PAPER

Improving Air Quality Models in New York State
Utility of the 1995 Nationwide Personal Transportation Survey

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INTRODUCTION

The New York State Department of Transportation (NYSDOT) is legislatively responsible for the management of 14 percent of the 112,000 mi of public roads that carried 52 percent of the 118 billion vehicle miles of travel (VMT) in 1996. These roads are comprised primarily of the Interstate and State Highway System that serve as the backbone for highway transportation in the state. As a state agency, the department is concerned with many issues including infrastructure maintenance, safety, mobility, economic development, congestion management, and air quality. The department's capital program is multimodal with investments in public transportation facilities, as well as constructing, operating, and maintaining the highway infrastructure. Its goal is to ensure transportation access and mobility to all of its citizens.

This paper will describe several analyses of the 1995 Nationwide Personal Transportation Survey (NPTS) undertaken by the NYSDOT. These analyses are presented to illustrate the value of the NPTS for New York State (NPTS-NY) and the ability of NYSDOT to focus transportation studies on state-based travel characteristics. The analyses address issues raised by the New York State Department of Environmental Conservation (ENCON), the state's environmental agency, and the NYSDOT. They were identified during the development of the Air Quality State Implementation Plan, and related activities, such as creating VMT inventories, updating ENCON's emission model, and the conformity analyses of the department's transportation program.

BACKGROUND

Early travel surveys, limited primarily to automobile and truck travel, were conducted in a number of states between 1930 and 1940 and again between 1950 and 1960. As transportation planning evolved, metropolitan area surveys became more common. In 1961, a survey was conducted by the FHWA to determine on a nationwide basis the characteristics of travel, and the ownership and use of automobiles. In 1969, the NPTS as we know it was conducted. Since then this survey has been conducted almost every 5 years, expanding in scope and geographic coverage. In 1990 and 1995, it was possible for metropolitan areas and states to participate with FHWA to obtain additional samples for greater local coverage.

In each survey prior to 1995, New York State was represented more by its largest urban area (New York metropolitan area), because of its sheer size within the nation than by the distribution of population in other areas—both urban and rural—within the state.

New York State has 12 large urban areas: 3 of which have populations around 100,000; 5 between 250,000 and 500,000 in population; 2 between 700,000 and 800,000 in population; and 1 at 1.2 million in population. The 12th, and the largest, is the 10-county New York metropolitan area with a population of 11.2 million (with 6 of the 10 counties having populations greater than 1 million). Yet as urban as New York State seems, a population of 2.8 million resides in the non-urban counties, making the state the fourth most rural state in the nation in the 1990 Census.

This very diverse population distribution shows why participation in a survey such as the NPTS is important for describing the personal travel characteristics of the different urban and rural areas, or for characterizing the state as a whole. Given the diversity in population sizes, New York State is a microcosm of the country. The nature of the transportation problems are diverse and transportation planning issues facing the state during the next 20 years require a broad but detailed state-level database. Although individual metropolitan planning organizations have conducted area-specific surveys over the years, the most recent comprehensive statewide home interview survey for transportation was collected during the late 1960s.

The recognition of the limitations of existing data that are available to characterize travel on a statewide and urban-area basis and the need to understand non-urban travel led the NYSDOT to choose to become an add-on participant with the FHWA in the 1995 NPTS. The 1995 NPTS, as conducted in New York State, surveyed 11,000 households. The sample varied in size from 425 to 650 households in the primary counties in each urban area and 1,400 households in the remaining rural counties. The New York metropolitan area had almost 4,000 households sampled within its 10-county area. Each county represented a separate sample area varying from almost 300 to 500 households.

In addition to participating in the 1995 NPTS, NYSDOT undertook two separate but related initiatives to address the transportation planning challenges facing the state. The first initiative was the acquisition of a detailed county and sub-county forecast of demographics and business economics, and the development of a VMT model driven by these data. This model is calibrated against the Highway Performance Monitoring System (HPMS) travel data for each of the 12 large urban areas, and the small urban and rural aggregated areas. The second initiative was a review of the state of the practice(s) in travel demand modeling currently in effect in each of the urban areas. Both initiatives, along with the NPTS add-on, will enable NYSDOT to better address the patterns and characteristics of current and future travel in the state.

This paper examines five issues that arose during the reevaluation of air quality inventories and modeling for conformity analysis of the department’s transportation program.

- Telecommuting or Work at Home—a comparison of results from the 1990 Census and the 1995 NPTS. It studies the emerging pattern of an increasing number of workers who “work at home” that suggests a possible reduction in the number of work trips. The remaining four topics originate from the desire of NYSDOT to reflect New York State-based data in ENCON’s use and adaptation of the EPA’s MOBILE Emission Model.
- Hourly Vehicle Distributions—a comparison of hourly NPTS-based vehicle trip

distributions with hourly ground count data.

- Area-Wide Speeds—a comparison of NPTS-derived speeds with four-step model-based network speeds.
- Vehicle Use—a comparison of NPTS-based estimates of annual vehicle usage (miles traveled) with distributions developed by the EPA for use with its MOBILE 6 Emissions Model.
- Engine Mode of Operation—a comparison of NPTS-based estimates of area-wide 24-hour hot and cold starts with the four time period estimates currently being used in ENCON's MOBILE 5b Emission Model.

TELECOMMUTING OR WORK AT HOME

After the 1995 NPTS data became available, analysis of total travel, not just journey to work travel as in the 1990 Census, became possible. One of the first questions posed was whether telecommuting or working at home was affecting the journey to work. If technology such as cellular telephones, laptop computers, and Internet access typically used by the mobile work force were having an impact, then a significant change in the number of workers working at home should appear in the data. Unfortunately, neither the Census nor the 1995 NPTS specifically addressed "telecommuting" as a work activity. While this is a definite shortcoming, both surveys identified in different ways the number of workers who worked at home.

Focusing on this issue, the 1990 Census asked about mode to work: "How did this person usually get to work last week?" One possible response was "work at home." The 1995 NPTS asked a very different question: "What is the one-way distance from your home to your workplace?" Possible NPTS responses included the specific number of blocks or miles coded as "goes to work," and two alternatives when distance was not provided, "no fixed work place" or "works at or out of home." The intent of the 1995 NPTS category "no fixed work place" was meant to capture migrant workers following work, as in construction or farming. This category may also contain sales persons, such as a manufacturer's representative who did not have a fixed-work location, and who may not have work from home. Unfortunately, the 1995 NPTS lacked a category to describe the classification of the work site, job, or why a person was working at home.

Table 1 illustrates the number of workers and the percentage of those who "work at home" for both the 1990 Census and the 1995 NPTS-NY. The data for New York State are summarized in this table for the sample strata with the constituent counties noted. The number of workers who "work at home" in the 1995 NPTS-NY was about double that of the 1990 Census. The 1990 Census sampled 16.7 percent of the households in New York State. The 1995 NPTS sampled 0.2 percent of the households in 1995, a smaller number, but reliable at the 95 percent confidence level. Table 1 shows that the number of workers who "work at home" in New York State has increased from 2.6 percent of all workers in the 1990 Census to 5.1 percent in the 1995 NPTS-NY. This doubling has occurred in most areas shown in Table 1. However, it is interesting to note that the share of the workforce working at home is highest in Ithaca, Glens Falls, Poughkeepsie, Westchester, Putnam, and Rockland counties and the aggregate "rest of state" area. These areas may be viewed as places where workers may commute a much longer distance to an employment location in a nearby urban area (e.g., Ithaca to Syracuse or Binghamton, Glens Falls to Albany, Westchester, Putnam, and Rockland counties to New York City, and any of the rural counties to an urban area).

