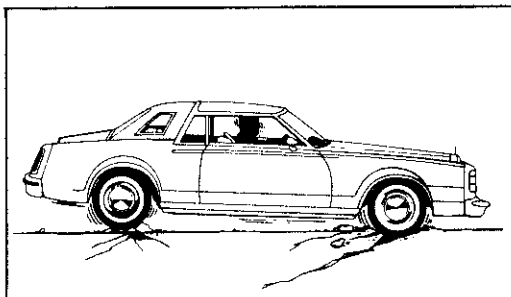
Highway Performance Monitoring System

Case Study Procedural Manual - Vehicle Occupancy



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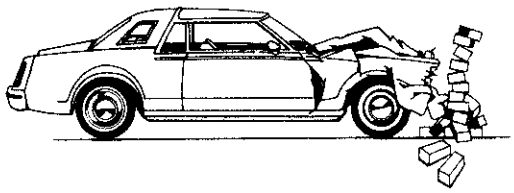

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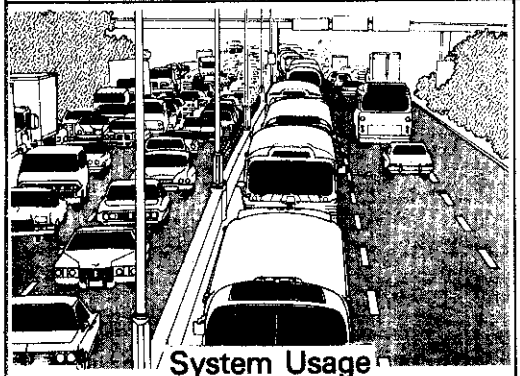

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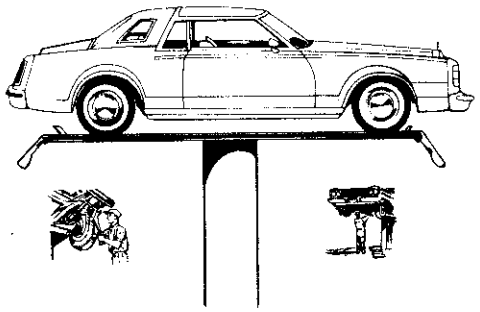

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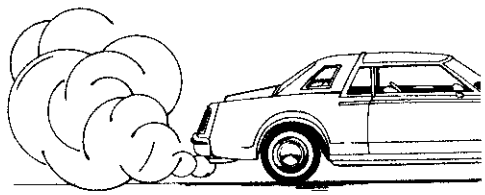

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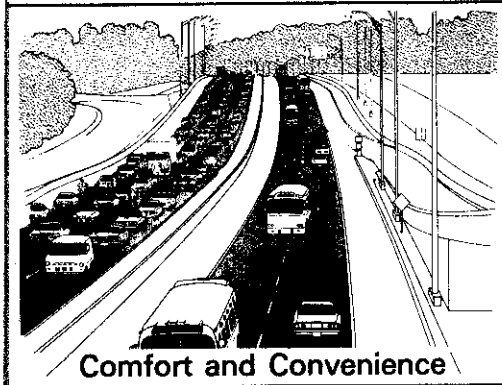

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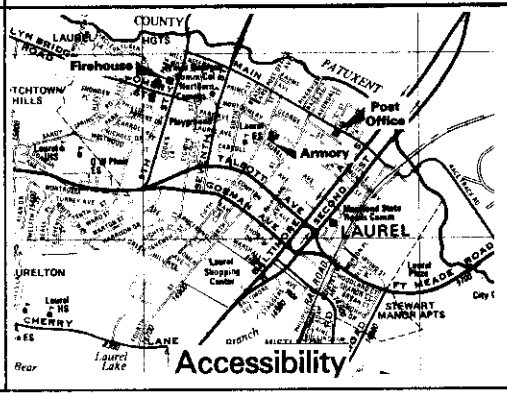

