behavior of drivers of passenger cars following specific LDT types. It is hypothesized that the presence of a light-duty truck in front of a passenger car causes the passenger-car driver to be more cautious because of the LDT's large size and the resulting diminished sight distances. This may cause the headways of passenger cars to be larger; and, if so, this increase must be considered in the overall capacity reduction due to LDTs.

The regression equations developed in the current effort predict the mean clearance time of queued traffic at signalized intersections – given the composition (type and ordering) of the

queued traffic. As a result, the marginal effects of changes in the traffic composition on the capacity of a signalized intersection can be estimated.

The dependent variable – clearance time or “*TIME*” – is measured for a queue of vehicles discharging at an intersection. The numbers and pairings of different vehicle types in the queue are the explanatory variables. To observe the effect of a preceding vehicle on the headways of following passenger cars, there are five vehicle-pair variables; these are: passenger car-passenger car, passenger car-small SUV, passenger car-long SUV, passenger car-van, and passenger car-pickup. Indicator variables are introduced for the type of lead/starting vehicle in the queue – with the exception of passenger cars (since their value is the reference value and is subsumed in the constant term of the regression). The constant term estimated in the regression equations represents the sum of lost time associated with the first several vehicles (due to acceleration delays) and the time required by a starting passenger car to clear the intersection’s entry point (*i.e.*, cross the stop bar) minus the response time of the starting car’s driver. The lag in response to the changing of the signal color is not included in this parameter value because the variable *TIME* begins with the physical movement of the starting vehicle – rather than with the changing of the signal color. In notational form, the full model can be represented as follows:

$$TIME = \alpha + \sum_{j=1}^{j=m} \beta_j D_j + \sum_{k=1}^{k=p} \gamma_k X_k + \sum_{i=1}^{i=n} \delta_i Y_i + \epsilon \dots \dots \dots (2)$$

where

- TIME* = total time required by a queue of vehicles to clear the stop bar
- α = lost time associated with the first several queued vehicles plus time required by a lead passenger car to clear the intersection’s entry point
- β_j = mean additional time required by an LDT of type *j* to cross the

- γ_k = stop bar, relative to a passenger car
= mean saturated-flow headway associated with a preceding vehicle-passenger car pair of type k
- δ_i = mean saturated-flow headway associated with an LDT of type i
- m = number of indicator variables included for different types of first-vehicle in queue (with passenger car indicator variable excluded)
- p = number of distinct preceding vehicle-passenger car pairs
- n = number of LDT categories analyzed
- D_j = indicator variable for whether first vehicle in queue is of type j
- X_k = number of vehicles in a queue of type k preceding a passenger car
- Y_i = number of LDTs in queue of type i
- ε = error term representing time accrued by the unobserved attributes of all vehicles and their drivers in a queue

PASSENGER CAR EQUIVALENTS:

The so-called “headway method” is the most common method employed to estimate passenger car equivalents (PCEs) for trucks. This procedure is used here to arrive at PCEs for different vehicle types that fall into the LDT category (*i.e.* SUVs, vans, and pickups). When computing the PCE values, the additional time, if any, taken by passenger cars to cross the

$$PCE_i = \frac{\delta_i + \Delta\gamma_i}{\gamma_p} \dots\dots\dots(3)$$

intersection when following an LDT (relative to that in following a passenger car) is also considered. The headway values estimated by the regression functions described above are used to generate the PCE values using the following equation:

where:

- PCE_i = passenger car equivalent for vehicle type i ,
- δ_i = mean headway associated with LDT type i ,
- γ_p = mean headway associated with a passenger car following another passenger car, and
- $\Delta\gamma_i$ = mean additional delay caused by a type i LDT following a passenger car.

DATA COLLECTION:

The following criteria were used in the selection of the study sites:

1. High traffic volumes;
2. Level terrain;
3. Exclusive left-turn lane and protected signal phase for left turns;
4. Exclusive right-turn lane;
5. Ease of set up;
6. Good mix of different vehicle types;
7. No parking allowed;
8. Insignificant disturbance from bus stops.

