UMTA-IT-09-0076

1977 Travel-Time and Auto Occupancy Study

For The

Kansas City Metropolitan Region

May 1978

Prepared by Mid-America Regional Council in Cooperation with Kansas Department of Transportation, Missouri State Highway Department, Federal Highway Administration, and the Urban Mass Transportation Administration

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INTRODUCTION

This report presents the findings of the 1977 Travel-time and Auto Occupancy studies undertaken by MARC, in cooperation with the Missouri State Highway Department and the Kansas Department of Transportation. The program ran from June 1, 1977 to August 15, 1977, with additional data collected in the fall of 1977. The primary purpose of this study was to obtain the average travel times and vehicular occupancy data for the major streets and highways within the KCMR.

The test car technique, recommended in the literature, was used to collect travel-time data. The data were collected during the summer of 1977 by groups of two persons per car using two stop watches.

The afternoon peak-hour and peak-direction was considered suitable for the test runs since this is the period when delays are generally at their highest, and hence most critical. Peak period starting times were chosen randomly between 4:30 and 5:30 p.m. A recommended procedure based upon the difference in travel times of test runs on the same route was used to establish the sample number of test runs.

Once the data were collected and verified, the results were summarized to give the information by the total lengths of the test routes as well as by the lengths of each control segment. This information is available from MARC as part of the Data Appendix to this report.

Automobile Occupancy and vehicle classifications were made at 44 locations by roadside counting teams of two persons each. This data also was verified and summarized by location.

The results of the data gathered from the 1977 Travel-time and Delay Study has several uses such as a data base to check speeds in current networks and determine speeds for future computer assignments. Since time is a uniform measure free from serious differences in interpretation, it is used to evaluate the service level of the roadways. Auto occupancy data is useful for translating the traffic flow characteristics of a facility into a measure of person's travel.

The urbanized portion of the region was selected as the study area. The analysis of the results included: A) Analysis of Travel-time and B) Analysis of Delay-time. The analysis revealed that most of the area can be reached within 25 minutes driving time. Average speeds of 45.0 mph., 29.8 mph. and 25.6 mph. were observed for Freeway, Principal Arterials and Minor Arterials respectively. Average delays per mile of 3, 18 and 44 seconds were observed respectively for the same classifications.

Travel-time on Interstate freeways is less than the rest of the area. Travel-times on the arterial system indicates that problems exist. The majority of the streets and highways have better than average speeds. Traffic signals and traffic congestion are predominant causes for delay.

Detailed tabulations of travel-time data for each test route and automobile occupancy and classification data for each location are contained in a Data Appendix to this report. This report is available on request from MARC.

TRAVEL TIME STUDY

The results of this study are analyzed by characteristics of the areas and by classification of the routes. For this purpose, the total study area was divided into three analysis areas,

A. Kansas City, Missouri Central Business District (CBD). This is defined for this study as the area inside the Freeway loop.

B. Inner Area. This is approximately the area of the map on Figure 1.

C. Outer Area. This is approximately the area on Figure 2.

The 1985 Functional Classification Map, established by the Transportation Review Committee of MARC, as shown in the above mentioned figures, was used to determine street classifications.

It was not possible to survey all the routes as shown on Figures 1 and 2 because of limited time and resources. Only a sample of major routes of regional significance was selected, routes in all directions were covered as much as possible. The network of selected routes is illustrated in Figure 3.

Peak Period Travel Times

Figure 4 shows driving time from 10th and Main in the Kansas City, Missouri Central Business District to the outskirts of the KCMR at five minute intervals. Divergence of the contour lines outward reflect higher accessibility along the specific corridor; while convergence of the lines inward reflect a relatively lower accessibility, in terms of driving time.

Overall, the contour plot indicates that much of the inner urban area can be reached within 10 minutes of driving time, while most suburban areas can be reached within 25 minutes of driving time.

A travel-time contour map was also prepared showing driving time in 5 minute intervals from KCI (Figure 5).

The travel-time on corridors along the Interstate freeways is much better than the rest of the metropolitan area. The freeway system allows traveling longer distances in the shortest time and represents the most desirable routes for travel even during peak periods. However, driving along I-70 eastward and I-35 southward seems to involve relatively higher travel-time.

The travel-time in corridors along arterial systems indicates that major problems do exist in such corridors. Particularly within the inner city area, they reflect much slower driving conditions. Important among routes involving relatively higher travel-times are Kansas Ave./Metropolitan Ave. corridor on the west and Independence Ave./Truman Rd. corridor on the east. Travel-times along Southwest Trafficway/Ward Parkway corridor on south and U.S.-169/North Broadway corridor on the north seems to reflect relatively better driving conditions.