Accessibility

U.S. DEPARTMENT OF TRANSPORTATION

Federal Highway Administration

Program Management Division

June 1979

HIGHWAY PERFORMANCE MONITORING SYSTEM

Case Study

VEHICLE OCCUPANCY

June 1979

Vehicle Occupancy

Introduction

The Highway Performance Monitoring System (HPMS) will provide the Federal Highway Administration (FHWA) with the capability to (1) periodically assess the extent and condition of the highway systems and (2) monitor the performance of the highway systems on a continuing basis. Performance will be monitored through the assessment of the extent and physical condition of the highway systems and the safety, efficiency, and economy of the systems in serving the movement of goods and people. This information base will permit the assessment of the impacts of existing programs and policies and the potential impacts of proposed programs, policies, and alternatives. The HPMS will satisfy the management information needs for most special national studies.

With the energy crisis, increasing fuel costs, and increasing attention to air pollution, the efficiency of the highway systems in moving both vehicles and people has become very important. Traditionally, FHWA has been concerned with the movement of vehicles expressed in terms of estimates of vehicle miles of travel (VMT). The growing concern with the movement of people has been addressed in HPMS by establishing performance measures related to the parameter, person miles of travel (PMT).

Basically, system estimates of PMT will be generated as a function of the vehicle types using the sampled sections of each system, the average occupancy of these vehicle types and the mileage driven by these vehicle types. Since the collection of vehicle occupancy on each HPMS section would be very cost/labor intensive, a case study approach has been chosen to obtain typical values of vehicle occupancy. This case study will be limited to the typical vehicle occupancy of passenger vehicles, including motorcycles and light two-axle, four-tired vehicles. Large vehicles (two-axle six-tired, and larger) are excluded and typical occupancy figures for these vehicle types will be obtained through other means. Buses are also excluded as the States are being asked to provide areawide estimates of bus PMT because HPMS does not adequately sample bus routes, buses are infrequent, and the number of occupants are difficult to observe.

Vehicle occupancy has been measured in several existing programs which include: (1) Vanpool and carpool programs; (2) urban CBD cordon or screenline studies in a few metropolitan areas; and (3) research efforts to develop procedures for obtaining areawide vehicle occupancy in urban areas. Most of the existing programs are not applicable to this case study since they are limited by their focus on special programs or CBD-oriented travel.

Scope

A minimum of 30 observation sites is necessary in each case study State. The sites are to be distributed to provide data by geographical area and functional class of

highway. While a minimum of 30 sites has been requested, States are encouraged to collect data at more than 30 sites as the increased effort will improve the accuracy and representativeness of the data.

To the extent practical, vehicle occupancies are to be obtained for all passenger vehicles, excluding buses and large trucks. Passenger vehicles include motorcycles and all two-axle, four-tire vehicles, such as pickups and vans and recreational vehicles. Two-axle, six-tire and heavier vehicles are excluded.

For this effort, data on the number of occupants will be reported in the following groups: 1, 2, 3, 4, 5-6, 7-8, and 9+ occupants per vehicle. This grouping conforms to vehicle sizes that aid the observation and recording of data. For example, fully loaded standard autos usually carry 5-6, fully loaded station wagons and some vans carry 7-8 and large vanpools carry 9 and more. All persons observed, including children, should be included. The observation sites should be conducted generally for an 8-hour period to cover both work and nonwork travel periods.

Vehicle occupancy data collected are likely to provide a representative average vehicle occupancy only at the statewide level when including all 30 stations. At the national level, however, the aggregation of data from several States, which obtained data on different days of the week, should provide representative vehicle occupancies for the rural and urban functional systems.

Observation Site Selection Considerations

Within the constraints of this effort, the selection of observation sites should be related to the underlying factors which affect vehicle occupancy. These factors were investigated in the 1969 Nationwide Personal Transportation Study (NPTS). (While the NPTS data is quite extensive, it is not broken down by functional class and Federal-aid geographical area; thus, making the results insensitive to HPMS requirements.) The NPTS found that occupancy rates of passenger cars are affected by the purpose of the trip more than any other factor. Trip purposes that encourage family activities, such as social and recreational trips, results in higher occupancy rates. On the other hand, trips which a single family member usually takes, such as to and from work, result in lower occupancy rates. It is noteworthy that in 1969 nearly three-fourths of all trips taken to and from work were taken in one-occupant, driver only cars. Vehicle occupancies by major trip purpose are given in Table 1.