The observation that the increase in "work at home" is occurring across the state, and is an increasing proportion of all workers in areas with "long commutes" to a nearby urban area, raises a number of further policy questions. In what areas will "work at home" continue to increase and at what rate? In which industries, job classifications, or professions are these workers engaged? Can reasons for working at home be enumerated? Clearly the findings of Table 1 suggest that the design of the year 2000 NPTS must focus more attention on these questions.

TABLE 1 Working at Home, Census Versus NPTS

	1995 NPTS			**1990 Census**		
	Work Location			**Table P49—Journey to Work**		
	All Workers	**Work @ Home**	**Percent**	**All Workers**	**Work @ Home**	**Percent**
Upstate Areas (Sample Counties)						
Albany (Albany, Rensselaer, Saratoga, Schenectady)	410,418	20,636	5.0	382,229	8,474	2.2
Glens Falls (Warren, Wash.)	58,973	5,633	9.6	51,864	1,933	3.7
Utica–Rome (Herkimer, Oneida)	150,829	8,446	5.6	135,041	3,891	2.9
Syracuse (Onondaga)	244,025	13,694	5.6	223,650	5,295	2.4
Ithaca (Tompkins)	49,853	3,050	6.1	45,175	1,990	4.4
Rochester (Monroe)	366,085	11,307	3.1	347,088	7,403	2.1
Buffalo (Erie, Niagara)	562,013	16,997	3.0	531,122	9,808	1.9
Elmira (Chemung)	40,657	1,784	4.4	40,325	881	2.2
Poughkeepsie (Dutchess)	136,474	8,371	6.1	125,726	2,991	2.4
Binghamton (Broome, Tioga)	114,967	4,920	4.3	121,274	3,201	2.6
Newburgh (Orange)	157,607	7,984	5.1	141,664	3,406	2.4
Upstate Urban Area Total	2,291,901	102,822	4.5	2,145,158	49,273	2.3

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TABLE 1 (*continued*) Working at Home, Census Versus NPTS

New York Metropolitan Area (Sample Counties)						
Bronx	447,511	16,723	3.7	429,777	5,379	1.3
Kings	966,600	30,513	3.2	907,010	14,510	1.6
New York	845,535	56,275	6.7	754,148	41,102	5.5
Queens	950,510	41,488	4.4	918,063	13,372	1.5
Richmond	194,047	3,751	1.9	174,090	2,456	1.4
New York City Total	3,404,203	148,750	4.4	3,183,088	76,819	2.4
Nassau	672,349	30,490	4.5	650,947	16,383	2.5
Suffolk	701,974	37,757	5.4	652,989	12,794	2.0
Putnam/Rockland (Combined for NPTS)	192,409	13,915	7.2	177,973	4,481	2.5
Westchester	439,844	33,930	7.7	437,753	13,813	3.2
New York Metropolitan Suburban County Total	2,006,576	116,092	5.8	1,919,662	47,471	2.5
Rest-of-State	1,071,958	77,166	7.2	972,705	39,659	4.1
New York State	8,774,638	444,830	5.1	8,220,613	213,222	2.6

Shown by NYS 1995 NPTS Sample Stratum.
Source: Unpublished 1995 NPTS data extracted from FHWA NPTS website: http://www-cta.ornl.gov/npts. 1990 Census, Journey-to-Work, available from BTS on 1990 CTPP CD-ROM or from Census website: http://www.census.gov. Prepared by: NYSDOT, Planning and Strategy Group, March 1998

HOURLY TRAFFIC DISTRIBUTION ALTERNATIVE

Air Quality Analysis is a cooperative activity between ENCON, which performs the emission's analysis, and NYSDOT, which develops the VMT inventory and related highway measures for use with the state implementation plan. The VMT inventory provides county level area-wide estimates of VMT based on HPMS data by rural, small urban, and large urban areas, as well as by roadway functional classification.

This section will focus on the use of the 1995 NPTS-NY as a source for hourly vehicle distributions to provide greater detail to improve upon the traffic count distributions developed in 1992. That year, ENCON observed that modeled emissions began to increase in the morning and then drop off by 10 a.m., but did not rise again until early afternoon following the apparent pattern of the hourly ground count distributions. This was in stark contrast to ozone formation that was observed to increase throughout the day. The NPTS collected travel data across the entire day, every day for a whole year. It is possible, therefore, that the 1995 NPTS-NY could shed some light on this problem.

The 1995 NPTS-NY was summarized by urban area strata, for the proportion of hourly "personally occupied vehicle" trips as a percent of the entire day. Since these data represent travel on all roadways within the individual areas, a software routine was developed to construct comparable area-wide hourly vehicle distributions from traffic counts on the state highway system.

Figure 1 contains two curves. The first is the hourly distribution from the NPTS for the Capital District (the counties of Albany, Schenectady, Saratoga, and Rensselaer)—a typical upstate urban area. The second is the comparable area-wide weighted average hourly traffic count distribution for the State Highway System for the same area. This figure shows that the NPTS-NY hourly distribution of vehicle trips generally follows the State Highway System traffic count pattern, especially for the peak periods. However, a midday peak not present in the actual ground count data is observed. This peak is more typical of local nonarterial traffic not typically measured in State Highway System arterial counts.

Since midday peaks occurred in the hourly distributions from the NPTS-NY for all urban areas, a computation of the average hourly trip length was undertaken. If the midday peaks are representative of local traffic, it is reasoned that the average trip length would likely be shorter. Figure 2, for the Capital District Area, illustrates the finding for all urban areas, the average trip length is shortest during the midday peak. The very high values in the early morning hours result from fewer observations and longer trip lengths.

Figure 3 shows the area-wide hourly distributions from both the NPTS-NY and the State Highway System for New York County.

As in Figure 1, the prominent midday peak is present along with two or more significant peaks in the evening period. This particular pattern was found in the hourly distributions for each of the five counties within New York City. The counties of Nassau and Suffolk, east of New York City, and the counties of Westchester, Rockland, and Putnam, north of New York City, exhibited hourly distribution patterns similar to typical urban areas in the state, as depicted by Figure 1. Depending upon the individual county within New York City, the size of the peaks varied. However, each showed an evening rush hour peak around 5 p.m., an after rush hour peak around 7 p.m., and a smaller