FIGURE 1
INNER AREA

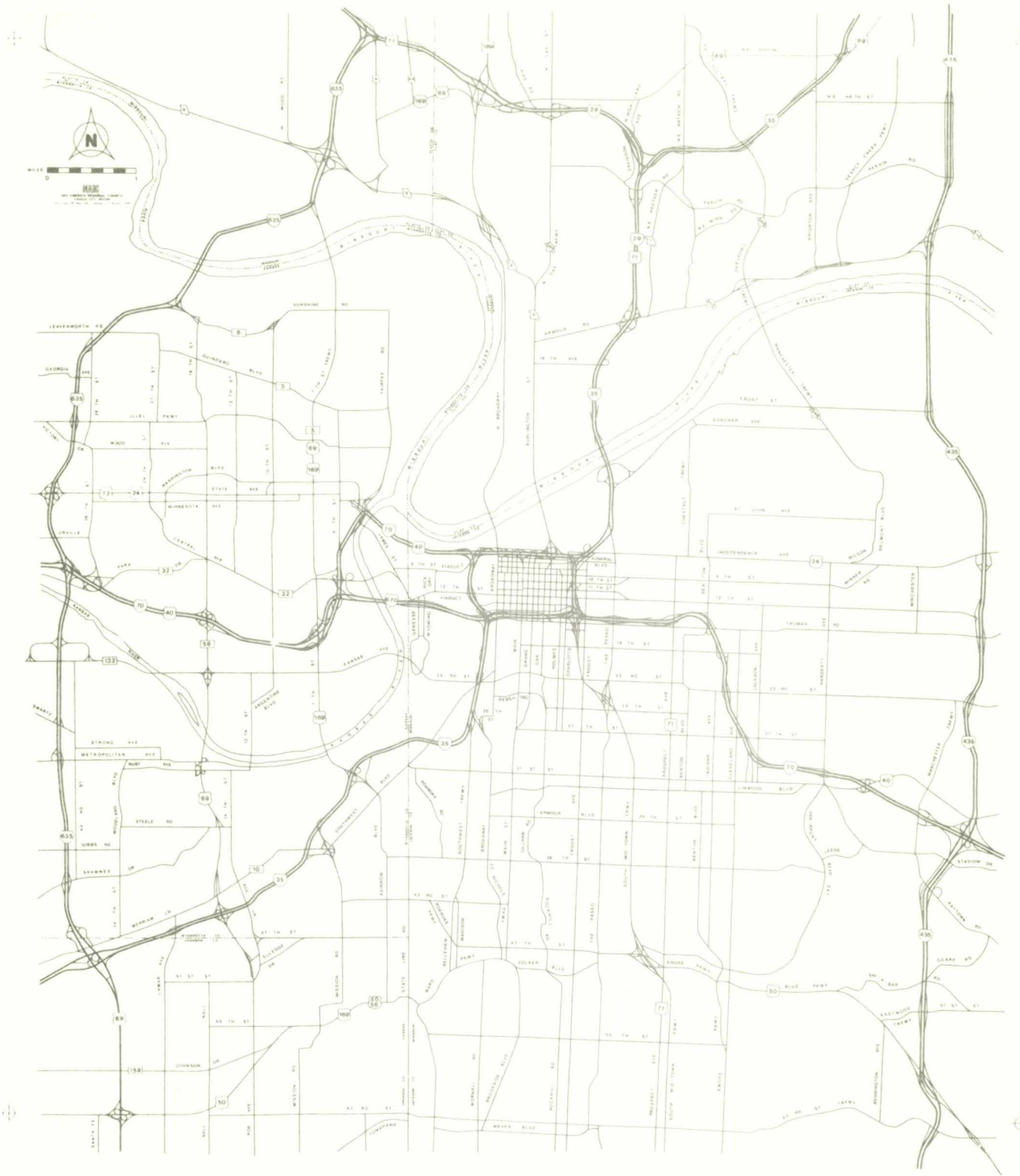
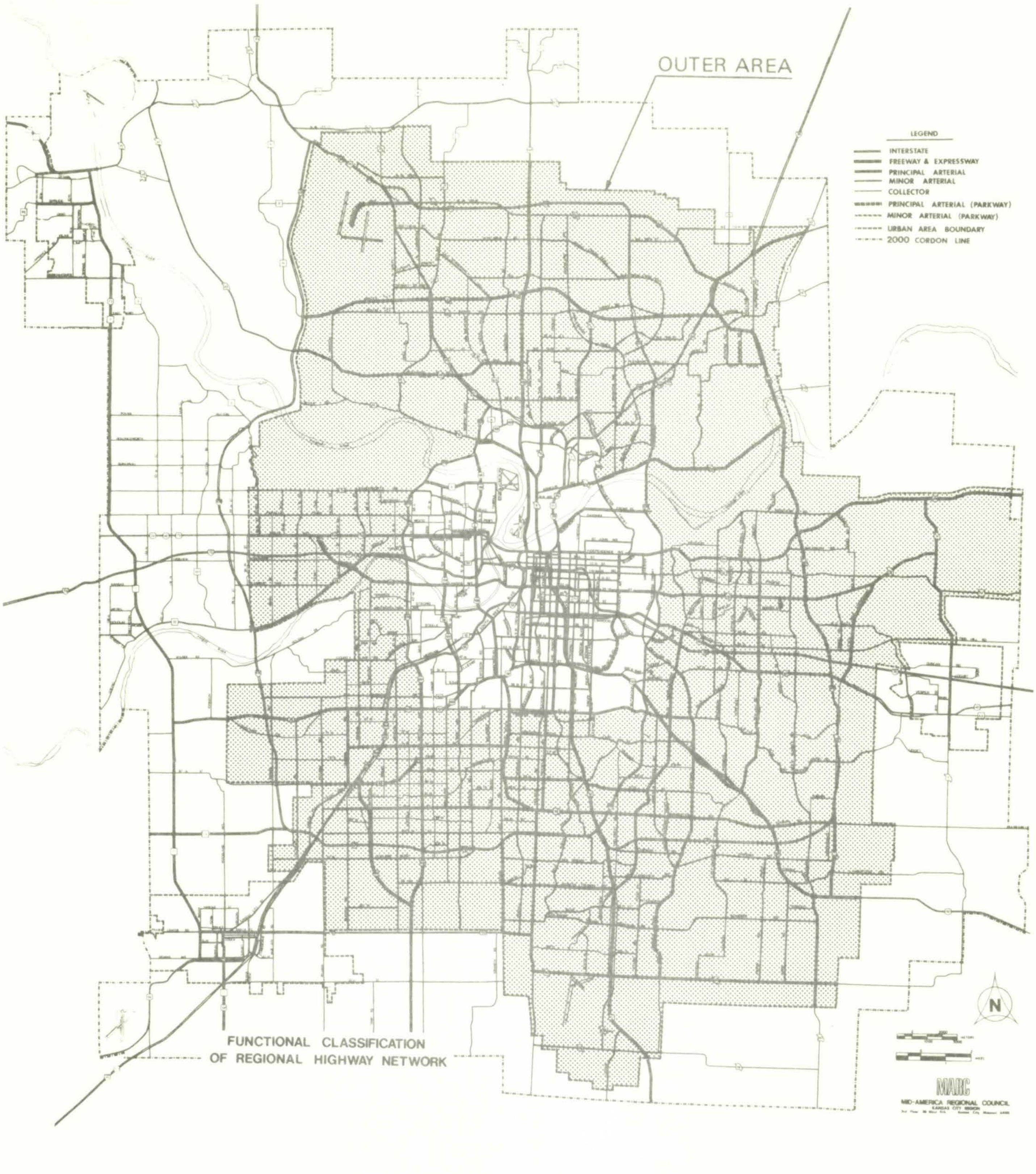