The Lamar–Barton Springs and the Martin Luther King Jr.–Interstate 35 Frontage Road intersections in Austin, Texas, met these criteria and were selected for this study. The westbound approach of the former was used to gather through and left-turning traffic data, while the southbound approach of the later was used to gather right-turning traffic data. A protected left-turn signal phase was available for the left-turning vehicles at the Lamar–Barton Springs

intersection. A separate signal phase was available for the right-turning traffic at the MLK Jr.-I35 Frontage Road. This right-turn phase partially coincided with a walk signal on the eastbound approach; however, there were very few pedestrians, so right-turning vehicles maneuvered without being disturbed by crossing pedestrians.

The traffic flow data were gathered using a video camera. All data were collected under dry-weather conditions and during evening and morning peak hours. Data were recorded on 8mm video camera tapes and later copied onto regular videocassettes. A time strip was generated on the video display using an F22 Time Code Generator/Reader that enabled one to record time required by each queue to discharge with a precision of .033 (1/30th) seconds.

The basic methodology used to analyze the collected traffic data was the measurement of the elapsed time from the moment the first vehicle in the queue started moving from rest until the time the rear axle of the last vehicle in the queue crossed the stop-bar reference line. Only those vehicles that came to a complete stop before the signal turned green were considered in the queue. In each queue, the number of different vehicle types and pairings was recorded, along with the type of lead/starting vehicle. Only one lane of queued data was considered for each distinct observation.

Since the purpose of the study is to ascertain the effects of light-duty trucks on the capacity of signalized intersections, the following five vehicle classes were defined and only those observations which contain only these vehicles are included in the analysis. These are:

1. Passenger Cars;
2. Large Sport-Utility Vehicles (defined as SUVs over 200 inches in length – *i.e.*, Chevrolet Suburbans, Lincoln Navigators, Ford Expeditions, and any other vehicle very closely resembling these);

3. Small Sport-Utility Vehicles (every other type of SUV not included in category 2);
4. Vans;
5. Pickups.

STATISTICAL ANALYSIS:

The analysis relies on equation (2) – a regression equation built upon headways associated with different vehicle types. Such an equation predicts the total travel time required by a queue of vehicles based on the number and type of vehicles present. Also the capacity of an intersection can be determined, provided traffic composition is known.

Non-constant variance or “heteroscedasticity” may be present in the data since the variance of “TIME” will tend to increase in proportion to the number of headways/vehicles observed. The data were analyzed for the presence of heteroscedasticity using White’s test (White 1980). Essentially, TIME was first regressed against the variables defined in equation (2). The squares of this regression’s residuals were regressed against the total number of vehicles in a queue. This regression was statistically significant only in the case of the right-turning data. To accommodate the heteroscedasticity in these data, a weighted least squares estimation was employed (with weight being the reciprocal of the total-number-of-vehicles variable).

The parameter estimates for this regression when applied to *through* traffic are shown in Table 1. The estimated headways of small and large SUVs in left- and right-turning traffic were contrary to expectations (in that the smaller SUVs were estimated to have larger headways), so these two categories of LDT were combined ultimately. The results of these modified models are reported in Tables 2 and 3 – for left- and right-turning traffic, respectively. The adjusted R-squared values are above 0.90 in all cases, indicating that the models fit the data extremely well.