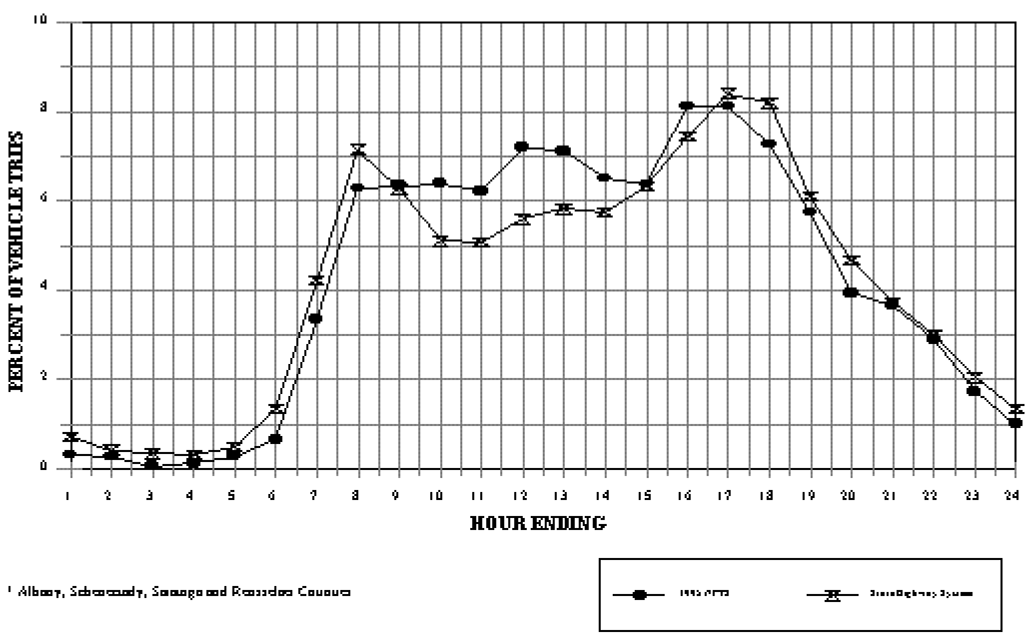
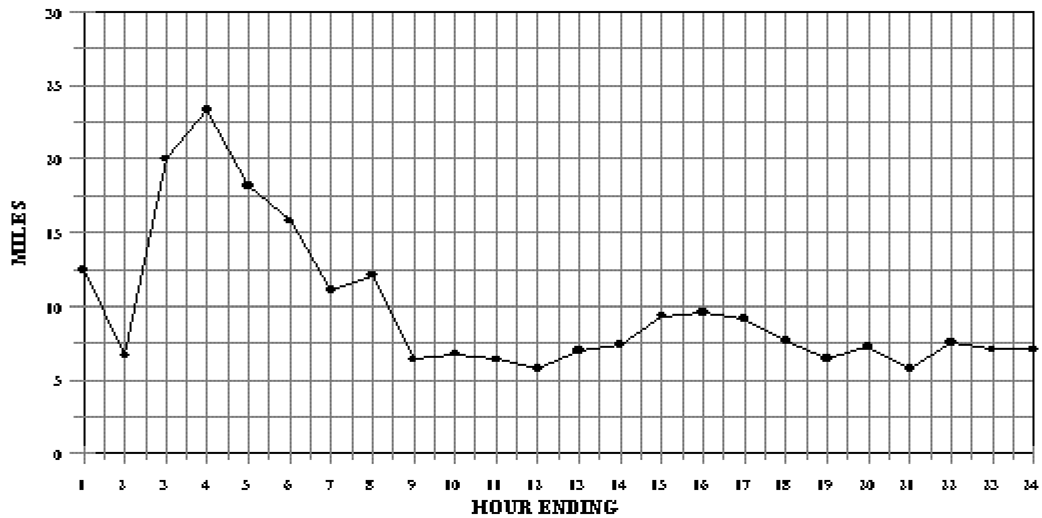


FIGURE 1 24-hour vehicle distribution—Capital District Area.



* Albany, Schenectady, Saratoga and Rensselaer Counties

FIGURE 2 Average trip length by time of day—Capital District Area.

late night peak around 10 or 11 p.m. It is probable that the characteristics of New York City, (population density, the individuality of each county as a city within a city, or the nature of local self-contained neighborhoods) may explain the personal vehicle travel behavior noted in the evening peak, compared with that of Figure 1 for typical upstate areas.

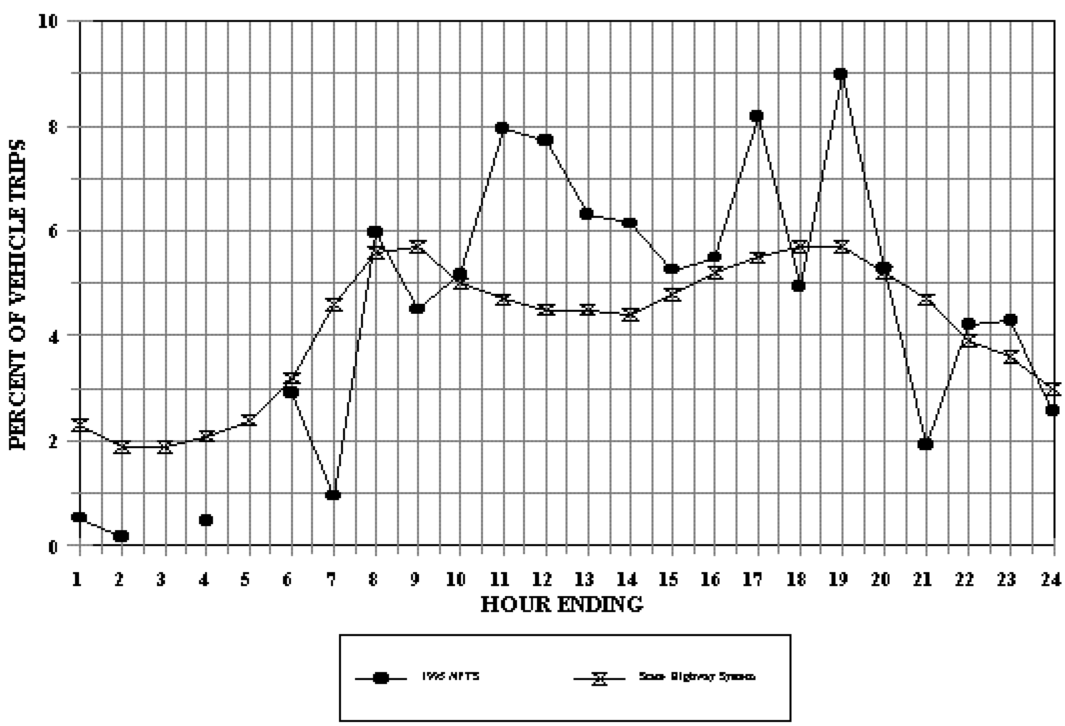


FIGURE 3 24-hour vehicle distribution—New York (Manhattan).

These data were provided to ENCON for each of the urban areas in New York State. For the New York metropolitan area, the 10 individual county distributions were provided. ENCON replaced the upstate, downstate, and rural hourly distributions with specific NPTS-NY hourly distributions and tested the effects on the EPA MOBILE Emissions Model output. This test showed that the modeled hourly emission results more closely correlate with the increasing hourly profile for the measured ozone data with no significant net change in the overall level of emissions.

In summary, the data from the NPTS-NY has provided more reliable area-wide hourly traffic distribution for use with ENCON's MOBILE Emissions Model. The distribution fits the expected progression of area-wide emissions throughout the day. The NPTS-NY has also shown that the department's ground count program, when taken in the aggregate, is a good indicator of hourly arterial traffic distributions, but not overall areawide traffic that includes local roads. Lastly, the NPTS-NY has identified differences in hourly distributions for the evening peak period within the five counties of New York City that requires further examination.

SPEED FROM TRIP LENGTH AND TRAVEL TIME ESTIMATES

One of the critical input parameters for EPA's MOBILE Emissions Model is the estimate of speed by roadway functional class and time of the day. All transportation projects planned for an air quality non-attainment area are required to demonstrate conformity with the area's emission target. Low speeds and an increasing number of stops per mile are indicative of both high levels of congestion and emissions. As a result, NYSDOT was interested in validating and assessing the accuracy of the speed estimates in current usage.

In 1992, speed estimates by functional classification were developed from each of the urban area network travel-demand models. They were based upon Highway Capacity Manual volume to capacity ratios (V/C) and empirical speed data gathered from the field. Three years later, the NPTS-NY collected respondent trip length and travel time that could be used for computing a respondent trip speed. In addition, NYSDOT had the Research Triangle Institute geocode all trip ends during the conduct of the NPTS-NY. As a result, a separate geocoded data set exists for New York State.

This section compares several survey-based speed computations and the network travel-demand model-based speeds on an urban area-wide basis. In order to examine these different speeds, it is important first to acknowledge some problems with the data:

Survey-based travel time clusters around the hour, half, or quarter-hour period. Survey-based distances are reported in whole units and usually rounded to the nearest mile.

The geocoding of the origins and destinations are accurate to the street address, nearest intersection, or zip code centroid.

Computation of a straight-line distance between an origin and destination ignores the actual path within the grid-based street network that a traveler might use.

