Critique of ITE Trip Generation Rates and An Alternative Basis for Estimating New Area Traffic

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The commonly used household vehicle trip rates from the Institute of Transportation Engineers' Informational Report, Trip Generation, are nearly twice as large as equivalent data from survey-based sources such as the 1977 National Personal Transportation Study and the various regional planning agencies. A number of potential reasons for the difference, including sample demographics, underreporting, and non-home-based trips, estimating the effect of each. Major factors are the atypically large incomes and family sizes of areas from which the ITE data came. The quantifiable factors explain two-thirds of the difference. Other reasons, such as the ITE rates being measured in new areas without maturity of land uses or resident's habits, are speculated as the cause of the remaining difference. Even the quantifiable reasons for differences in characteristics between a new area and the one from which source data come are often ignored in traffic estimates. Considering these factors ITE data are claimed to lead to excessive local road capacity decisions. Survey-based rates are more consistent with other national accounts and observations of travel. An alternative method for traffic estimation for new residential developments, based on available survey sources, is presented and recommended.

Traffic load estimates and road requirements for new residential developments are often based on per-household trip rates from the Institute of Transportation Engineers Informational Report, Trip Generation (1). ITE rates for the typical number of vehicle trips per day produced by single and/or corresponding multifamily housing types are multiplied by the mixes of housing planned to give the traffic expected. Other steps or refinements may adjust the basic rates for the demographics of the area, determine peak-hour trips, subdivide the estimates by zones and a road network, add non-residential and external trips, and/or apply traffic level of service standards to determine the number and sizes of roads required for the development.

Typical of the tripmaking rates in the ITE manual is the claim that the average single-family housing unit generates 10 vehicle trips per day. Generation rates from 3.7 to 6.1 are given for different densities of multifamily housing. These rates are considerably higher than reported for population averages by most national and regional survey sources.

The National Personal Transportation Study (NPTS) reports that the average U.S. household made 4.0 vehicle trips/day in 1977 (2). Characteristics of Urban Travel Demand, a compilation of travel survey data from about 40 metropolitan areas in the United States in the 1960s, averages to 5.3 home-based person trips per day (equivalent to about 4.4 vehicle trips/day between all locations) (3). The 1976 Urban and Rural Travel Survey of 7600 households in the six-county Southern California Association of Governments (SCAG) region reported an average vehicle-trip rate of 5.7/household/day (4).

Even if the ITE figures are weighted by the corresponding mixes of the housing types in the above populations, they still imply twice the national rate and 50 percent higher than reported in southern California--7.8 and 8.5 vehicle-trips/day, respectively.

There are straightforward reasons for some of these differences. Data-collection methods and demographics are different for the sources. However, as the next section of this paper shows, the ITE generation rates are still 34 percent high after adjustments are made for identifiable factors. This suggests that estimates of road requirements for new residential developments based on the ITE rates may lead to construction of excessive capacity and unnecessary expenditures. At a time when automobile travel may be leveling off or even decreasing and resources are scarce, this should be remedied.

The paper goes on to apply an alternate method of estimating traffic to an actual new community based on travel survey data. The result is compared with an independent estimate based on ITE-type data, with the latter again appearing excessively large. The conclusion speculates on the persisting part of the differences. Because of the biases implied in the ITE sampling methods, travel survey data are recommended as the basis for sizing new roads.

ADJUSTMENTS FOR DIFFERENCES BETWEEN ITE AND NPTS METHODS

Before detailing the quantifiable differences between the two sources, issues that do not contribute to their differences must be cleared away. All the data sources make a distinction between person and vehicle trips and are stated for the latter. Vehicles in the NPTS survey include, in addition to automobiles, vans, light trucks, recreational vehicles (RVs), motorcycles, and mopeds. Though the other sources do not define their inclusion of vehicles, they are unlikely to be more comprehensive. So the NPTS rates apparently include at least the vehicles in the cordon measurements. All sources define a trip as each one-way leg, so a round trip counts as two vehicle trips. Reports on trends in tripmaking rates between the early 1970s and 1977, the interval between most of the ITE and NPTS observations, do not show significant changes (2,5,6). There was a 6 percent decline on a per household basis due to greater household growth than for travel or the population. This effect is not included here, but it may have a bigger effect on future projections and is discussed later.