Table 1

VEHICLE OCCUPANCY BY MAJOR TRIP PURPOSE

	Earning A Living	Shopping And Family Business	Social And Recreation	Average
Occupants Per Trip	1.4	2.0	2.5	1.9
Occupants Per Vehicle Mile of Travel	1.6	2.3	2.9	2.2

Source: "Automobile Occupancy," NPTS #1, FHWA, 1972, p. 8.

Vehicle occupancies are higher when computed on a VMT basis than on a trip basis, because vehicle occupancy increases with increasing trip length. For example, the average occupancy for work trips of 1.4 increases to 1.5 for trip lengths of 16-20 miles, 1.7 for 21-30 miles, and drops to 1.5 for 31 miles and over. Average vehicle occupancy increase significantly with increased trip lengths as illustrated by the specific trip purposes of shopping and recreation in Table 2.

Table 2

VEHICLE OCCUPANCY BY SELECTED TRIP PURPOSE AND TRIP LENGTH

Trip Length	To & From Work	Shopping	Recreation	Total
0-15 (Average)	1.4	2.0	2.6	1.9
16-20	1.5	2.3	2.6	1.9
21-30	1.7	2.6	2.9	2.1
31-40	1.5	2.1	3.0	2.3
41 & Over	1.6	2.5	3.4	2.6

Source: "Automobile Occupancy," NPTS #1, FHWA, 1972, p.13.

Vehicle occupancy by day of the week remains the same for Monday through Thursday, and increases for Friday, Saturday, and Sunday reflecting the increased nonwork travel made over the weekend. Vehicle occupancy will vary by hour within a day as the mix of trip purposes changes from work travel in the peak period to nonwork travel in the off-peak periods.

In this case study, vehicle occupancy sites should be located so as to intercept a reasonable quantity of vehicular travel representative of the major trip purposes and trip length groups. For example, sites on the higher functional classes of highway would normally intercept the longer trip lengths for all trip purposes. Likewise, sites located near small urban areas or shopping centers of large urban areas, especially on Friday or Saturday, would provide data on the shopping trip purpose.

The sites are to be distributed among rural, small urban, and urbanized areas in proportion to each area's relative VMT. Likewise, within a geographical area (e.g., rural), the sites are to be distributed among the functional systems (Interstate, Other Principal Arterial, Minor Arterial and Collector) based on VMT proportions. The VMT is considered to be a much more appropriate criterion than miles of highway for distributing sites within a State due to the close relationship to PMT. The VMT gives greater weight to the higher functional classes (e.g., Interstate), since these facilities carry long trips which typically have the highest vehicle occupancy. Table 3 shows the average national distribution of VMT by geographic area, by functional class of highway. In addition, the distribution of VMT among rural, small urban, and urbanized areas is shown in Table 4 for the States having the lowest, the average, and highest statewide proportions of VMT occurring in urban areas.

Table 3

NATIONAL VEHICLE MILES OF TRAVEL

by Geographic Area and Functional Class of Highway

	Average Percent by System					
	I	OPA	MA	Collector	Local	Total
Rural	19	20	21	28[b/]	12	100
Small Urban	12[a/]	37	23	11	17	100
Urbanized Area	31[a/]	27	20	9	13	100

a/Includes Other Freeways and Expressways.
b/Includes Major and Minor Collectors.

Source: "National Functional System Mileage and Travel Summary," from the 1976 National Highway Inventory and Performance Study, FHWA, 1977, pp. II-1, 4, 7.