Speeds estimated from calibrated network travel-demand model assignments are predominantly from arterials and subject to the uniform applicability of capacity type calculations and assumptions about headway and observed V/C at given speeds. Additionally, the tolerance for link volume variations from actual traffic count volumes may introduce variability for V/C and therefore speed calculations from network assignments.

Only area-wide speeds can be computed from the NPTS-NY. These are obtained by dividing the reported survey trip length by the reported travel time and for the geocoded records by using the computed coordinate length between the origin and the destination (the straight-line distance). For comparability, the network travel-demand model speeds by roadway functional class were weighted by VMT to construct area-wide speeds for each of the urban areas or counties.

Table 2 contains five columns that compare the computed area-wide speed estimates for the different urban areas or counties. The definitions for these columns are:

1. Speeds computed from all NPTS-NY trip records for personally occupied vehicle trips using the respondent's reported trip length and travel time;
2. Speeds computed from the respondent's reported trip length and travel time using personally occupied vehicle trip records from the 82.5 percent of all records for which geocoded information exists;
3. Speeds computed from the geocoded straight-line trip length and the respondent's travel time using the same data records as in (b);
4. The speed ratio derived from (c) divided by (b); and
5. The VMT weighted average area-wide speeds used by ENCON's MOBILE Emissions Model.

Speeds from the NPTS-NY are computed in a fashion similar to the interval grouping for speed-based ground counts. The trip records are summarized by speed intervals and the percentage of the total computed for all records within each urban area or county. The weighted harmonic average speed for each area is then computed using the midpoint of each speed interval and its percentage.

Several interesting observations regarding Tables 2 and 3 are noted.

The speeds from the selected set of survey records that have geocoded trip ends (b) are not appreciably different from those of the entire survey data set (a) for New York State.

In less congested upstate urban areas, the network-based speed estimates (e) from the travel-demand model assignments provide speeds that are on average 25 percent higher than the survey-based speeds (b).

In the 10 individual counties within the New York metropolitan area, the conclusions on speed are varied. For the five counties within New York City except the Bronx, and the suburban counties of Rockland and Putnam, the network-based speed estimate (e) is lower than the survey-based speed (b). In most instances the network speed seems to fall between the survey speed (b) and the coordinate length estimates (c) except New York County. In this instance, the network speed estimate (e) is half the survey estimate (b).

TABLE 2 Estimated Speeds by Stratum

	(a)	(b)	(c)	(d)	(e)
	All NPTS records	**NPTS records with O/D coordinates**			
Stratums[1]	Survey Trip Length/ Survey Travel Time	Survey Trip Length/ Survey Travel Time	Coordinate Trip Length/Survey Travel Time	Coordinate Trip Length(c)/Survey Trip Length(b)	NYS ENCON (Weighted Average Area Speeds 1992 SIP)
Upstate Areas					
Albany	28.05	29.94	23.36	78.0%	35.8
Glens Falls	29.22	30.78	25.67	83.4%	39.5
Utica–Rome	29.29	32.14	26.11	81.2%	37.0
Syracuse	29.83	31.60	22.66	71.7%	33.7
Ithaca	28.31	31.09	25.73	82.8%	38.1
Rochester	28.97	30.64	23.03	75.2%	31.6
Buffalo	26.35	29.28	22.20	75.8%	40.5
Elmira	27.02	27.67	21.45	77.5%	35.1
Poughkeepsie	28.83	31.05	25.11	80.9%	35.8
Binghamton	29.22	30.72	26.99	87.8%	36.8
Newburgh	21.22	22.07	18.88	85.5%	36.1
Small Urban and Rural Areas					
Small urban in rural counties	24.54	28.78	25.92	90.0%	
Rural counties w/o small urban	31.57	34.61	29.07	84.0%	
New York City					
Bronx	18.57	19.71	15.06	76.4%	21.0
Kings	17.40	18.96	12.49	65.9%	16.6
New York	19.93	19.53	14.88	76.2%	9.6
Queens	21.79	21.33	17.45	81.8%	17.5
Richmond	20.84	21.49	16.44	76.5%	18.7
Nassau	22.91	26.10	19.62	75.2%	17.5
Suffolk	27.98	28.63	22.75	79.5%	23.7
Putnam/ Rockland	30.51	30.87	20.61	66.8%	29.5
Westchester	25.21	25.42	20.06	78.9%	26.7
			Average Ratio (c)/(b)	78.7%	
			SD	5.9%	

[1] NYS 1995 NPTS Add-on Stratum (Primary Urban County).

TABLE 3 Estimated Speeds by Trip Purpose

	(a)	(b)	(c)	(d)
Trip Purpose (1)	**Survey Trip Length/Survey Travel Time**	**Survey Trip Length/Survey Travel Time**	**Coordinate Trip Length/Survey Travel Time**	**Coordinate Trip Length(c)/Survey Trip Length (b)**
Work		31.80	23.95	75.3%
Shop		28.04	22.64	80.8%
School/Religion		26.41	20.11	76.2%
Personal		27.25	20.65	75.8%
Social/Recreation		30.87	22.85	74.0%
Home		27.82	21.85	78.5%
			AVG ratio	76.8%
			SD ratio	2.2%

[1] WHYTRP95 Re-code Home = codes 17; Work = codes 1–3; Shop = codes 4; School Religion = codes 5–6; Personal Business = codes 7–10; Social Recreation = codes 11–16.

DIFFERENCES IN TRIP LENGTH ESTIMATES

Column (d) in Table 2, shows that the NPTS-NY straight-line speed (c) is 78.7 percent of the survey length-based speed (b) with a deviation of ±5.9 percent. Travel time is constant in each of the speed estimates and the ratio of these two weighted average speed measures essentially yields the ratio of the coordinate and survey trip length. This means that the coordinate-based trip length is 73 percent to 85 percent of the respondent-based trip length in the survey.

Table 3, column (d) shows that even for different destination trip purposes, the proportional relationship of speed based upon the survey in column (b) is 76.8 percent of the speed based upon the coordinate or straight-line distance (c) with a deviation of ±2.2 percent. This indicates that trip purpose is not a factor in this difference.

Straight-line distance between two points views the urban street grid system from the standpoint of the Pythagorean Theorem. Evaluating a right triangle with values of two sides between 0.25 and 7.0 in one-quarter increments shows that the ratio of the hypotenuse to the sum of the other two sides is 77.7 percent, with a variation of ±7.4 percent. Therefore, the difference between straight-line or coordinate distance and survey trip length may be attributed to highway system geometry and not respondent estimation error, because people do not generally travel in a straight line.

In a somewhat related analysis that examined a geographic information system (GIS) -based network routing solution for geocoded trip data in the Syracuse urban area, a much more interesting finding was discovered regarding the accuracy of respondents' reported trip length estimates. The average NPTS-NY personally occupied vehicle trip length in the Syracuse area is 9.08 mi. For personally occupied vehicle trip records with intersection geocoded origins and destinations, 63 percent of the time the respondent's estimate of trip length was longer than the network-based trip routing solution by no more then 5 percent. Moreover, the respondent's trip length estimate was 5–10 percent longer than the routing solution 36 percent of the time. Only 1 percent of the respondents exceeded the network routing solution by more than 10 percent. A 5 percent error in the respondent's trip length, converts to a difference of less than a half mile. Considering that the respondent is probably rounding distance to at least the nearest mile, this difference suggests that the respondent's estimate may be very reliable.

The examination of the NPTS-NY and its geocoded data leads to the conclusion that the network travel-demand model estimated speeds are a reasonable approach. However in the less congested upstate urban areas, the network speeds tend to provide higher calculated area-wide speeds than the survey would suggest. In the more congested counties within the New York metropolitan area, they are much closer to the survey-based area-wide speeds. The only exception is in New York County (Manhattan), which requires further examination. Straight-line trip length appears to be less accurate than the respondent's trip length estimate. However, the GIS network-based trip routing solution for intersection geocoded data in the Syracuse urban area suggests that the respondent's estimate is an accurate estimate of the actual trip length.