Table 1: OLS Estimation Results of Through-Traffic Data

Variables	Coefficient	t-statistic
Constant	2.18	6.79
Indicator Variables for First Vehicle		
Small SUV	-0.30	-0.70
Long SUV	0.59	1.48
Van	0.43	0.92
Pickup	0.61	2.18
Lead-Follower pairs for passenger cars		
No. of cars following another car	1.73	37.8
No. of cars following small SUV	1.70	10.8
No. of cars following long SUV	2.04	6.70
No. of cars following van	1.88	7.57
No. of cars following pickup	1.68	10.2
No. of small SUVs	1.88	18.0
No. of long SUVs	2.13	9.56
No. of vans	2.16	12.7
No. of pickups	2.02	20.2
$R_{adj}^2 = 0.959, N_{obs} = 159$ queues		

Table 2: OLS Estimation Results of Left-Turning Traffic Data

Variables	Coefficient	t-statistic
Constant	2.71	8.63
Indicator Variables for First Vehicle		
Small SUV	0.13	0.50
Long SUV	0.13	0.50
Van	1.04	2.42
Pickup	0.38	1.59
Lead-Follower pairs for passenger cars		
No. of cars following another car	1.71	32.8
No. of cars following small SUV	1.71	10.8
No. of cars following long SUV	1.71	10.8

No. of cars following van	1.04	3.98
No. of cars following pickup	1.60	10.7
No. of small SUVs	1.65	13.6
No. of long SUVs	1.65	13.6
No. of vans	2.48	12.1
No. of pickups	1.97	19.8
$R_{adj}^2 = 0.908$, $N_{obs} = 191$ queues		

Table 3: OLS Estimation Results of Right-Turning Traffic Data

Variables	Coefficient	t-statistic
Constant	1.70	4.63
Indicator Variables for First Vehicle		
Small SUV	1.30	3.50
Long SUV	1.30	3.50
Van	-0.94	-1.94
Pickup	0.04	0.09
Lead-Follower pairs for passenger cars		
No. of cars following another car	1.89	36.15
No. of cars following small SUV	1.64	8.04
No. of cars following long SUV	1.64	8.04
No. of cars following van	2.37	10.3
No. of cars following pickup	2.19	9.12
No. of small SUVs	2.29	19.9
No. of long SUVs	2.29	19.9
No. of vans	1.77	11.8
No. of pickups	1.89	12.4
$R_{adj}^2 = 0.969$, $N_{obs} = 108$ queues		

STUDY RESULTS:

The PCE values obtained using equation (3) for various LDT categories are shown in Table 4.

Table 4: Passenger Car Equivalent (PCEs)

	Through Traffic	Left-turning Traffic	Right-turning Traffic
Small SUV	1.07	0.96	1.08
Long SUV	1.41		
Van	1.34	1.06	1.19
Pickup	1.14	1.08	1.16

The PCE values presented in Table 4 suggest that light-duty trucks have significantly higher headways than passenger cars when in through traffic but not so much when in right- and left-turning traffic. One reason for these results may be that while making a turn, the driver of a passenger car is able to see the queue of vehicles ahead of him and hence diminished sight distances due to an LDT's bigger size is not an issue here. [Note: LDTs average 28% higher and 8% wider than passenger cars sold in 1997.] This leaves the length and performance of vehicle (and driver behavior in the LDT itself) as the only other factors affecting headways.

The PCE values presented in Table 4 support a separate consideration of LDTs when analyzing the capacity of intersections, so as to more accurately reflect actual traffic conditions. As the fraction of LDTs in our traffic streams change, so with the capacity of our intersections – and roadways in general.

As discussed previously, the *Highway Capacity Manual* recommends use of a heavy-vehicle adjustment factor to modify the capacity of a signalized intersection based on the percentage of heavy vehicles in the traffic stream (see equation (1)). Based on the findings of

this research, the following modification reflects the impact of light-duty trucks on the traffic conditions at a signalized intersection:

$$f_{HV} = \frac{1}{\left[1 + P_T(PCE_T - 1) + P_{SSUV}(PCE_{SSUV} - 1) + P_{LSUV}(PCE_{LSUV} - 1) \right. \\ \left. + P_{VAN}(PCE_{VAN} - 1) + P_{PUP}(PCE_{PUP} - 1) \right]} \dots\dots(4)$$

where

- f_{HV} = heavy vehicle adjustment factor;
- $P_T, P_{SSUV}, P_{LSUV}, P_{VAN}, P_{PUP}$ = percent of trucks, small SUVs, large SUVs, vans, and pickups in the traffic stream, respectively;
- $PCE_T, PCE_{SSUV}, PCE_{LSUV}, PCE_{VAN}, PCE_{PUP}$ = passenger car equivalent of trucks, small SUVs, large SUVs, vans, and pickups, respectively.