Table 4

NATIONAL VEHICLES MILES OF TRAVEL

by Geographic Area

Area	Most Rural State	Average	Most Urban State
Rural	83	45	32
Small Urban	17	8	5
Urbanized	0	46	63
	100	100	100

No request has been made as a part of this case study to collect data on local roads and streets. If a need for such data arises, data for collector highways will be considered representative of local roads and streets. Locations for data collection should have typical traffic characteristics. However, for a State's own purposes, some preference might be given to present data collection locations. For example, typical locations that might include an ATR would also provide seasonal, daily and hourly traffic distributions. At sites with relatively low traffic volumes, one observer can collect data for both directions simultaneously. In cases where significant volumes are being observed, additional observers will have to be used or, alternatively, directional or lane observations will have to be made.

A major consideration is vehicle occupancy data in urbanized areas, especially the large urbanized areas. It is suggested that States with less than 40 percent of their VMT in urbanized areas gather information from one urbanized area whereas States with a larger portion of VMT in urbanized areas should gather data from a minimum of two urbanized areas.

For those States collecting data in two or more urbanized areas, it is preferred that each of the following population groups be represented: 50,000 to 199,999; 200,000 to 999,999; and 1,000,000 and over. Preference should be given to the larger urbanized area groups in cases where only two urbanized areas are being sampled.

Table 5 provides an example of how 35 sites (assuming five more sites than the required minimum) would be distributed if a State, sampling two urbanized areas, has a VMT distribution similar to the national distribution in Table 3. The initial distribution of sites by relative VMT was modified by adding two sites in urbanized areas to allow for data collection in two areas and adding three sites in the small urban area to allow for coverage of all classes. Preferably, each State will use its own urban/rural VMT relationships to distribute its observation sites among areas and functional classes. In the event that VMT information is not available, it is suggested that the source of Table 3 be used. A minimum of two sites is generally desirable in each area/functional class category.

Table 5

DISTRIBUTION OF VEHICLE OCCUPANCY SITES

by Geographic Area and Functional Class of Highway
for States with 40% or more VMT in Urbanized Areas

	I	OPA	MA	COLLECTOR	TOTAL
Rural	4	3	3	4[b/]	14
Small Urban Area	1	2	1	1	5
Urbanized Area #1	2[a/]	2	2	2	8
Urbanized Area #2	3[a/]	2	2	1	8
	10	9	8	8	35

a/Includes Other Freeways and Expressways.
b/Includes Major and Minor Collectors.

Observation Period Considerations

Table 6 provides the national seasonal distribution of VMT. In both urban and rural areas, the largest amount of VMT occurs in the summer quarter, 26.3 and 28.9 percent respectively. Since the summer is generally a heavy season for recreation and vacation travel, an increased proportion of the high vehicle occupancy trips should also occur during this period. However, it should be noted that just because VMT is not as high in the winter season it is still important to monitor vehicle occupancy during this period. Vehicle occupancy can be high due

to vacation and recreation travel in the South and skiing in the North. Some evidence suggests that vehicle occupancy for work trips may increase during this period. The last row provides a seasonal allocation of observation sites.

Table 6

1977 SEASONAL DISTRIBUTION OF VMT

	MAR-MAY	JUNE-AUG	SEP-NOV	DEC-FEB
Rural, VMT (%)	25.0	28.9	25.3	20.8
Average Trip Length (miles)	9.5	11.1	9.5	9.6
Urban, VMT (%)	25.5	26.3	25.3	22.9
Average Trip Length (miles)	7.8	9.6	8.2	7.6
Total Sites Allocated	9	11	9	6

Sources: "Traffic Volume Trends," Table 9B, FHWA, December 1978.
"Seasonal Variations of Automobile Trips and Travel," NPTS Report # 3, FHWA, 1972, p. 8.

Table 7 shows that the highest percentage of VMT occurs on Saturday (15.2%) and the second highest daily percentage of VMT (14.9%) occurs on Friday. Vehicle occupancy and PMT are much higher on Saturday and Sunday, a result of the high vehicle occupancy of shopping trips and the high vehicle occupancy and long trip lengths of weekend social-recreation trips.