ANNUAL VEHICLE UTILIZATION

Vehicle emissions are a factor of vehicle age, type, and annual usage during the year. Emissions vary by vehicle model year, as well as a model year's proportion of the total vehicle population. Vehicle age distributions by vehicle type are readily obtainable from the New York State Department of Motor Vehicles registration data files, but actual vehicle usage is not. The NYSDOT was concerned that national level data recommended for use with EPA's MOBILE 6 Emissions Model would not be appropriate for New York State. One of the component data sets in the NPTS is the vehicle file. The vehicle data from this file were examined to compare the average annualized vehicle odometer readings with the U.S. distributions and fitted data being supplied with EPA's MOBILE 6 Emissions Model.

Figure 4 shows this comparison for light-duty gas vehicles (LDGV) or "autos." Figure 5 shows this comparison for light duty gas trucks (LDGT) or "pickups, sports utility vehicles, and vans." Both figures show the raw data and the fitted exponential curves for both the United States and New York State.

Figures 4 and 5 contain the fitted exponential curves calibrated against the New York State and U.S. average annualized vehicle odometer readings. The figures show that the fitted EPA data are significantly different from the fitted New York State data. Of 75,217 vehicle records in the U.S. data set, average annualized mileage was computed for 42.7 percent of the vehicles. Of the 17,606 vehicle records in the New York State data set (which are part of the national set), average annualized mileage was computed for 46.2 percent of the vehicles.

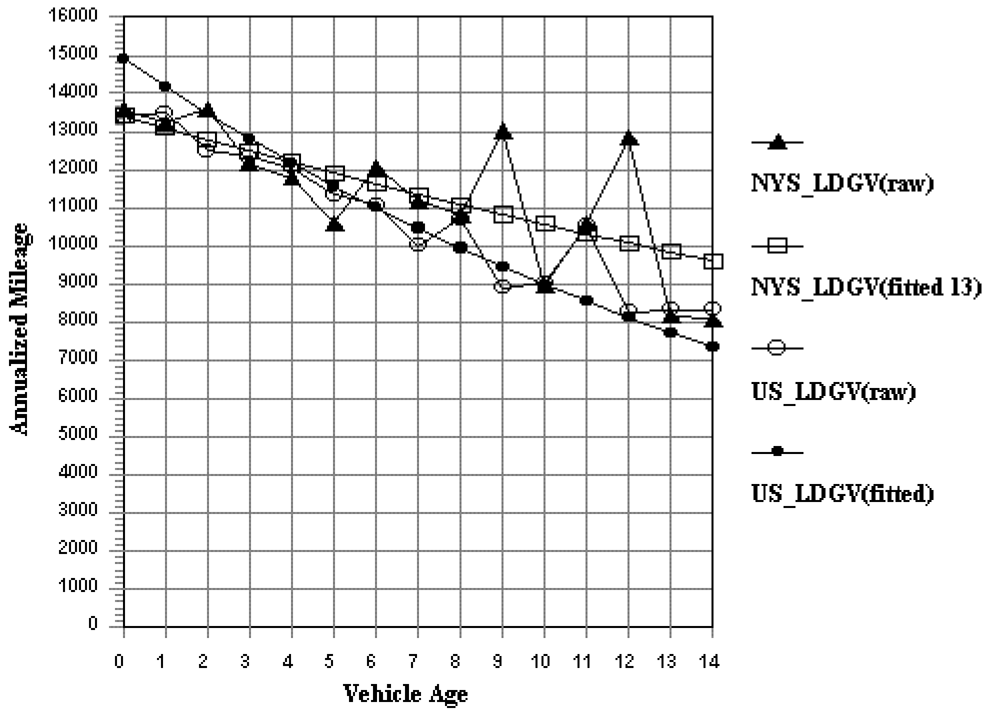


FIGURE 4 Annual vehicle utilization—LDGVs (autos).

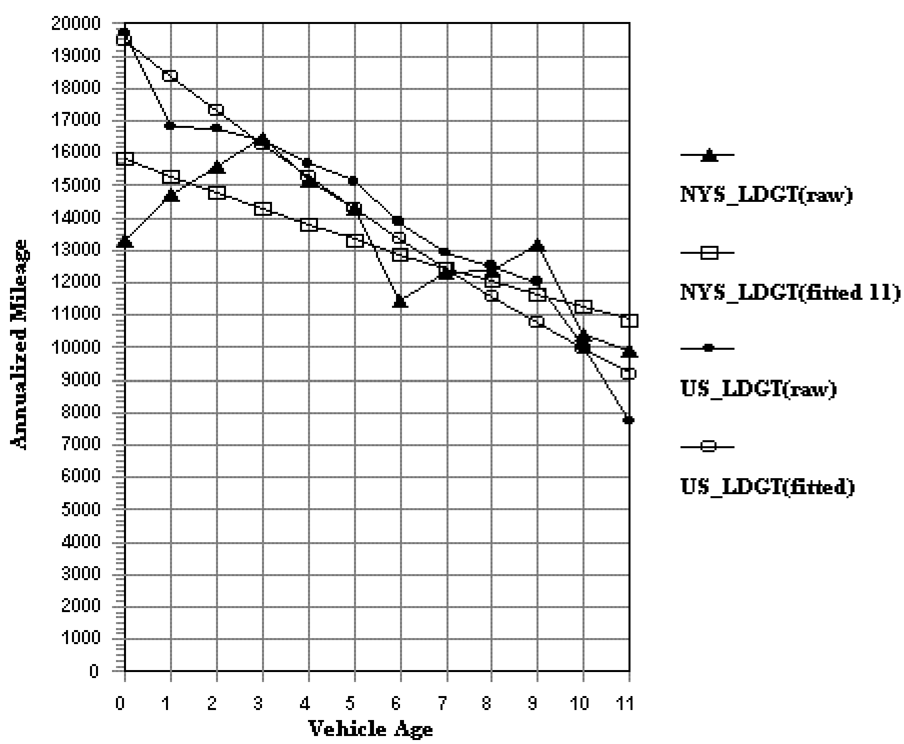


FIGURE 5 Annual vehicle utilization—LDGTs (pickup, SUV, and van).

Examination of the New York State data set shows extremely wide variations in annualized mileage for vehicles older than 14 or 12 years of age (not shown), respectively, for both autos or light trucks. Table 4 shows the average number of data points represented by each average annualized mileage point for all vehicle ages and those in Figures 4 and 5. Variability in a data set due to outliers or, in this case, too few observations, significantly influences the ability to fit a reliable curve to the raw data. Although these observations are readily identifiable in the New York State data set, the number of observations used in the EPA analysis for MOBILE 6 is not known. A larger data set drives average annualized mileage variation toward the mean in each age cohort and significantly reduces the variability in the data. If this were a problem in the EPA data set, its resolution is unknown, because the data do not exhibit extreme values for average annualized mileage. As a result, the equations fitted for the New York State data were done for vehicle ages 0–13 years for autos, and 0–11 years for light duty trucks as in Table 4.

Examination of the resultant fitted curves in Figures 4 and 5, showed that the New York State average annualized mileage does not decline as rapidly as the national data set, especially for autos, and that newer light trucks in general have a lower rate of use than in the nation. Figure 4 shows auto use in New York State remains higher over a longer period than for the United States. The initial annual utilization rates for autos and light trucks are noticeably lower in the first 3 years than it is for the United States. Last, while LDGTs have a lower initial average annualized mileage it rises above the national average as the vehicle moves into the 7–10 year age group.