FIGURE 2
OUTER AREA



1977 KCMR TRAVEL TIME STUDY
This map prepared in cooperation with
Kansas Department of Transportation
Missouri State Highway Commission

FIGURE 3
NETWORK OF TEST ROUTES

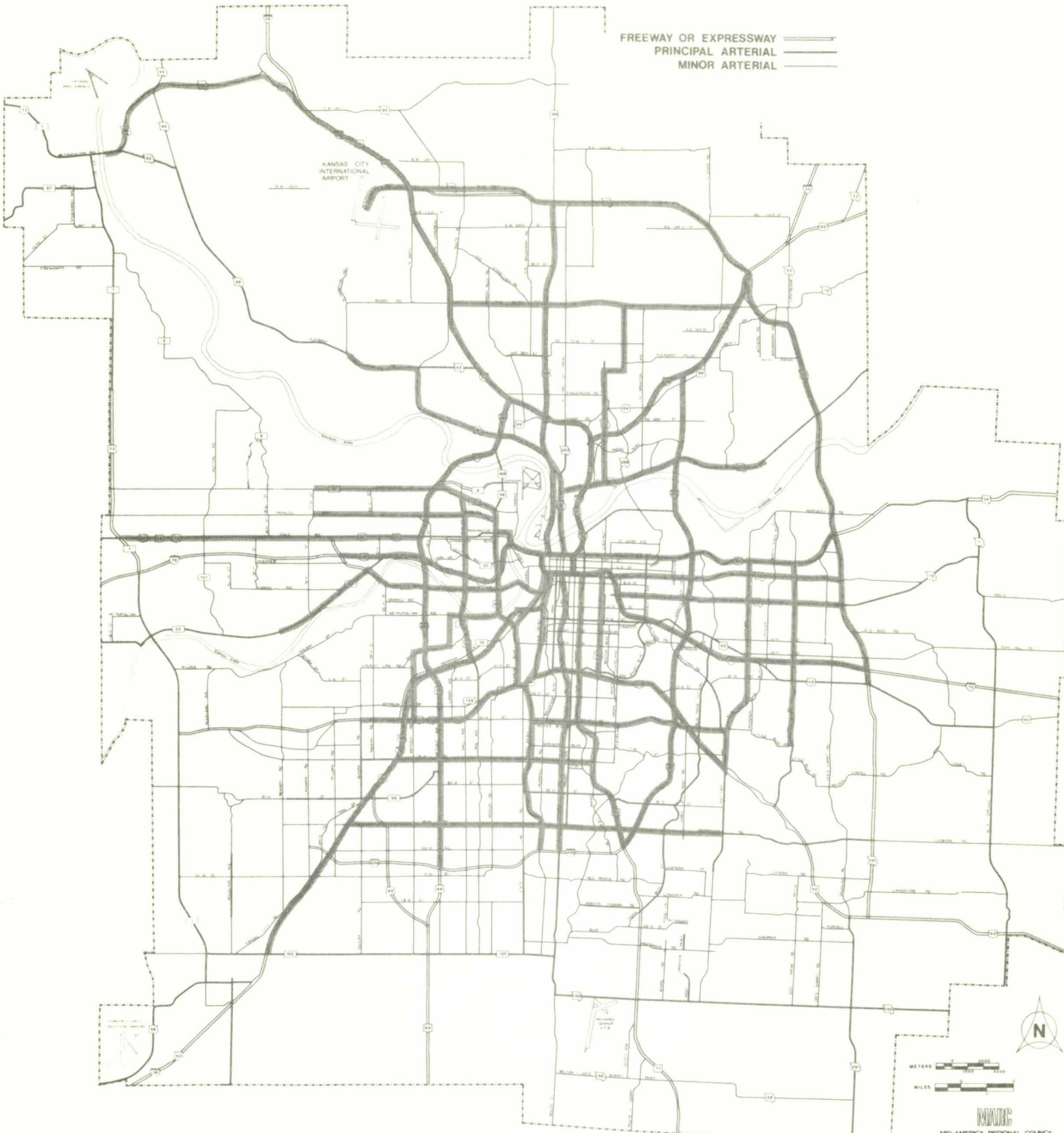


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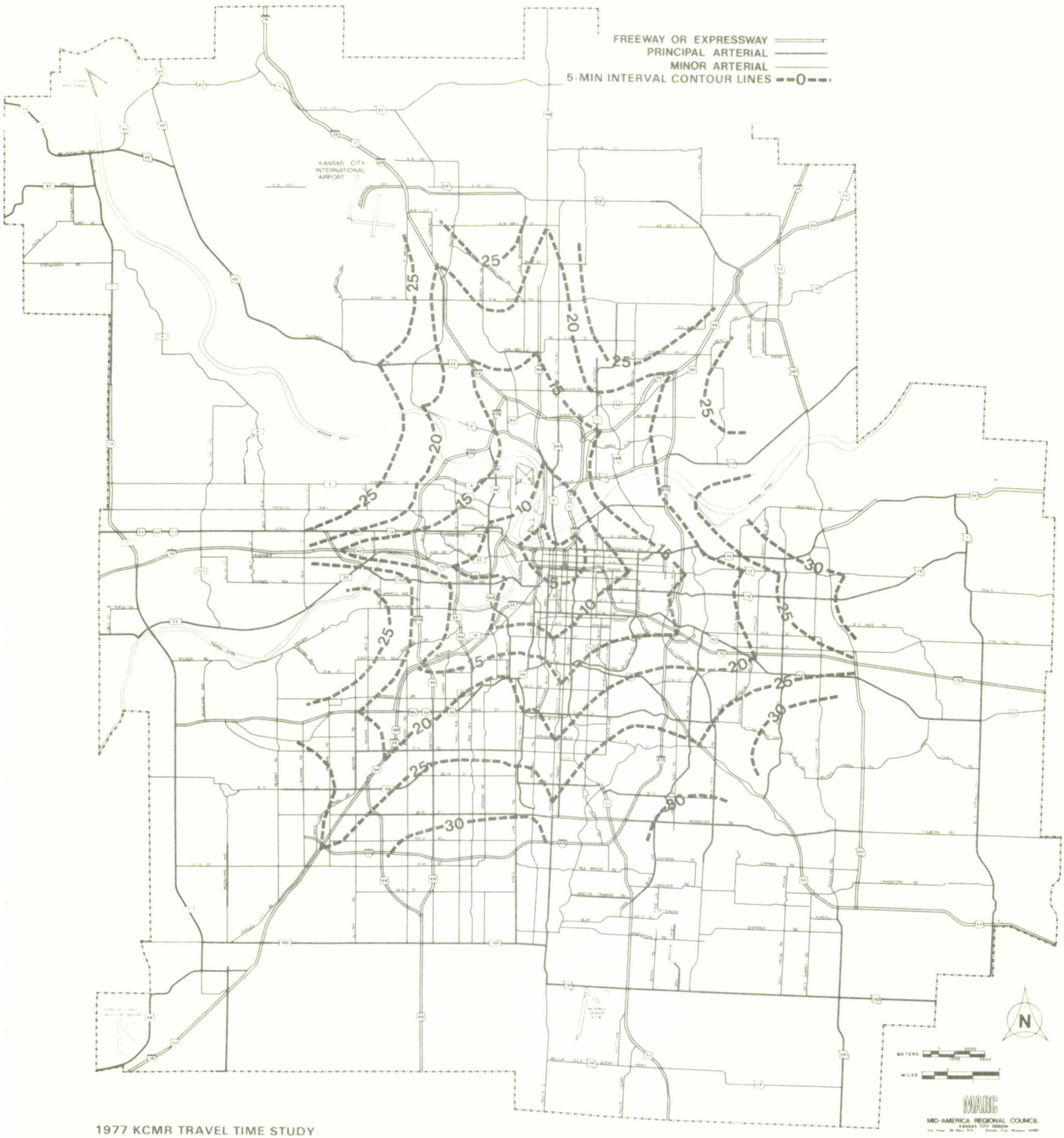