The initial set of adjustments below is to reconcile the obvious differences in data collection between cordon line and survey methods. Following this, adjustments are also made for the apparent atypical demographics of the ITE sample. The reconciliation procedure is to start from the average trip rate of one of the sources (NPTS) and adjust it for each quantifiable difference in data-collection method or demographics to try and represent the basis of the other source (the ITE rates averaged at the U.S. housing mix).

First, the NPTS trip rates are adjusted to the same (cordon line) basis as the ITE sources by subtracting non-home-based trips and then adding back proxy data for the trips coming to houses by nonresidents (visitors, service vehicles, etc.). National data typically report about 80 percent of trips to be home-based. In the SCAG area 70 percent are home-based. In the San Francisco region, 21 percent were non-home-based in the 1960s. The national figure of 20 percent is subtracted from the NPTS rate in the second row of Table 1 for this factor.

The SCAG data and data from the Washington, D.C., region indicate that non-resident trips to homes amount to 16-19 percent of total area trips (+21 to +23 percent of home-based trips) (7). The third row of Table 1 adds 21 percent to the NPTS rate for this effect.

Another probable reason for differences is the underreporting of trips by interviewees. Two indications of the size of this effect are available. Correction factors are typically applied to survey-based models of regional tripmaking to gain agreement with ground counts. The models of the California Department of Transportation (Caltrans) LARTS Division, Los Angeles, indicate an adjustment factor of 19.6 percent between SCAG area reported trip rates and (LARTS-DTIM) production rates per household. Adjustments in the Sacramento region run from 0 for work trips to 20 percent for other home-based trips. Checks of reported miles driven against driver trips multiplied by trip distances within the NPTS data suggest about 28 percent underreporting. Omission of trips probably accounts for the bulk of this error. About 20 percent is taken to represent this underreporting, the third adjustment factor shown in Table 1. This brings the survey rates to equivalence with the cordon line basis of the ITE data.

The ITE descriptions of the average demographics of their single-family category suggest other important reasons for the trip rate difference. Homes in this sample have an average of 3.7 persons, 1.6 vehicles; are built at a density of 3.5 units/acre; are newer than the average; and, following from all these characteristics, have higher incomes. Each of these factors contributes to the ITE rates being higher than surveys of typical tripmaking.

Table 2 shows additional adjustments to the survey-based trip rate to try and make it represent a residential area with the average demographic and economic characteristics of the ITE sources. The rates are adjusted by using information on the sensitivity of tripmaking to the relative demographic characteristics of the ITE and the national samples [derived from the SCAG study (4); national demographics are from the 1976 housing census].

The first identifiable demographic difference is a NPTS sample family size of 2.92 persons/household versus 3.17 for ITE (when weighted by the U.S. housing mix). The NPTS average household incomes were $12 460/year in 1976. No direct report of incomes was given with the ITE data. However, its other demographic, automobile ownership, and sample area characteristics were very similar to Orange County, California, in 1976. The $15 400 average household income for that county was thus inferred to represent the ITE sample. Individually, these demographic differences imply a 6.4 percent and a 21 percent higher vehicle trip rate for the ITE sample for family size and incomes, respectively. Assuming a correlation factor of 0.33 between family size and income, the joint effect of these factors is a 23 percent higher trip rate. This is shown as the first adjustment in Table 2.

The ITE data were taken in new and low-density areas where transit shares of trips are insignificant. The nationwide transit share of all trips was 2.8 percent in 1977 according to NPTS. This last adjustment in Table 2 brings the survey-based trip rate to equivalence with measurements taken in areas without transit.

Table 2 still concludes with a 34 percent unexplained difference between the adjusted NPTS vehicle trip rate and that from ITE. A similar set of adjustments on the southern California trip surveys leave 21 percent of the difference between it and the ITE data unexplained. Thus, even if the ITE trip rates were applied to areas in the nation with the same average demographics as the ITE sources, traffic estimates would typically be 34 percent too high. As stated originally there would be discrepancies of nearly 100 percent if ITE rates were applied directly to areas with average national demographics.