Table 7

DAY OF THE WEEK DISTRIBUTION OF TRIPS, TRAVEL AND VEHICLE OCCUPANCY

	MON-THUR	FRI	SAT	SUN	7 DAY
Trips (%)	14.8	16.0	13.4	11.5	100.1
Travel (%)	14.0	14.9	15.2	14.0	100.1
Vehicle Occupancy					
Based on Trips	1.8	1.9	2.1	2.4	1.9
Based on Travel (VMT)	2.0	2.2	2.5	2.7	2.2
Estimated PMT (%)(Rows 2 x 4)	51.0	15.0	17.0	17.0	100.0

Sources: Developed from NPTS Reports #1 and #10.

Table 8 contains a sample schedule reflecting the effect of daily distributions of travel. If the data can only be collected in one season then Table 8 should be used.

Table 8

DISTRIBUTION OF STATIONS BY DAY OF THE WEEK

	R	U_1	U_2	U_3	Total
Sunday	4	-	1	1	6
Monday	1	1	1	2	5
Tuesday	1	-	2	1	4
Wednesday	1	1	1	1	4
Thursday	2	1	1	1	5
Friday	2	1	1	1	5
Saturday	3	1	1	1	6
Total	14	5	8	8	35

Preferably, data collection on vehicle occupancy can be conducted over a minimum of two seasons. Table 9 provides the distribution of stations when two seasons, say, late summer and early fall, are available. It should be noted that most of 3 weeks in the summer and 2 weeks in the fall would be required for data collection unless stations were conducted simultaneously requiring additional personnel. (Table 10 provides an idealized distribution of stations over four seasons.)

Table 9

DISTRIBUTION OF STATIONS OVER TWO SEASONS

	SUMMER				FALL/WINTER				
	R	U_1	U_2	U_3	R	U_1	U_2	U_3	Total
I/FWY	SA, SA SU	-	SU	F SU	SU	M	F	W	10
OPA	W SU	W	SA	TH	SA SU	-	TU	M	9
MA	M TU	F SA	W	M	W	-	M	SA	9
COLL.	TH	-	TU	-	F TH	TH	TH	TU	7
TOTAL	8	3	4	4	6	2	4	4	35

U_1 = City with 5,000 to 49,000 population
U_2 = City with 50,000 to 199,000 population
U_3 = City with 200,000 and over population

Table 10

IDEALIZED DISTRIBUTION OF STATIONS OVER FOUR SEASONS

	R	U_1	U_2	U_3	Total
SPRING					
I/FWY	SA	-	-	W	2
OPA	SU	F	TU	TH	4
MA	-	-	M	M	2
COLL	F	-	-	-	1
SUMMER					
I/FWY	SU	M	SU	F	4
OPA	F	W	SA	-	3
MA	TU	SA	-	-	2
COLL	TH	TH	-	-	2
FALL					
I/FWY	SA	-	F	SU	3
OPA	SU	-	-	-	1
MA	M	-	W	SA	3
COLL	TH	-	TU	-	2
WINTER					
I/FWY	SU	-	-	-	1
OPA	SA	-	-	M	2
MA	W	-	-	-	1
COLL	-	-	TH	TU	2
					35

U_1 = City with 5,000 to 49,000 population
U_2 = City with 50,000 to 199,000 population
U_3 = City with 200,000 and over population

Tables 8, 9, and 10 are scheduling guides only. Flexibility is probably necessary in the scheduling of days and seasons to provide data by December 31.

At all but four of the observation sites, it is requested that 8-hour observations be made. Table 11 provides NPTS data on the proportion of the expected PMT that occurs during various hourly periods of the 24 hours. Based on this data if a continuous 8-hour shift was scheduled from 11 a.m. to 7 p.m., it would likely monitor 52 percent of the 24-hour PMT. Also, in some States, it is a working practice to sometimes schedule an early morning shift, 7 to 11 a.m., a mid-day break, and an afternoon shift from 2 to 6 p.m. This split shift has the advantage of covering both the morning and the evening peak periods in 8 hours of data collection. Also, if nearby highways have similar characteristics, the two 4-hour periods would permit data to be collected at the similar locations and, therefore, increase the number of locations covered in the sample.