FIGURE 4
PEAK-HOUR TRAVEL—TIME FROM DOWNTOWN, K. C., MO



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This map prepared in cooperation with
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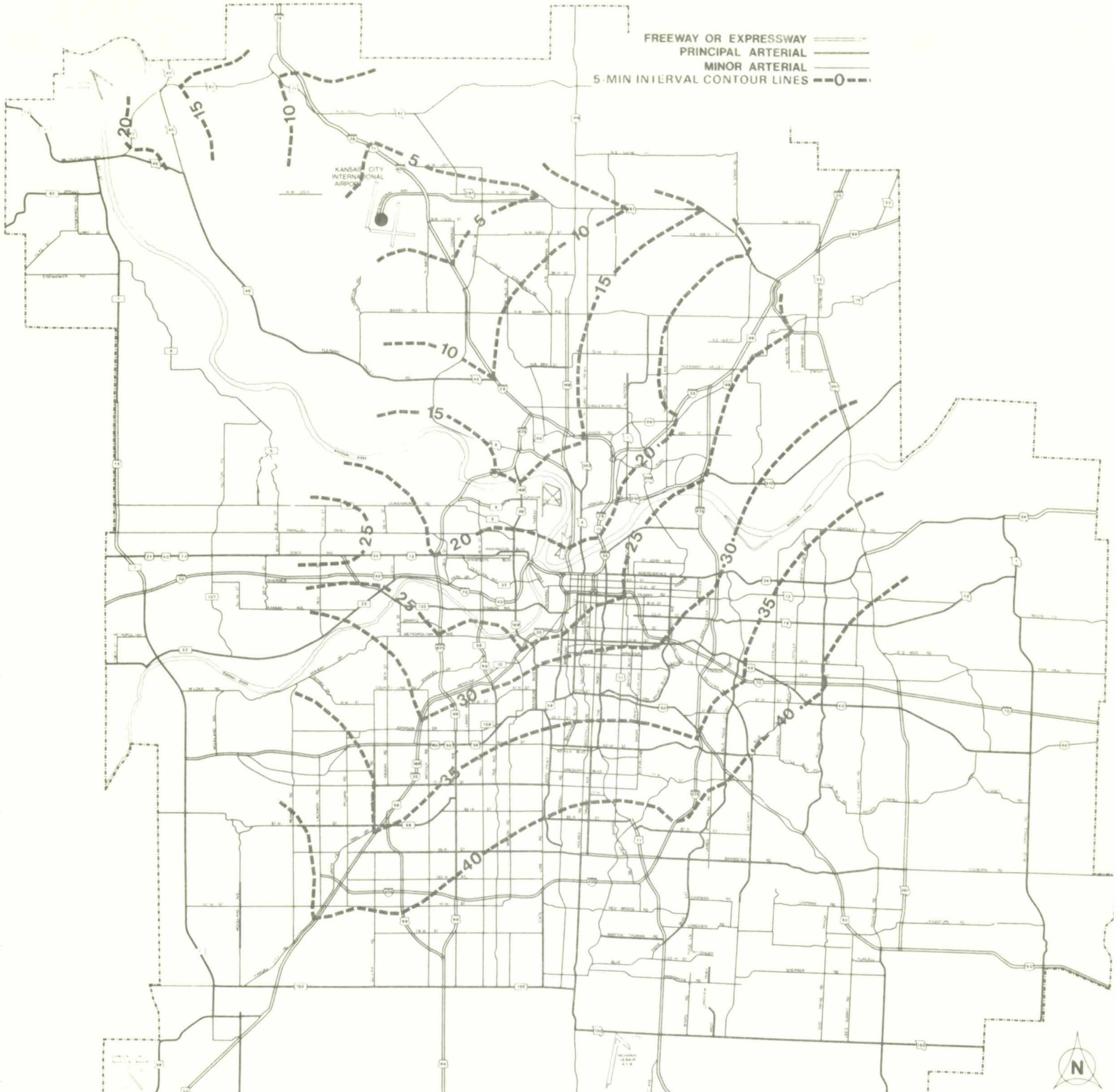
FIGURE 5