When using this methodology, the PCE values listed in Table 4 are recommended. However, it may be difficult to determine the percentages of various light-duty-truck types at distinct signalized intersections – and these may not differ much across intersections. Given a known mix of LDT types, one can condense the values in Table 3 to a single PCE value for all light-duty trucks. One way of achieving this is by running another regression wherein variables representing different LDT categories are combined, yielding average headways associated with passenger cars and light-duty trucks only. Accounting for the additional delay caused by a preceding LDT on a passenger car, if any, and using the formula presented in equation (3), a PCE value for a “typical” LDT can be computed. However, the value so obtained would be biased if the percentages of various LDT categories in the collected data are not representative of their percentages in the overall traffic stream.

In order to calculate the PCE value for light-duty trucks in such a way that it represents the actual percentages of different LDT categories, the following formula is used here:

$$PCE_{LDT} = \sum_i Percentage_i \times PCE_i \dots \dots \dots (5)$$

To obtain the percentages of different LDT categories, 1997 sales figures are used here. It should be noted that although these figures do not represent the actual percentages of LDTs presently in the overall traffic stream, they may represent the composition of the overall LDT stream in the near future. Out of about 7 million light-duty trucks sold in 1997 (excluding commercial chassis LDTs), the percentage sales of small SUVs, large SUVs, vans, and pickups were 27.1 %, 8.6%, 23.6%, and 40.6%, respectively. Using these percentages and the PCE values from Table 4 in equation (5), the light-duty-truck PCE values of 1.19, 1.03, and 1.14 are obtained for the through, the right-turning, and the left-turning traffic, respectively. Hence the following modification is recommended in the formula for calculating the heavy vehicle adjustment factor used in the HCM for through and right-turning traffic:

$$f_{HV} = \frac{1}{[1 + P_{HV}(PCE_{HV} - 1) + P_{LDT}(PCE_{LDT} - 1)]} \dots \dots \dots (6)$$

where

P_{LDT} = percent of light-duty trucks in the traffic stream;

PCE_{LDT} = passenger car equivalent of LDTs (1.19 for through traffic, 1.03 for left-turning traffic, and 1.14 for right-turning traffic).

Figures 1, 2 and 3 show estimates of capacity reduction due to different PCE values and percentages of light-duty-truck types in through, left-turning, and right-turning traffic. The same effect is shown in Figure 4 for a PCE value of 1.2, as recommended for LDTs in through traffic.

The ideal saturation flow rate for an all-passenger car traffic stream is assumed to be 1,900 pcphgpl, as defined in the HCM (though this figure is expected to be significantly higher with the removal of LDTs from the HCM's "passenger car" definition); and the capacity reduction due to LDT presence is computed via use of equation (6)'s adjustment factor.

As can be inferred from Figure 1, having large SUVs represent 25% of the vehicles in through traffic is expected to reduce a signalized intersection's capacity by about 9.3%. This same percentage of small SUVs, vans, and pickups is expected to reduce capacity by 2.2%, 7.6%, and 4.1%, respectively. With a PCE value of 1.2 representing all the categories of LDTs in the through traffic stream, a 50% share of LDTs in the traffic stream leads to roughly a 10% decline in overall capacity. Current sales trends indicate a similar imminent composition of the overall traffic stream and thus a significant addition to already severe congestion problems on urban streets and highways.