Figure 6 compares the age distributions for LDGVs and LDGTs in the 1996 national fleet with the 1997 New York State Department of Motor Vehicles “Vehicles in Operation” data, and the 1995 vehicle age distributions from the NPTS-NY. The proportion of 5- to 10-year-old vehicles in the New York State fleet exceed that for the nation based on the area under the curve for these age cohorts. In addition, for all vehicle age cohorts of 2–10 years, the New York State vehicle fleet has higher distribution proportions than the national of which it is part. This indicates that a vehicle’s retention in the fleet lasts longer in New York State. It is possible that this is the result of the high level of public transit use, primarily in New York City, and the lower per capita vehicle ownership that results. The rate of vehicle retention coupled with the difference in annual usage rates for autos and light trucks in Figures 4 and 5 will affect emissions.

TABLE 4 Number of Survey Records with Annualized Mileage

Age Cohort	LDGV Average Number of Records		Age Cohort	LDGT Average Number of Records
0–13	391		0–11	164
14–62+	15		12–77+	12

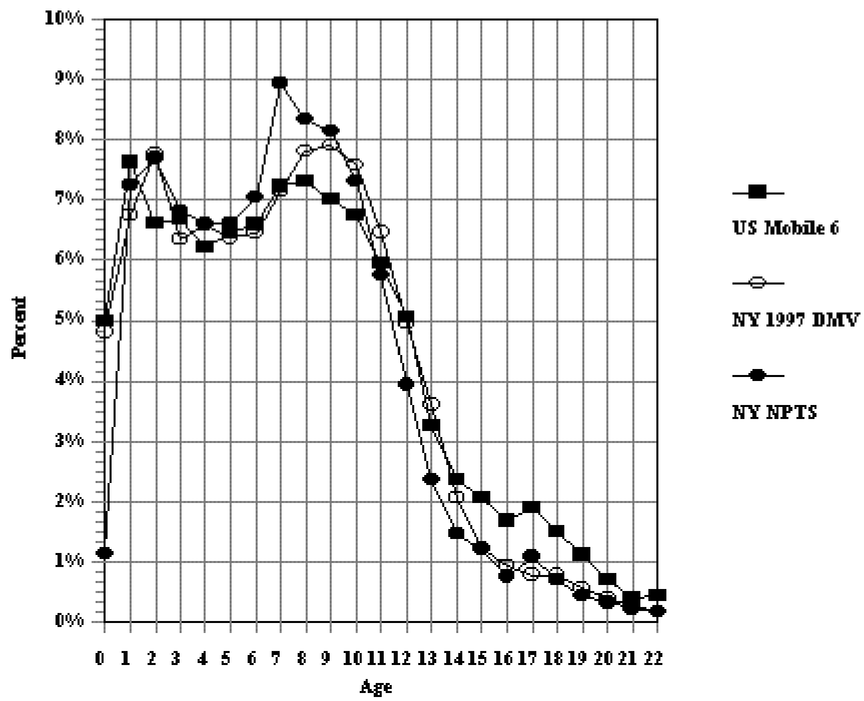


FIGURE 6 Vehicle age distribution—autos and light trucks.

ENGINE MODE OF OPERATION

Estimates of hot and cold start percentages are the most problematic of the input parameters to the MOBILE Emissions Model. In particular, the range of cold start modes of operation can have as much impact on emissions as speed and ambient temperature input ranges; yet it is more difficult to assess. The current MOBILE 5b Emissions Model in use by ENCON relies upon percent cold proportions established in 1992. These data were based upon estimates derived from several studies described in the literature dating from the late 1970s to the late 1980s. The percentage of hot and cold starts were synthesized for four time periods. The time periods or bands reflected peak and off peak periods in a typical 24-hour traffic volume distribution. The data were prepared for three highway categories (Interstate and Expressway, Arterial, and All Other Roadways). The data were also weighted by the VMT in each highway category. At the time this approach relied upon engineering judgment and the best available data.

The 1995 NPTS-NY provided the opportunity to reexamine this issue both geographically and temporally within a 24-hour period. Because the 1995 NPTS-NY was a residential home interview-based survey, it was only possible to compute area-wide estimates. This approach required the computation of the number of hot and cold starts for the trips taken by each vehicle in the household. By sequencing the trips for the individual vehicles, the duration between the end of one trip and the beginning of the next can be calculated. If the duration between trips was greater than 60 minutes, a cold start was determined. A cold start was assumed for the first trip of the day for all vehicles.

Engine mode of operation was classified into four categories. These categories are based on the length of time (duration) between the ending of one trip and the beginning of the next and in the trip length measured in minutes. The 1995 NPTS-NY trip travel time was compared to 9 min to reflect the 505 second Federal Test Procedure engine start and driving cycle.

The duration is more than 60 minutes:

- Cold Start-Cold Mode (CS_CM)—vehicle started cold, driven less than 9 min.
- Cold Start-Hot Mode (CS_HM)—vehicle started cold, driven more than 9 min.

The duration is less than 60 minutes:

- Hot Start-Cold Mode (HS_CM)—vehicle started hot, driven less than 9 min.
- Hot Start-Hot Mode (HS_HM)—vehicle started hot, driven more than 9 min.

Figure 7 shows the 24-hour distribution of the four engine modes of operation for statewide vehicle trips as a percent of all vehicle trips and the percentage of hourly vehicle trips. Categories CS_HM and HS_HM when taken together represent the hot stabilized emission mode of vehicle operation.

Figure 8 uses the duration between engine starts to classify hot or cold starts. The data are presented for statewide vehicle trips as a percent of all vehicle trips and for the percentage of hourly vehicle trips.

Figure 9 shows the number and percent of statewide vehicle trips less than and more than 9 min in duration for vehicle trips as a percent of all vehicle trips and the percentage of hourly vehicle trips.

The 24-hour distribution of statewide vehicle trips in Figures 7, 8, and 9 reflect the temporal traffic distribution described in Figure 1. The morning, midday, and evening peaks are evident in these figures. Figures 2 and 9, describing average trip lengths and trip time, also show consistency. However, differences in the percent of vehicle trips in hours 1 and 24 are displayed in Figures 7 and 8, and to a lesser extent, Figure 9. This may result from too few trips being reported in this period or problems with coding trips that did not start or end on the “travel day.”

Figure 10 shows the hot/cold start distribution from the New York State Department of Environmental Conservation’s MOBILE 5b Emissions Model for “All Other Roads” as the hourly percentage of vehicle trips (in this roadway category statewide). The short individual trip lengths in the NPTS best reflect the “All Other Roads” category (Minor Arterial, Major and Minor Collectors, and Locals) rather than the longer distance trips that would more likely use the “Interstate or Expressways” and/or “Principal Arterial” roadways. Figure 10 suggests that the peak period CS_CM, the midday CS_HM, and the midday stabilized some similarity with those periods in the engine mode of operation data obtained from the NPTS-NY 24-hour statewide distribution in Figures 7, 8, and 9. Variation throughout the day, as shown in Figure 10, is obviously not handled well by the current hot and cold start estimates. The availability of a 24-hour distribution from the NPTS-NY for these data, as well as developing these data for different metropolitan areas within New York State, will clearly have an impact on the accumulation of emissions throughout the day. The mode (CS_HM and HS_HM) estimates currently being used