PEAK-HOUR TRAVEL-TIME FROM KCI TERMINAL



1977 KCMR TRAVEL TIME STUDY

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Kansas Department of Transportation
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The contour maps also reveal that the developing areas north of the Missouri River have significantly better access times to the Kansas City, Missouri Central Business District than do similar areas in Johnson and Jackson Counties.

Average travel speeds were calculated for each functional classification for the CBD, Inner Urban and Surburban areas, as delineated on Figures 1 and 2. The average peak period, peak direction travel speeds are presented on Table I.

Also presented on Table I are the standard deviations of travel speeds by study segment. Study segments average between one and two miles in length, but varied above or below this figure according to density of development. These standard deviations were considered reasonable except for Suburban Principal Arterials.

In attempting to explain this wide variance in speeds, Suburban Principal Arterial data was disaggregated according to land use. The results of this disaggregation are also shown on Table I.

Suburban Principal Arterials abutting commercial land use was shown to be significantly slower than residential and rural land use. The standard deviations of the disaggregated data are considerably less than the original figure, suggesting that land use is an important variable to describe average travel speed on Suburban Principal Arterials. It is also apparent that commercial development on suburban arterials tends to decrease travel speeds.

TABLE I

Average Travel Speeds - Peak Period, Peak Direction
1977 Travel Time Study

(miles per hour)

	Freeway & Expressway	Principal Arterial	Minor Arterial
CBD	--	--	10.31 (4.51)
Inner Urban	44.87 (9.46)	25.40 (7.62)	24.64 (6.85)
Suburban Area-Total	47.75 (9.23)	30.82 (10.46)	26.68 (6.46)
Commercial Land Use	--	23.19 (5.14)	--
Residential Land Use	--	28.98 (6.74)	--
Rural Land Use	--	45.53 (5.49)	--

The numbers in parentheses below the average speeds are the standard deviations in miles per hour.

The Average Delay Rate per mile is given on Table II for each street and area classification. "Delay" was defined for purposes of this study as the amount of time the vehicle is actually stopped. Some studies define "delay" as the amount of time a vehicle is traveling below a certain speed such as 5 miles per hour. This would result in higher delay rates than are given here. The use of stopped time for a measure of delay is a more reliable and easily quantified parameter and was thus used in this study.

TABLE II

Average Delay Rate
1977 Travel Time Study

(In minutes per mile)

	Freeway & Expressway	Principal Arterial	Minor Arterial
CBD	--	--	2.25
Inner Urban Area	.07	.33	.43
Suburban Area	.03	.30	.33

Table II shows that there is an inverse relation between delay rate and average speed, as would be expected. Delays decrease and speeds increase slightly in suburban areas. Freeways and Expressways have less delay than Arterial Streets.

Next, the predominant causes for delay were looked into. As shown in Figure 6, traffic congestion was found to result in 76% of the delays for the Principal Arterial and Minor Arterial classifications respectively. The delay-cause information was further broken down by the specific study areas, as given in Table III.

TABLE III

Causes of Delay

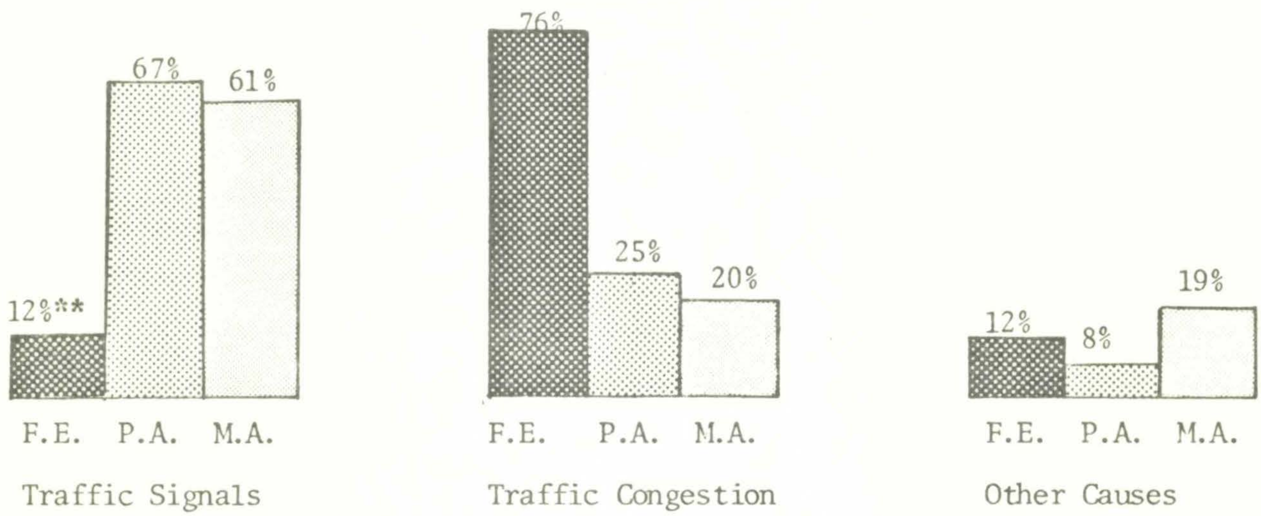
	Freeway & Expressway	Principal Arterial	Minor Arterial
CBD			
Traffic Signals			47%
Traffic Congestion			28%
Other Causes*			25%
Inner Urban Area			
Traffic Signals	0%	63%	74%
Traffic Congestion	81%	28%	10%
Other Causes*	19%	9%	16%
Suburban Area			
Traffic Signals	33%**	70%	82%
Traffic Congestion	66%	23%	4%
Other Causes*	0%	7%	14%

* This includes delays due to: vehicle parking or un-parking, vehicle turning left or right, stop signs, toll payment, etc.