Apparently there are significant reasons beyond the adjustments in Tables 1 and 2 for the ITE trip rates to differ from recent surveys. No adjustments were made for land use densities above; weighting of the average ITE rate by the housing type mix may not correct for density differences. No account was made for possible differences due to the maturity of the areas or the ages of their populations. Further reasons are speculated for this difference in the conclusions. Of course, all of the adjustment factors applied in the table for underreporting and other effects are subject to error.

The difference in the trip rates is large compared with likely errors in the adjustment factors. It is larger than any of the individual adjustments. Either underreporting or income adjustments would have to be more than 50 percent to account for it.

The NPTS rate is also much more consistent with national accounts of vehicle miles traveled and annual energy consumed by personal vehicles. If the 7.8 trips/day U.S. average implied by the ITE rates are multiplied by the average trip lengths, number of households, and fuel efficiency of vehicles for 1972, the annual energy consumption implied is about 17 quadrillion Btu's, also about twice the published reports of U.S. energy consumption by personal passenger cars (8).

Because the difference in the ITE data remains excessive under examination, an alternative method for estimating the traffic for a new residential development based on travel survey data is presented

Table 1. Reconciliation of NPTS to ITE trip generation rates for data-collection methods.

Source or Adjustment Factor	Adjustment (%)	Resulting Vehicle Trips per Avg Household per Day
NPTS	Baseline	4.0
Remove non-home-based trips	-20	3.2
Add visitor and service vehicle trips	+21	3.9
Add for underreporting	+20	4.6
Cumulative adjustments for cordon equivalence	+16	4.6

Table 2. Reconciliation of NPTS to ITE trip generation rates for demographic differences.

Source or Adjustment Factor	ITE Sample Parameter	NPTS Sample Parameter	Adjustment[a] (%)	Resulting Vehicle Trips per Avg Household per Day
NPTS rate adjusted to cordon basis (from Table 1)			+16	4.6
Family size	3.17/household	2.92/household	+6.4 } [b]	5.7
Income per household			+21 }	
Transit trips	2.8 percent share	Negligible	+2.8	5.8
Cumulative cordon and demographic adjustments			+45	5.8
Avg ITE vehicle trips per household at U.S. housing mix				7.8
Remaining difference ITE versus NPTS (adjusted)			34	

[a]Trip rate sensitivities to changes from Caltrans (4). [b]Correlation of 0.33 assumed between income and family size.

next. As well as being based on more realistic data for trip rates, the new method accounts for the expected demographic and economic characteristics of the area's residential market and the effects of recent fuel prices. This will be compared with a traffic estimate by a consultant for the same area plan based on ITE-type data.

TRAFFIC ESTIMATION BASED ON HOUSEHOLD TRAVEL SURVEYS

The revised estimate is for the total residential vehicle traffic generated by the 43 000 dwelling units planned for the 18 000-acre Chino Hills area of San Bernardino County, California. Only average household vehicle trip rates and the total traffic produced by the land uses in the plan will be estimated. The consultant's estimate distributed traffic over the transportation network of the area. Though a network analysis is beyond the scope of this study, a useful comparison can be made of the total trips produced by both estimates and inferences made for their proportional effect on the road network. The estimate here goes beyond the prior one in source data and demographic and economic adjustments.

Table 3. Vehicle driver trips per household by income level and housing unit type.

Household Income ($)	SH	MH	Overall
Los Angeles County			
Under 6000	3.6	1.8	2.5
6000-9999	4.6	3.4	3.9
10 000-14 999	5.9	4.8	5.4
15 000-24 999	8.4	6.6	7.9
25 000-39 999	9.7	5.6	8.8
40 000 and over	9.6	6.9	9.1
Overall	6.8	3.8	5.5
Orange County			
Under 6000	4.3	2.4	2.9
6000-9999	4.9	4.8	4.8
10 000-14 999	7.2	5.2	6.2
15 000-24 999	7.8	6.6	7.5
25 000-39 999	10.2	8.0	9.9
40 000 and over	9.2	-[a]	9.2
Overall	7.6	4.8	6.5
Riverside and San Bernardino Counties			
Under 6000	3.3	1.8	2.8
6000-9999	4.9	4.9	4.9
10 000-14 999	6.4	6.4	6.4
15 000-24 999	9.1	5.9	8.7
25 000-39 999	10.7	6.5	10.5
40 000 and over	9.3	3.0	8.8
Overall	6.2	4.1	5.8

[a]No usable data.