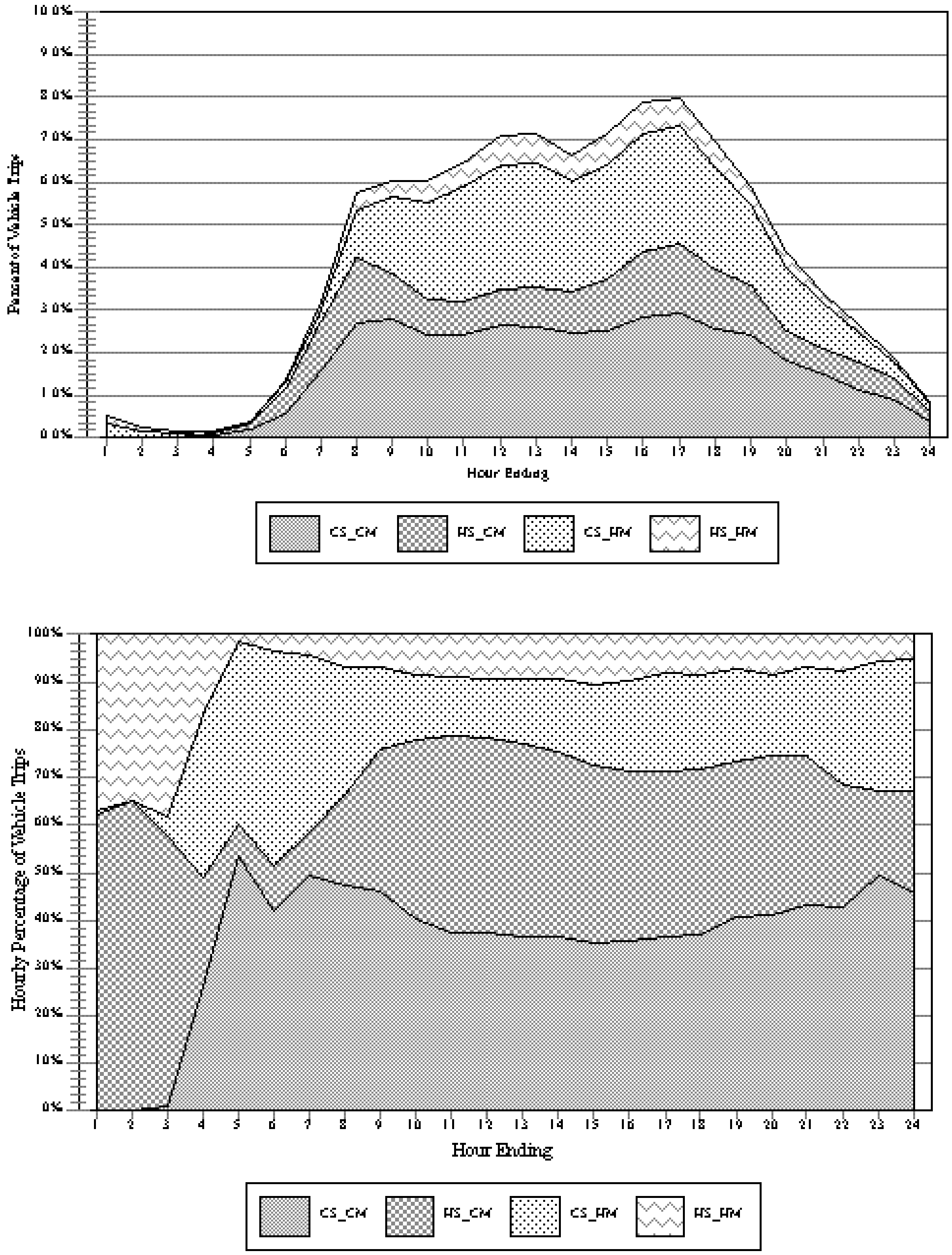


FIGURE 7 Engine mode of operation.

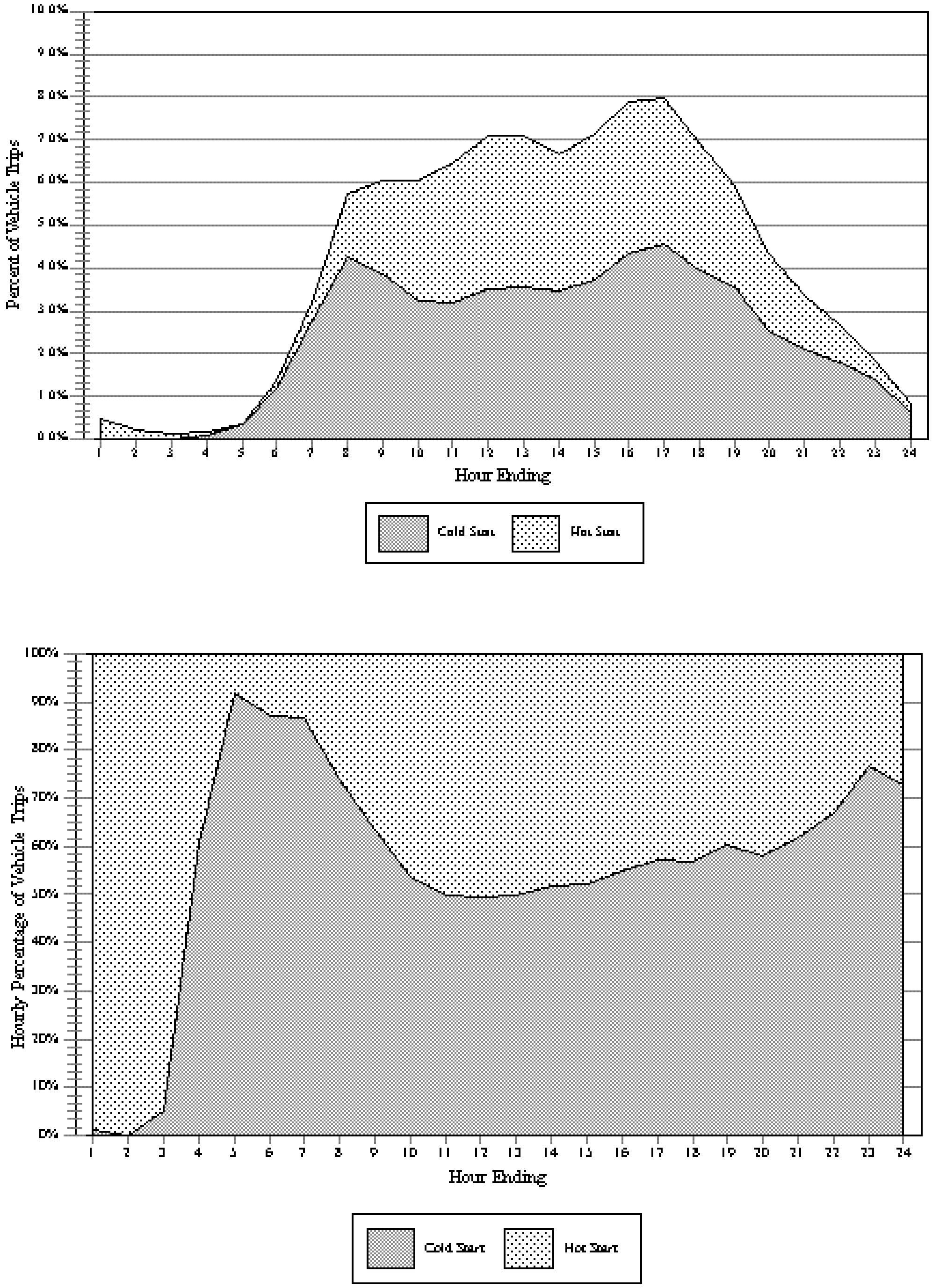


FIGURE 8 Duration between engine starts.