** This is due to the presence of traffic signals on certain expressways such as K-10, U.S.-50, etc.

FIGURE 6

DELAY-CAUSE PERCENTAGES: TOTAL STUDY AREA



**This is due to the presence of traffic signals on certain expressways such as K-10, US -50 etc.

Traffic signals account for the majority of delay on arterial streets. As expected, traffic signals account for more delay on minor arterials than on principal arterials. Traffic congestion is a greater cause of delay in inner areas than in suburban areas.

The average delay-rate did not occur consistently on each street of a given classification. There was a great amount of variation in the duration of delay time. Usually, a few segments in each classification had significantly higher delay time than average.

The average speeds and standard deviations from Table I were used to identify street segments that are significantly less than the regional average. For this purpose, all street or highway segments which are more than one standard deviation below the average speed for the appropriate functional and urban area class are considered to be relatively slower than the regional average. These are identified on Figure 7.

Off Peak Travel Speeds

The preceeding analysis used peak period, peak direction average travel speeds to measure system performance under its most critical load. Additional travel-time data was collected on weekdays between 1:00 p.m. and 4:00 p.m. to represent off-peak travel speeds.

Off-peak travel-time data was compared with peak period, peak direction data on the same route and direction to obtain ratios of off-peak to peak period travel-time by class and area. These ratios were used to calculate average off-peak travel speeds on Table IV. Inner urban freeways and minor arterials are significantly faster during the off-peak hours. Suburban freeways showed only slight speed increase. The off-peak speed shown for suburban freeways and expressways is less than for inner urban freeways and expressways. This is probably due to inclusion of expressway data in the suburban figure, and possibly not enough suburban off-peak data to establish a reliable average speed.

TABLE IV

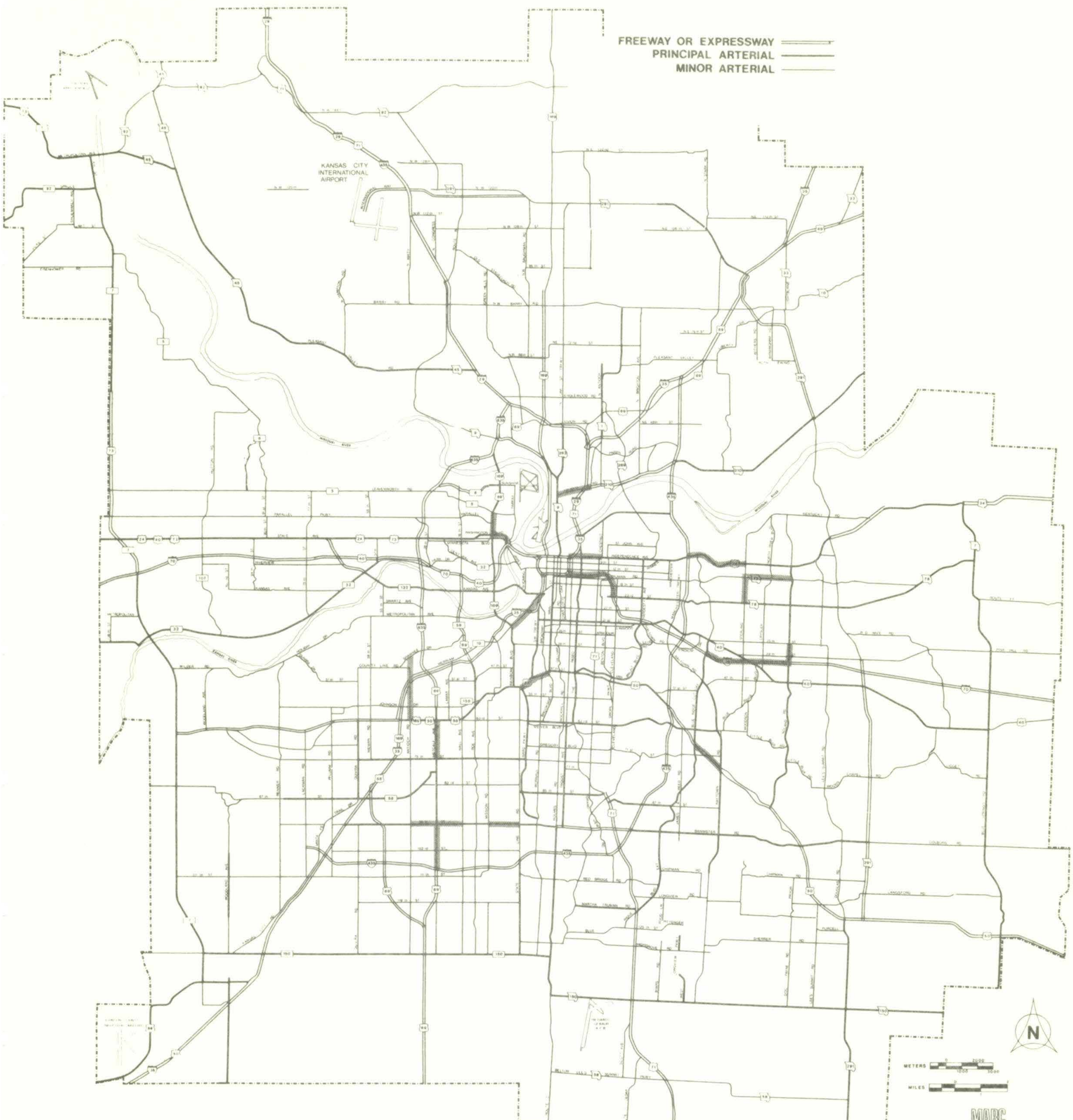
Average Travel Speeds--Off-Peak
1977 Travel Time Survey
(Miles per hour)

	Freeway & Expressway	Principal Arterial	Minor Arterial
CBD	--	--	*
Inner Urban	53.04	25.20	26.81
Suburban	50.10	33.21	31.88

* No data collected for off-peak period.