For the remaining 4 of the 35 (or 30) observation sites, it is suggested that the observation periods be extended beyond the 8-hour count period to more closely represent the daily (24-hour) vehicle occupancy. The extended observation periods should cover the daylight hours or 16 hours in lighted areas. These observations will compensate for any bias in 8 hours of data collection. Two of these sites should be located in rural areas and two in urbanized areas. Within an area one of the two observation periods should be on a summer Friday or Saturday, and the second should be conducted on a Monday through Thursday in early fall.

Table 11

DISTRIBUTION OF ESTIMATED PMT
BY THE HIGHEST HOURS WITHIN A DAY

Length (Hours)	Period	Percent of 24 Hour PMT
4	7 a.m. - 11 a.m.	21
4	3 p.m. - 7 p.m.	33
8	11 a.m. - 7 p.m.	52
12	7 a.m. - 7 p.m.	73
16	6 a.m. - 10 p.m.	88
24	6 a.m. - 6 a.m	100

Sources: "Automobile Occupancy," NPTS Report #1, 1972, p. 19.
"Home to Work Trips and Travel," NPTS Report #8, 1972, p.78.

Some sites will be on high volume multilane facilities. At such locations, it may be appropriate to use more than one observer or take short counts of vehicle occupancy. A short count is a 15-minute (suggested) vehicle occupancy count on each lane in turn. Such short counts would also be applicable to high volume periods on normally low-volume highways. Both traffic directions should be covered in the short count periods.

Reporting of Vehicle Occupancy Information

The resultant vehicle occupancy information should be coded on the attached forms and submitted to FHWA, HHP-12, by December 31, 1979. These copies of the forms are bound as the last pages for ease of detachment from this report.

The coding instructions are bound next to the coding forms, likewise for ease of detachment (see Appendix C). Appendix A contains the State codes and Appendix B contains the urbanized area codes.

APPENDIX A

TABLE OF STANDARD CODES FOR STATES, DISTRICT OF COLUMBIA AND PUERTO RICO

NAME	CODE	NAME	CODE
Alabama	01	Nevada	32
Alaska	02	New Hampshire	33
Arizona	04	New Jersey	34
Arkansas	05	New Mexico	35
California	06	New York	36
Colorado	08	North Carolina	37
Connecticut	09	North Dakota	38
Delaware	10	Ohio	39
District of Columbia	11	Oklahoma	40
Florida	12	Oregon	41
Georgia	13	Pennsylvania	42
Hawaii	15	Rhode Island	44
Idaho	16	South Carolina	45
Illinois	17	South Dakota	46
Indiana	18	Tennessee	47
Iowa	19	Texas	48
Kansas	20	Utah	49
Kentucky	21	Vermont	50
Louisiana	22	Virginia	51,
Maine	23	Washington	53,
Maryland	24	West Virginia	54
Massachusetts	25	Wisconsin	55
Michigan	26	Wyoming	56
Minnesota	27	Puerto Rico	72
Mississippi	28		
Missouri	29		
Montana	30		
Nebraska	31		

URBANIZED AREA CODE

State	Urbanized Area	Code
Alabama	Anniston	254
	Birmingham	035
	Columbus (Ga.)	109
	Gadsden	192
	Florence	255
	Huntsville	184
	Mobile	067
	Montgomery	115
	Tuscaloosa	183
Alaska	Anchorage	256
Arizona	Phoenix	033
	Tucson	073
Arkansas	Ft. Smith (Okla.)	202
	Little Rock-North Little Rock	092
	Pine Bluff	219
	Texarkana (Texas)	211
California	Antioch-Pittsburg	257
	Bakersfield	117
	Fresno	080
	Los Angeles-Long Beach-Pomona-Ontario	002
	Modesto	234
	Oxnard-Ventura-Thousand Oaks	224
	Sacramento	042
	Salinas	229
California (cont.)	San Bernardino-Riverside	048
	San Diego	023
	San Francisco-Oakland	006
	San Jose	032
	Santa Barbara	187
	Santa Cruz	258
	Santa Rosa	235
	Seaside-Monterey	236
	Simi Valley	237
	Stockton	119
Colorado	Boulder	238
	Colorado Springs	153
	Denver	024
	Pueblo	149
Connecticut	Bridgeport	051
	Bristol	239
	Danbury	240
	Hartford	047
	Meriden	212
	New Britain	154
	New Haven	064
	New London-Norwich	259
	Norwalk	176
	Springfield-Chicopee-Holyoke (Mass.)	043
	Stamford	103
	Waterbury	118