The results suggest that if the effect of LDTs on the capacity of signalized intersection is not accounted for in design and other engineering calculations, saturation flows computed using current *HCM* methodology will produce inflated values of intersection capacity and levels of service that are biased high. Moreover, since intersection signal-timing strategies are based on saturation flows, estimates of "optimal" cycle lengths are likely to be biased low. This is likely to result in unnecessarily long queues and additional delays or, in other words, inefficient intersection control.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this study, one can conclude the following:

1. Light-duty trucks adversely affect the capacity of signalized intersections. Their increasing number in the current traffic stream is expected to worsen the already severe congestion

problems present in cities in the U.S. and abroad. With the average LDT taking the place of 1.2 passenger cars in through traffic, the nation's trend toward a 50% share of LDTs is expected to be responsible for roughly a 10% fall in signalized-network through-traffic capacity. When a network is already operating close to capacity for an hour or more each day, such a decline can mean severe bottlenecks and gridlock.

2. Different light-duty-truck categories have different impacts on capacity, with large SUVs appearing to have the most negative effects.
3. Not only is vehicle length found to be a factor, but – in the case of through traffic – the effect of vans on the headways of following passenger cars is pronounced and highly statistically significant. This effect is not so evident in the left-turning and the right-turning traffic data, perhaps because, when making a turn, the driver of a passenger car is able to see the distribution of vehicles ahead of the preceding LDT and diminished sight distance (due to LDT size) is no longer an issue. Thus, estimated PCE values for light-duty trucks in left- and right-turning traffic are not as high as in through traffic.
4. If the first vehicle in a queue is a light-duty truck (excluding small SUVs), it generally takes significantly longer for this vehicle to clear the stop-bar than it does a passenger car. Tables 1 through 3's indicator variables for non-cars leading the queue suggest that LDTs generally add to lost time. In the case of through, left-turn, and right-turn traffic, a starting LDT is estimated to contribute about 20% more time to lost time than a starting passenger car.¹ In the case of right-turns, starting SUVs are estimated to contribute up to 90% more lost time than starting passenger cars. This significantly longer time may be attributed to a lower power-to-weight ratio for SUVs (and LDTs in general, relative to passenger cars) as well as

the small turning radii afforded vehicles in a right-turn maneuver – relative to the larger wheelbase of many SUVs.

The results of this research suggest that light-duty trucks require longer headways than passenger cars and should be considered separately when determining the capacity of critical signalized intersections. The following methodological changes are recommended for the *Highway Capacity Manual* in calculating the saturation flow rate:

1. The heavy-vehicle adjustment factor may be modified to incorporate LDT representation in the traffic stream, using equation (6):

$$f_{HV} = \frac{1}{[1 + P_{HV}(PCE_{HV} - 1) + P_{LDT}(PCE_{LDT} - 1)]} \dots\dots\dots(6)$$

2. When considering through, right-turning, and left-turning traffic, PCE values of 1.19, 1.03, and 1.14 correspond to the average light-duty truck (based on 1997 sales percentages).
3. By removing LDTs from the HCM’s passenger-car definition, ideal saturation flow rates for lanes at a signalized intersection are expected to rise well above 1,900 pcphgpl.

In conclusion, LDTs have undesirable effects on traffic flows and congestion. As Kockelman (1999) points out, relatively lax federal regulation of these vehicles has resulted in other negative consequences – including environmental and safety impacts – and inappropriately low pricing, leading to higher-than-optimal ownership of LDTs. Taken together with the delays LDTs are found here to impose on other drivers, the toll is substantial and the situation is in need of remedy.

ENDNOTES:

¹ These estimations are based on an estimate of lost time for the cycle and then attributing half of this to the first vehicle. In a separate experiment, perception-reaction times of lead vehicles averaged 1.79, 1.74, and 1.65 sec. for through, left-turning, and right-turning traffic. If one assumes that the stop-bar clearance time is 0.5 seconds (the time to clear 18 feet of vehicle when traveling at 25 mph), then average lost time by the approach's vehicles can be estimated as the following: $Lost = Constant\ of\ Regression - 0.5 + Response\ Time$. This results in lost times of 3.47, 3.95, and 2.85 sec for the three respective movements. Assigning half of this to the lead vehicle and comparing this with the average indicator levels (.32, .45, and .26 seconds, respectively, when weighted by 1997 LDT sales percentages) results in proportions on 0.18, 0.22, and 0.18. For right-turning SUVs, this calculation produces a proportion of 0.92.