FIGURE 7

SECTIONS OF ROUTES WITH SPEEDS OF (X—1S) OR LESS



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Comparison of Fall and Summer Travel Speeds

The next step in the analysis of travel-time data was to study the variation in summer/fall data. It may be recalled that the data for this travel-time study was collected during summer of 1977. A few sample test runs were conducted for each classification during the fall in order to check the seasonal variation in the data. The hypothesis that fall speeds were significantly different than summer speeds was tested by assuming that the data was normally distributed and performing a Z-test. Table V shows that freeway and expressway travel-time averaged two percent longer in the fall than in the summer, that principal arterial travel time was 11 percent longer, and that minor arterial travel-time was one percent longer. All of the Z values indicate that the seasonal variation in travel-time is not significantly different from zero at the 95% confidence level (i.e., z is less than 1.96).

The study of seasonal variation in travel-time reveals that although travel-time during the fall season is slightly higher than that of the summer season, the variation is practically insignificant. This means that the application and use of peak hour travel-time information collected during the summer season may be considered as valid for the entire year.

TABLE V

Comparison of Fall and Summer Data

	Freeway & Expressway	Principal Arterial	Minor Arterial
Ratio of Fall to Summer Travel Times	1.02	1.11	1.01
Z-value *	0.12	0.33	0.06
Is the Travel Time Difference Significant? (95% confidence level)	No	No	No

$$* \text{ Z-value} = \frac{F-S}{s}$$

Where F = Average Fall travel time per mile
S = Average Summer travel time per mile
s = Standard deviation of Summer travel time

If Z-value is greater than 1.96 then at the 95% confidence level, the hypothesis that Fall and Summer travel times are equal can be rejected.

AUTO OCCUPANCY STUDY

Auto occupancy and motor vehicle classification data was collected at 10 Freeway, 8 Principal Arterial, 5 Minor Arterial, and 6 Collector Street locations. In addition, traffic entering and leaving the Kansas City, Missouri Central Business District (CBD) was counted at 9 Freeway ramps and 6 Arterial street locations. For this study, the CBD was considered to be the area within the Freeway loop. All but three of the counts were taken during the evening peak period, 4:00 p.m. to 6:00 p.m., during the months of June, July and August, 1977.

Although only a few sites were sampled, the total number of cars counted was large enough to give a statistically significant result. A total of 15,899 automobiles were counted for automobile occupancy, and 14,541 for motor vehicle classification. Non-commercial pickup trucks and vans used as private vehicles were included in the same category as automobiles for determining average occupancy.

Peak Period Auto Occupancy

The results of the peak period survey of automobile occupancy are presented in Table VI. For instance, Table VI shows that 69.9% of cars on freeway ramps entering and leaving downtown during the peak period carried only one person.

Outer Area Minor Arterials and Collectors were combined into one category in order to obtain a sample of over 1,000 vehicles. All categories in Table VI are based on samples of more than 1,000 vehicles.

TABLE VI

Peak Period Auto Occupancy

Area	Functional Class	Number of Occupants (%) 1	2	3	4	5	6	Avg. Auto Occupancy
CBD	Freeway Ramps	69.9	22.3	5.7	1.4	0.5	0.2	1.41
	Arterial Streets	62.2	28.5	6.6	1.4	0.4	0.9	1.52
Inner Area	Freeways	65.2	24.6	5.7	2.6	0.7	1.2	1.53
	Principal Arterials	66.7	22.5	7.1	3.0	0.6	0.1	1.49
	Minor Arterials	63.7	26.0	6.0	2.2	0.7	1.4	1.54
	Collectors	66.4	23.4	6.1	2.1	1.1	0.9	1.51
Outer Area	Freeways	65.3	24.2	5.8	2.5	0.7	1.5	1.53
	Principal Arterials	64.9	29.6	2.7	1.7	0.8	0.3	1.45
	Minor Arterials & Coll.	60.0	25.3	9.3	3.3	1.4	0.7	1.63

The lowest auto occupancy was found on freeway ramps to and from the CBD, where peak period average occupancy was 1.41 persons per car. The highest average automobile occupancy, 1.63, was for Minor Arterials and Collector streets in the outer area. All other categories have average automobile occupancies between 1.45 and 1.54 persons per car. The systemwide average is estimated to be 1.53 persons per car. This data compares very closely with the average automobile occupancy of 1.49 calculated from the 1970 Origin-Destination survey data.[1]

[1] Travel Impacts, No Build-Plan A, Tech. Memo. No. 20, KCMR Rapid Transit Study, Dec. 5, 1973, Attachment "B".

Although the 1970 average auto occupancy was calculated in a different manner, it is clear that there has been no significant change in average automobile occupancy between 1970 and 1977.

Table VI also shows that only 8 or 9 percent of the automobiles entering downtown carry three or more persons. Areawide, between 60 and 70 percent of all cars carry only the driver and no passengers.

Table VII seperates inbound and outbound afternoon peak period traffic entering or leaving the CBD. Although freeway data is nearly the same in each direction, the outbound traffic on arterial streets seems to have a slightly higher average occupancy than inbound traffic.

TABLE VII

Peak Period Auto Occupancy
Central Business District, Kansas City, Missouri

Classification	Number of Occupants (%) 1	2	3	4	5	6 or more	Average Auto Occupancy
Freeway Ramps-							
Outbound	69.9	22.6	5.6	1.3	0.4	0.2	1.40
Inbound	70.3	20.3	5.9	2.3	0.8	0.4	1.44
Arterial Streets-							
Outbound	59.0	31.0	7.3	1.3	0.4	1.0	1.56
Inbound	78.3	16.3	3.2	1.4	0.4	0.4	1.31

Off Peak Auto Occupancy

Auto occupancy data was collected at three locations for the period between 1:00 p.m. and 4:00 p.m. This data was insufficient to estimate off-peak occupancy averages. However, two of the three locations had higher off-peak auto occupancies than their peak period averages.