URBANIZED AREA CODE

State	Urbanized Area	Code
Delaware	Wilmington (N.J.)	063
Dist. of Col.	Washington, D. C., (Maryland, Virginia)	008
Florida	Daytona Beach	260
	Ft. Lauderdale-Hollywood	058
	Ft. Myers	261
	Gainsville	241
	Jacksonville	050
	Lakeland	262
	Melbourne-Cocoa	263
	Miami	021
	Orlando	087
	Pensacola	125
	St. Petersburg	057
	Sarasota-Bradenton	264
	Tallahassee	220
	Tampa	059
	West Palm Beach	097
Georgia	Albany	209
	Atlanta	025
	Augusta (S.C.)	131
	Chattanooga (Tenn.)	086
	Columbus (Ala.)	109
	Macon	143
	Savannah	100
Hawaii	Honolulu	052
Idaho	Boise City	217
Illinois	Alton	265
	Aurora-Elgin	172
	Bloomington-Normal	227
	Champaign-Urbana	181
	Chicago-Northwestern Indiana (Ind.)	003
	Davenport-Rock Island-Moline (Iowa)	074
	Decatur	169
	Dubuque (Iowa)	206
	Joliet	138
	Peoria	093
	Rockford	099
	St. Louis (Mo.)	011
	Springfield	146
Indiana	Anderson	223
	Chicago-Northwestern Indiana (Ill.)	003
	Evansville	114
	Fort Wayne	094
	Indianapolis	029
	Louisville (Ky.)	031
	Lafayette-West Lafayette	222
	Muncie	182
	South Bend (Mich.)	077
	Terre Haute	178
Iowa	Cedar Rapids	148
	Davenport-Rock Island-Moline (Ill.)	074
	Des Moines	071

URBANIZED AREA CODE

State	Urbanized Area	Code
Iowa (cont.)	Dubuque (Ill.)	206
	Omaha (Nebr.)	046
	Sioux City (Nebr., S.D.)	156
	Waterloo	150
Kansas	Kansas City (Mo.)	019
	St. Joseph (Mo.)	179
	Topeka	134
	Wichita	062
Kentucky	Cincinnati (Ohio)	017
	Huntington-Ashland, (W.Va.-Ohio)	105
	Lexington	144
	Louisville (Ind.)	031
	Owensboro	242
	Clarksville-Hopkinsville (Tenn.)	280
Louisiana	Alexandria	266
	Baton Rouge	088
	Lafayette	218
	Lake Charles	171
	Monroe	180
	New Orleans	022
	Shreveport	085
Maine	Lewiston-Auburn	196
	Portland	145
Maryland	Wash., D.C., Md., Va.	008
	Baltimore	012
Massachusetts	Boston	007
	Brockton	147
	Fall River (R.I.)	130
	Fitchburg-Leominster	189
	Lawrence-Haverhill (N.H.)	104
	Lowell	136
	New Bedford	127
	Pittsfield	199
	Providence-Pawtucket-Warwick (R.I.)	026
	Springfield-Chicopee-Holyoke (Conn.)	043
	Worcester	076
Michigan	Ann Arbor	142
	Battle Creek	267
	Bay City	186
	Detroit	005
	Flint	065
	Grand Rapids	061
	Jackson	190
	Kalamazoo	141
	Lansing	102
	Muskegon-Muskegon Hgts.	162
	Saginaw	123
	South Bend (Ind.)	077
	Toledo (Ohio)	044
Minnesota	Duluth-Superior (Wisc.)	113
	Fargo-Moorhead (N.D.)	188
	LaCrosse (Wisc.)	243
	Minneapolis-St. Paul	013
	Rochester	244
	St. Cloud	268