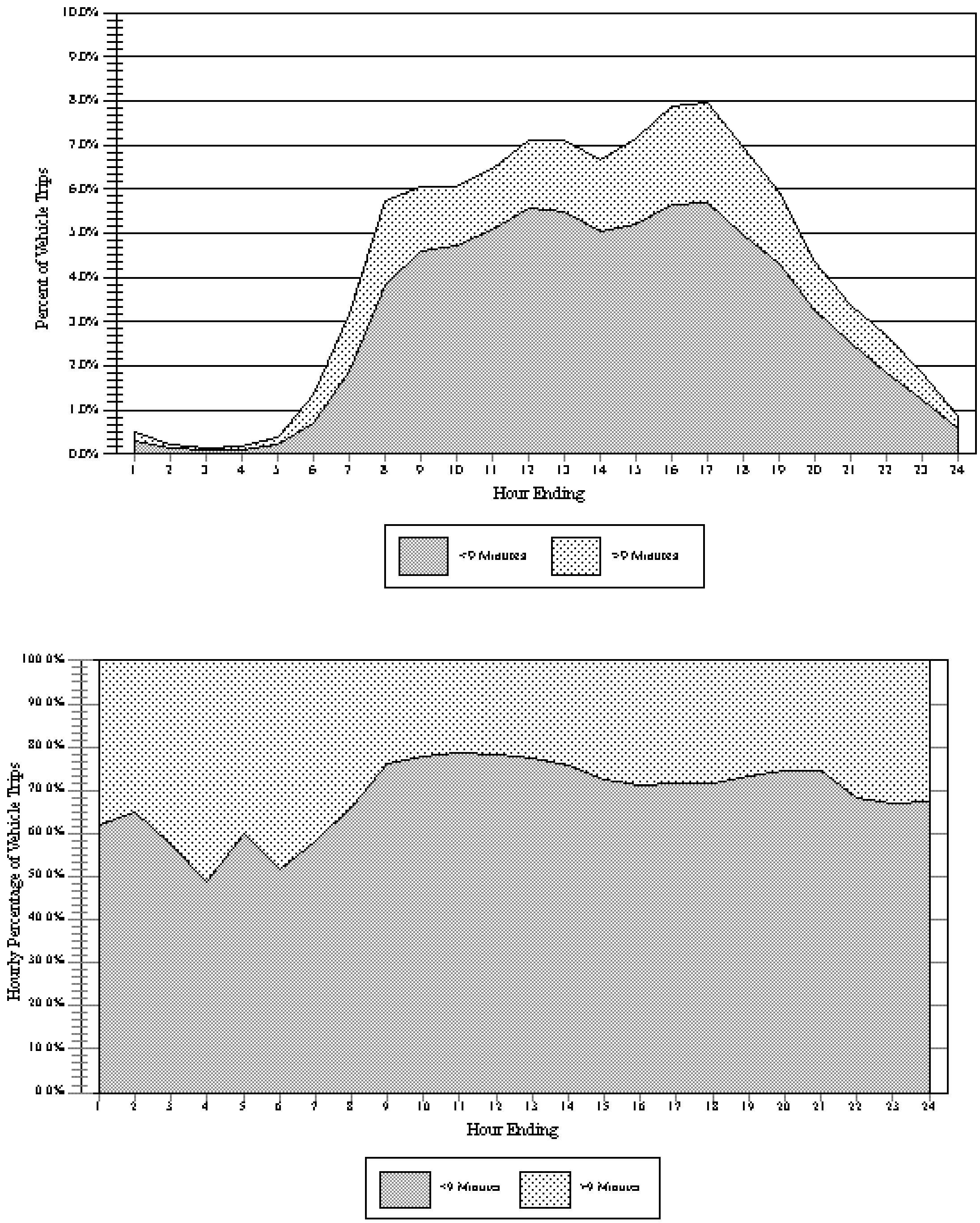


FIGURE 9 Travel time.

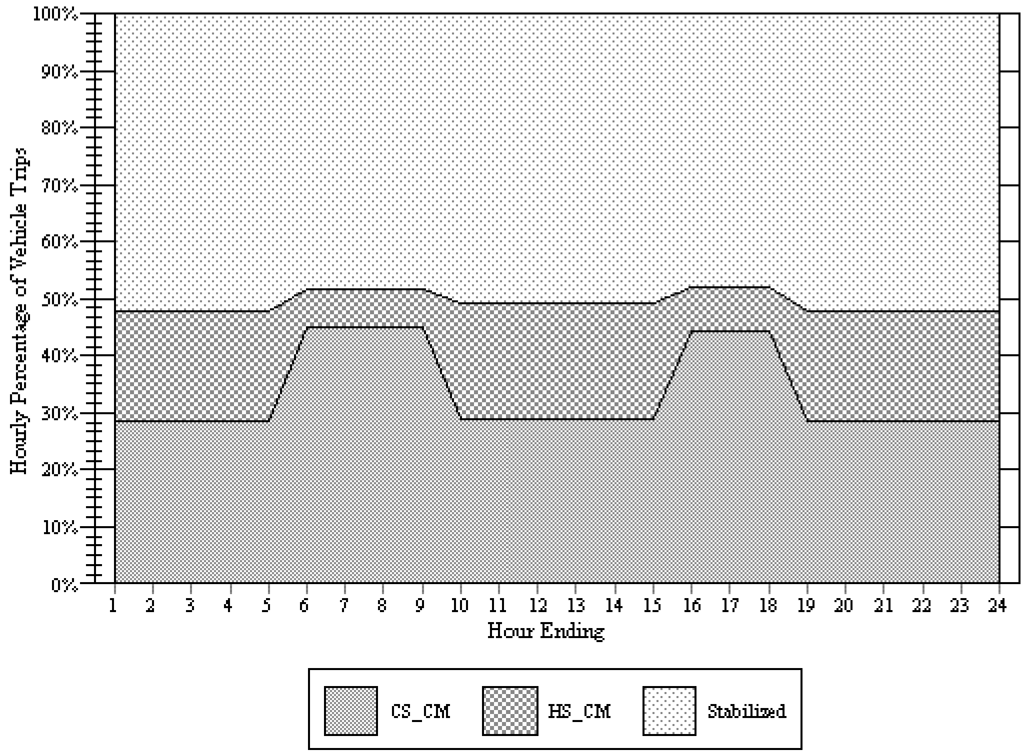


**FIGURE 10 Existing engine mode of operation—
NYSDEC—Mobile 5b (all other roads).**

shared continuous 24-hour statewide distribution obtained from the NPTS-NY also suggests that the hot and cold start estimates for the other two roadway categories may need to be reexamined in light of these findings.

GENERAL FINDINGS

The 1995 NPTS-NY provides a valuable metropolitan area, and in the case of the New York metropolitan area, a county data set to address a variety of transportation air quality related questions. Perhaps the most important finding is that a state specific survey has a major role in addressing state transportation issues, especially those related to using state values in EPA's MOBILE Emissions Model.

The survey shows that the number of workers working at home in 1995 is 5.1 percent of all workers—double that reported in the 1990 Census.

The survey also suggests that while the number of workers working at home is increasing, the real increase may be occurring with those workers who have long-distance commutes to other urban areas for employment.

The findings have demonstrated that this survey can serve as a source for area-wide hourly vehicle distributions.

These area-wide hourly vehicle distributions capture local traffic that is not part of arterial distributions available from traffic counts on the State Highway System.

The survey-based, hourly vehicle distributions have improved the correlation between hourly emission model results and measured ozone data.

Area-wide speed estimates developed from the survey are a useful measure for testing the reasonableness of the network travel-demand model speed estimates.

Area-wide speed estimates from the survey also indicate that the network-based speed methodology may overestimate speeds in less congested areas, and provide comparable speeds in more congested areas. However, speeds in New York County (Manhattan) may require further examination.

A GIS network routing solution for geocoded NPTS-NY vehicle trip data in the Syracuse urban area suggests that the respondents' trip length estimate may indeed be an accurate estimate of how far they travel. However, this requires further confirmation by examining other urban areas in the data set.

Analysis of the vehicle file in the NPTS-NY reveals that national average annualized mileage estimates for auto and light truck usage and the age proportion of these fleets differ noticeably from those for New York State.

Analysis of the engine mode of operation from the NPTS-NY discloses a 24-hour distribution that is significantly different from that currently being used. Implementation of this distribution will impact the accumulation of emissions throughout the day.

RESOURCES

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