The SCAG/Caltrans 1976 Travel Survey discussed above is the source of the trip rates for this estimate. Table 3 from this survey shows the vehicle trips made per household by various income and housing-type groups for three counties in the Chino Hills region. The vehicle rates are for all trips in the counties (including commercial trips except heavy trucks), even though they have been expressed per household (person trips/household were typically 1.4 times higher). Rates under the headings SH are those for single-family homes, those under MH are the trips per day for multifamily housing units. The overall rates are for the 1976 mix of housing types in each county.

The steps in estimating the residential traffic rates for the Chino Hills plan are

1. Start with the rates in nearby developed areas,
2. Correct for underreporting of trips by households,
3. Adjust for expected household incomes in area,
4. Subtract non-home-based trips,
5. Add incoming visitor and service-commercial trips,
6. Adjust for expected mix of housing types, and
7. Correct for recent declines in tripmaking.

All of these adjustments are summarized in Table 4 and detailed below. The joint effect of these adjustments is taken as the product of the individual percent adjustments. Correlations between all the factors are assumed zero except income and housing type; their correlation is accounted for with an assumed coefficient of -0.5.

The baseline for the trip rate adjustments is the average traffic produced by households in the county where Chino Hills will be developed. This is seen from Table 3 to have been 5.8 vehicle trips/day in 1976. Since the development is on the boundary of three counties and similar to those in the others, the unweighted average of the daily rates in San Bernardino, Orange, and Riverside (SB/ORA/RIV) Counties is computed from the table as a more representative baseline. This is 6.15 vehicle trips/day, the first entry in Table 4. The average demographics for these counties were 2.96 persons/household, 71 percent multifamily housing, and $13 000 household income in 1976.

The first adjustment is for the underreporting characteristic of household travel surveys. As stated above the correction factor for this in SCAG area studies is 20 percent. The effect of this adjustment is an average household rate of 7.4 vehicle trips/day, as shown in the second row of the table.

The 1979 average household income for the planning area was $22 400 annually. By using the average of the tripmaking rates of households in this income category from the table for SB/ORA/RIV Coun-

Table 4. Traffic estimate for Chino Hills residential development based on Caltrans/SCAG survey data.

Source or Adjustment Factor	Study Area Parameter	Adjustment (%)	Avg Vehicle Trips per Household per Day
1976 SCAG/LARTS survey	Baseline		6.15
Addition for underreporting	All home-based	+20	7.4
Factor for			
High income per household	$22 400	+31.7	9.7
High multifamily	33 percent multifamily	-2.0	
Remove non-home-based trips	0 percent[a]	-30.7	8.3
Add visitors and service trips	100 percent	+16.4	
Factor for fuel prices and economy	1980 conditions	-4.5[b]	7.9
Avg vehicle trip rate for all households			7.9
Total vehicle trips per day (43 391 housing units)			343 200

[a]Added separately later in traffic forecast. [b]From Travel and Related Factors in California (6).

ties indicates that they produce 32 percent more trips than the average. The income adjustment is taken here to include the effect of automobile ownership, which also influences tripmaking but is highly correlated to income.

In 1976 multifamily housing made up 28.6 percent of the stock in SB/ORA/RIV Counties. Assuming that the proportion of Chino Hills planned for 12 or more housing units per acre will all be multifamily, the area will have 33 percent multifamily units at full buildout. Caltrans survey tabulations on the dependence of traffic generation on housing type indicate that such a housing mix produces 2 percent fewer vehicle trips than the existing mix. The net effect of this and the correlated income factor is a 31 percent increase in the trips, or 9.7 vehicle trips per household per day. This effect is shown in the fourth entry of Table 4.