Vehicle Classification

Table VIII summarizes the classification of vehicles by type. For instance, automobiles comprised 83.1% of all vehicles on freeway ramps during the afternoon peak period in downtown Kansas City, Missouri. Vehicle classifications for off-peak traffic were not separately tabulated because their was insufficient data.

The bus classification included minibuses and limousines as well as full sized city and intercity buses. Pickup and panel trucks included personal as well as commercial vehicles. The "Other Vehicle" category included construction equipment and emergency equipment such as fire trucks, ambulances and police cars.

TABLE VIII

Vehicle Classification Percentages, Peak Period

Area	Functional Class	Auto-mobile	Bus	Motor-cycle	Pickup & Panel Truck	Semi-Trailer Trk.	Other Trucks	Other Vehicle
CBD	-Freeway Ramps	83.1	0.2	0.8	11.5	1.4	2.3	0.7
	-Arterial Streets	85.5	3.1	0.4	8.2	0.2	2.1	0.5
Inner Area								
	-Freeways	83.4	0.2	0.8	6.9	3.6	4.5	0.6
	-Principal Arterials	87.1	1.0	0.9	7.5	0.2	3.1	0.2
	-Minor Arterials	87.6	2.3	1.3	6.7	0.2	0.8	1.1
	-Collectors	81.7	1.7	2.4	8.9	0.2	3.9	1.2
Outer Area								
	-Freeways	84.1	0.6	0.9	8.6	3.5	1.6	0.7
	-Principal Arterials	88.4	0.7	1.0	9.0	0.2	0.5	0.2
	-Minor Arterials & Collectors	90.3	0.4	1.7	6.3	0.1	0.3	0.9

Table VIII shows that between 80 and 90 percent of the vehicles on urban streets and highways are private automobiles. The second most common classification is pickup and panel trucks, between 6.3% and 11.5% of vehicles.

Buses are most common on arterial streets leaving the CBD and on inner area minor arterials; where they make up 3.1% and 2.3% of the total traffic stream respectively.

Large trucks are most common on the freeway system. Semi-trailer trucks make up 3.5% to 3.6% of freeway traffic, but no more than 0.2% of the traffic flow on other urban streets. (Arterial streets in heavily industrial areas would have much higher percentages of heavy trucks, but were not sampled.)

Trucks of all sorts were most common on CBD freeway ramps, where 15.2% of all vehicles were pickup and panel, semi-trailer, or other trucks. This reflects delivery movements downtown and traffic to and from the industrial areas surrounding downtown. Traffic on innercity freeways is 15% total trucks, but there are more semi-trailer and less pickup and panel trucks than on the CBD freeway ramps.

The lowest percentage of total trucks is 6.7% on outer area Minor Arterials and Collector streets. This reflects the predominant residential service of the streets.

Table IX separates CBD traffic into Inbound and Outbound streams. Understandably, outbound CBD peak period traffic consists of a greater percentage of automobiles, reflecting the predominant outward flow of work trip travel in the afternoon peak.

TABLE IX

Vehicle Classification Percentages Peak Period
Central Business District, Kansas City, Missouri

Classification	Auto-mobile	Bus	Motor-cycle	Pickup & Panel Trucks	Semi-Trailer Trucks	Other Trucks	Other Vehicles
Freeway Ramps							
-Outbound	85.3	0	0.5	11.2	1.2	1.3	0.5
-Inbound	73.1	1.1	2.5	12.7	2.2	6.9	1.5
Arterial Streets							
-Outbound	86.5	2.5	0.4	8.0	0.3	2.0	0.4
-Inbound	80.9	5.9	0.4	9.4	0	2.4	1.0

Automobile classification data was further disaggregated according to size of car. According to the Federal Highway Administration, a sub-compact weighs less than 2,700 pounds when empty; a compact weighs between 2,700 and 3,600 pounds empty; an intermediate car weighs between 3,600 and 4,000 pounds; and a standard sized car weighs more than 4,000 pounds when empty.[2] Persons collecting classification data had to estimate which class each car fit as it drove past their station. This created a significant source of error. The resulting data, as tabulated in Table X, can only be considered indicative, rather than definitive.

TABLE X

Percent of Automobiles by Type

	Sub-Compact	Compact	Intermediate	Standard
CBD	19.9%	11.9%	26.3%	41.9%
Freeways	18.2	15.5	27.9	38.4
Principal Arterials, Minor Arterials & Collectors	25.3	17.5	22.0	35.2

Table X indicates that there are a substantial number of sub-compact cars operating on all classifications, but sub-compact and compact cars are most common on urban streets. The freeway automobile mix seems to tend more toward standard sized cars, with less small cars than on other urban streets. The mix of cars entering the CBD seems to be more like cars on freeways than on other city streets.

SUMMARY

The data collected in the summer of 1977 was designed to contribute to our knowledge of the street and highway system in the Kansas City area. The results of that study are reported herein.

[2] Cost of Owning and Operating an Automobile 1976, FHWA, P.L.

The results of this study can be used to check and validate travel forecasting procedures. It also is a benchmark to measure the performance of the system in 1977. In addition, it provides information on the performance of that part of the system which was specifically studied.

It may be pointed out that the two state highway agencies are involved in the use of sophisticated methods for investigating the traffic conditions on interstate and state highways. Local jurisdictions could also undertake similar investigations, as well as detailed studies such as spot speed study, stopped delay study, etc., for the roadway segments identified as having less than average performance. If the findings of this study are confirmed by such detail investigations, appropriate actions to alleviate the situation may then be considered.

In general terms, this study found that traffic moves freely on most streets and highways in the Kansas City metropolitan area, even during the peak period of traffic activity. Average automobile occupancy was found to have changed little, if at all, since it was last measured in 1970.