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Figure 1. Capacity Reductions due to Light-Duty Trucks in Through Traffic

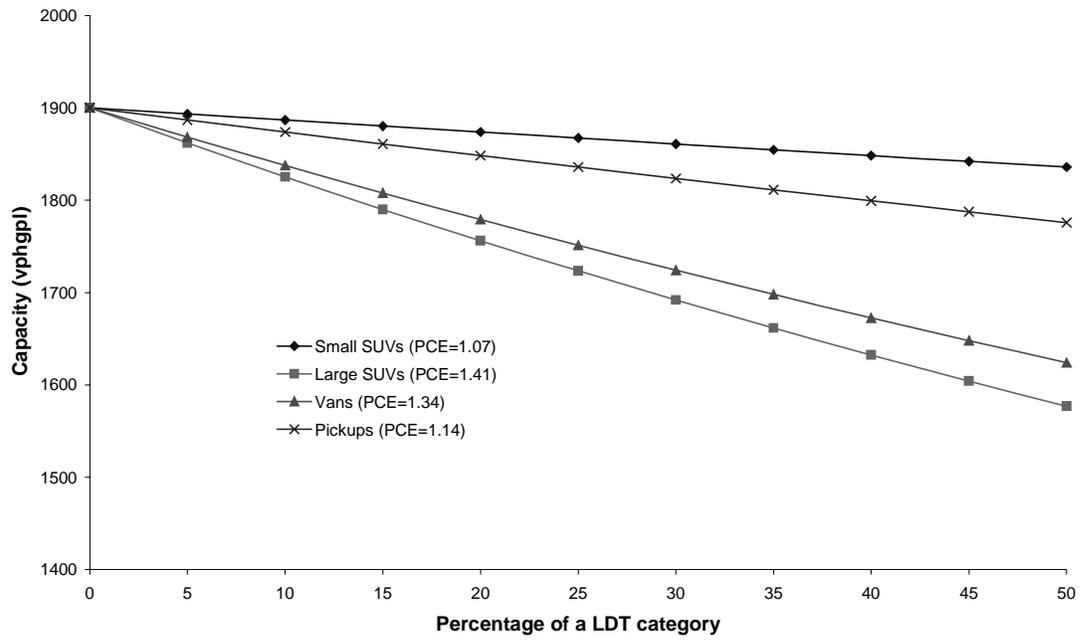


Figure 2. Capacity Reductions due to Light-Duty Trucks in Left-Turning Traffic