No adjustment is made for the densities planned for Chino Hills. At the gross area scale they are approximately equal to the existing developed areas from which the trip rates came. This contrasts with developments characterized by ITE that may be at half the prevailing densities. Sensitivities of vehicle trip rates to densities imply the ITE sample may give 15 percent more trips.

The Caltrans survey shows that non-home-based travel--for example, between work and/or personal business destinations--in San Bernardino County is 30.7 percent of the above figures. Thus residential-based traffic is that much lower. However, the traffic to residences by visitors, service vehicles, etc., must be added. Caltrans models for trip attraction show this to be 16.4 percent of all trips (from residential weight of "other-to-home" attractions, according to Gerald Bare, Caltrans District 7, LARTS Division, Los Angeles). The net effect of these two factors is a reduction of 14.3 percent from regional trips. This is shown as the fifth and sixth entries in Table 4.

Studies have shown that trip rates have been falling off more persistently in the late 1970s (5,6,9). The recent Caltrans report shows that vehicle miles traveled per household decreased 3.6 percent between 1978 and 1980, while vehicle trips per household went down 12.6 percent. By using the Caltrans rates of change, adjusted by the NPTS ratios of miles to trips, a decrease of 4.5 percent in vehicle trips per household is implied for California between 1976 and 1980. This adjustment is shown in the seventh entry of Table 4. Since fuel prices are likely to increase disproportionately with the rest of the economy in the future, this may only be the beginning of a continuing trend reducing travel and therefore requirements for road capacity.

The net effect of these corrections and adjustments indicates that the average vehicle trip rate from all housing in Chino Hills will be 7.9 vehicle trips/day. At this rate the 43 000 residences in the Chino Hills plan would generate 343 000 vehicle trips/day. A corresponding estimate made by the traffic consultant for the Chino Hills Plan was 447 000 vehicle trips/day to and from residences, or an overall average of 10.3 per household (10). This is 30 percent above the estimate based on the adjusted Caltrans survey data.

CONCLUSIONS

There is a significant difference between the new estimate and that based on ITE-type data. If the demographic-economic characteristics of the case study area were closer to the southern California average, the difference could have been 50 percent. The reasons for the difference appear to be that ITE household trip rates are from samples with the following special residential characteristics: (a) unusually high family sizes and incomes, (b) unusually low development densities, (c) pre-fuel-crisis observations, (d) little land use mix or balance of services, and (e) lack of maturity of community activities, their populations, and trip patterns. The first two simply represent the kind of identifiable differences in samples treated in Tables 1 and 2. The others are speculated reasons for the remaining 21 percent difference for the equivalent southern California comparison.

Area survey data cover land uses that have a development maturity more appropriate for long-range planning. The ITE data come from limited, exclusive use new areas in the late 1960s and early 1970s. They had not reached the maturity of supporting services, population age distribution, and activity habits of the residents that occur with the long-term fill out of the area--the maximum use condition for which traffic and roads need to be sized. New areas may not be established as a place to live and the new residents may have greater linkages to prior residences or the region as a whole. Some 56 percent of trips from residences are outside of local communities (more than 5 miles) and are influenced mainly by the regional context of travel. New residential developments have in the past been in regions with sparse additional uses because of land costs. They rarely had any significant travel mode alternatives for reaching desired activities. They avoided a mix of nonresidential land uses.

ITE sources usually excluded mixed land use areas because measurements on them would not be pure data for one use. But this fails to reflect the traffic reduction due to walking and short trips. Pure use data will overestimate traffic for larger developments. Current land developments are appropriately not the exclusive land-intensive residential suburbs of the 1960s. They provide a balance of residential and supporting land uses, significant transportation alternatives, and an attractive residential, shopping, and recreational environment to capture many trips. Pure use measurements may be an indication of the traffic on the most local streets, or for very small developments. Nationally, 10 percent of vehicle trips are under 0.5 mile.

Some of the reasons for the lower traffic estimate here may actually further reduce travel in the future. These are the recent declines in vehicle use due to fuel and other automobile prices, the trend toward greater housing density, vehicle leasing or renting, the growth of regional transit, the generally increasing age distribution of the population, and trends in decentralized work places and telecommuting. Thus the overestimates from ITE-type data suggested here for 1980 may become even larger in the future.

It might be argued that the trip rates used for new traffic estimates should be more liberal to account for future growth of household tripmaking or increases in housing densities. This may be a consideration, but if so it should be more explicit. With the present flattening or even decreasing of energy supplies and personal incomes, the saturation and falling off of travel rates in the 1970s may be the future pattern. Densification is more plausible for the future. However, with the price of housing and scarcity of capital, it may not be appropriate to burden new developments with such long-range speculation.

Travel survey data for an area similar to the one to be estimated are the basis of the recommended estimate above. The results here suggest that this would generally be a better basis for new area traffic forecasts than the ITE manual. Most metropolitan areas have travel survey data, by county or smaller areas, updated for current years. The transportation demand compilations of the Urban Mass Transportation Administration mentioned earlier are also a better basis for estimation. Even where these are lacking, choosing comparable survey data and adjusting them by the methods presented here would be preferable to accepting the probable inflation of the ITE data. (Use of the ITE data also assumes a transferability of its sources to areas for which they may not have been collected.)

In times of major fuel price increases and shortages, even people in exclusively suburban settings may not continue to greatly exceed average regional travel. As shown above, people's trip rates have been coming down since the ITE data were compiled. If we do not want excessive expenditures for transportation or unnecessary encouragement of travel by overcapacity, we should not be sizing our roads from traffic generation rates taken from pre-fuel-crisis suburbs.

The lower traffic estimate here suggests that road building for a new area based on the more traditional data would be an excessive use of resources--capital, energy, and land. It would produce a road system compatible with a much more intensive land use than intended by the plan. If uses were held at the intended plan maximums, the excess road capacity would give an over-automobile-oriented character to the area that encourages excessive automobile use and defeats other aspects of the plan to encourage transportation alternatives and stop the propagation of the old syndrome of more roads, more travel, more congestion, and more energy consumption.

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Publication of this paper sponsored by Committee on Passenger Travel Demand Forecasting.

Effect of Urban Character on Transferability of Travel Demand Models

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The effect of urban character on travel demand model transferability is investigated. Urban character was described by urban area size, type of activity concentration, and geographic characteristics, while travel demand measures consisted of trip frequency, trip length, and mode choice and were grouped by work and nonwork trip purposes and by metropolitan and nonmetropolitan areas. A generalized regression dummy variable approach was used for the analysis. The study results show that urban character bears significant influence on travel demand, and the model transferability varies with demand measures and model specification. The specific findings include (a) the type of activity concentration has a significant impact on trip frequency for nonmetropolitan areas and trip length for both metropolitan and nonmetropolitan areas; (b) the influence of urban area size on mode choice and trip length is significant for metropolitan areas; (c) the impact of geographic characteristics on travel demand can be ranked in order of trip length, trip frequency, and mode choice; (d) metropolitan trip frequency models are more transferable than their nonmetropolitan area counterparts, while the transferability of trip length models of both metropolitan and nonmetropolitan areas is very low; and (e) in nonmetropolitan areas, nonwork trip frequency models are more transferable than work trip models.

Experience in modeling indicates that a powerful organizing paradigm seems to generate its own problems. This is particularly true when dealing with such a complex reality as travel behavior in which influential elements observed may be merely partial and distorted. Some of the perceived elements are rigorously analyzed while others may have been completely overlooked. For instance, in the conventional method of trip generation analysis, land use variables have been used to determine trip production and attraction. However, these variables should not be considered as all-inclusive parameters that affect travel behavior. To illustrate, if the values of significant land use variables were identical for different urban areas, habitual travel behavior would indicate that each urban area would always remain different from that of every other. This implies that some other uncertainties must exist that also influence the desire for travel.

Each urban area has its own character, which may be typified by urban area size, activity concentration, geographic characteristics, etc. The urban character can be considered as the base conditions of a given urban area that dictate the activity sys-