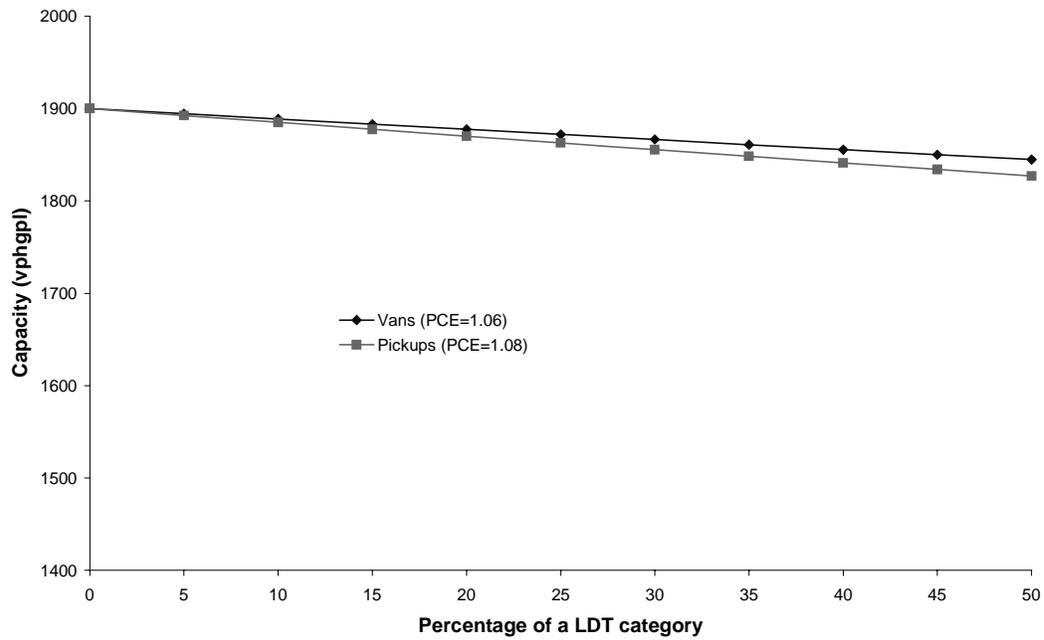


Figure 3. Capacity Reduction due to various LDT categories in the Right-Turning Traffic

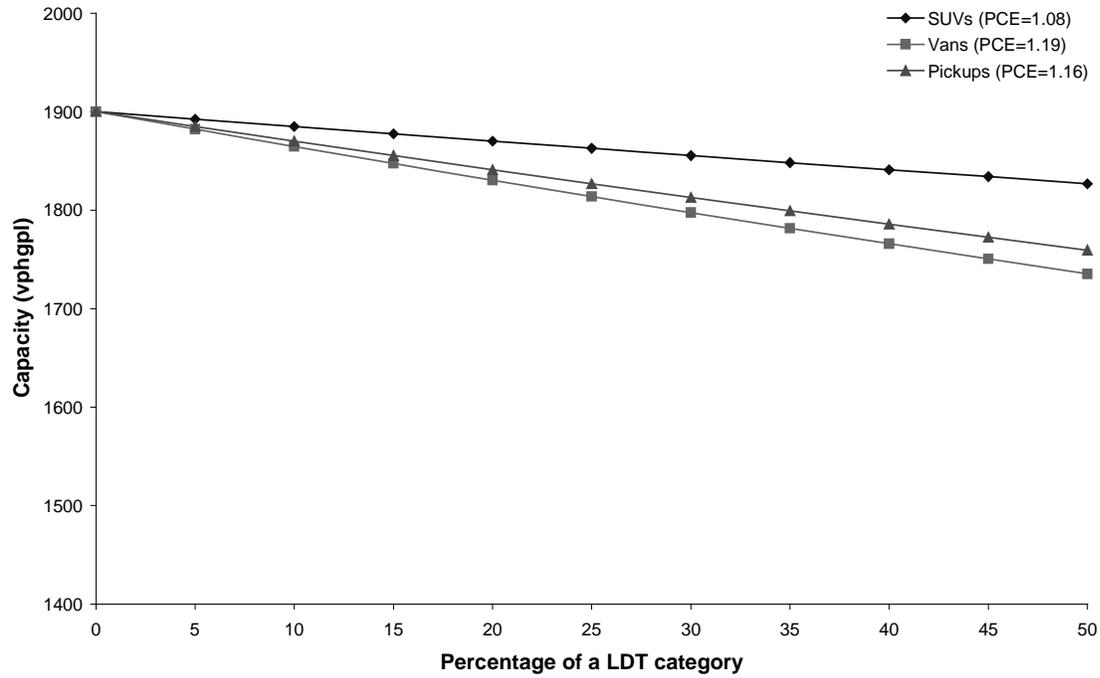


Figure 4. Capacity Reductions due to Light-Duty Trucks in Through Traffic

