

Commuter Parking at a Route-Terminal Metrorail Station

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Passenger service to and from the New Carrollton Metrorail Station, the first of the Washington Metropolitan Area Transit Authority (WMATA) route-terminal rapid transit stations, was begun on November 20, 1978. The New Carrollton Station marked completion of the first of nine suburban routes and branches on an approved 101-mile system, all of which will not be in place until 1990 or later. At New Carrollton, WMATA has provided 2251 automobile parking spaces for long- or short-term use. Surveys of parking-lot use were conducted in 1979. License-plate numbers on cars parked in the all-day lots (1874 spaces at the time of survey) were recorded on 50 different days (10 five-day weeks) during 1979. License numbers for all 50 days were matched by computer to established weekly and longer-term parking frequencies by persons who drove to the New Carrollton Station. Time-of-arrival and car-occupancy surveys were made during the course of these studies to establish commuter arrival habits. These data are being used to find out how all-day parking spaces are being used, who the users are, and something about how parking fees affect lot use. All-day parking lots at New Carrollton were fully occupied throughout the study period; lots were filled to capacity before 8:00 a.m. each day. About 8000 Maryland license numbers were recorded each week, and of these 3000-4000 were different numbers. Contrary to popular belief, fewer than 10 percent of the cars left in the lots were parked every day during the typical week. Data compiled for several weeks show that some drivers reappear about once a week, or once or twice a month, but nearly half (49.3 percent) of the different license numbers were seen only one time during the 50-day survey. The more than 80 000 Maryland license-plate numbers recorded during the 10-week period belonged to 14 700 different cars, which represents a significant fraction of the approximately 100 000 cars garaged in the travel corridor directly tributary to the New Carrollton Station.

The Washington Metropolitan Area Transit Authority (WMATA) in Washington, D.C., broke ground for construction of a 101-mile rail rapid transit system on December 9, 1969. Passenger service was initiated on the first 5.6 miles of the system in late March of 1976. More stations and route miles have been opened to passengers every few months since that date until, by the end of 1981, 44 stations and more than 39 miles of route were in service.

Plans for the completed (101-mile) Metrorail system call for more than 60 000 all-day Metro station parking spaces, owned and operated by WMATA, most of them located in the suburbs. Eleven of the stations now open to traffic will eventually be supplied with more than 10 000 parking spaces; some 5953 of these spaces are now available to Metrorail users.

When complete, the 101-mile system will consist of five main routes in downtown Washington, D.C., branching to nine route terminals, three of them (east of downtown, in Prince Georges County) ending just inside the Capital Beltway (see Figure 1). The other routes will extend beyond the Beltway by varying distances. To date, only two routes have been completed to their planned terminal stations. Both end just inside the Beltway in Prince Georges County--the Orange line at the New Carrollton Station and the Blue Line at the Addison Road Station.

Metro station parking facilities planned for the completed Metrorail system are based on long-range rail passenger forecasts and computerized modeling of the "mode of station access". Estimates of full-system patronage, made in 1969 following definition of the approved regional system, provided an initial basis for station design. The 1969 forecasts were updated in studies made in 1974-1976 and again in 1977-1978; another review and update were done in 1981.

All of the travel demand projections have relied on synthesis of future areawide tripmaking and allocation of trips between public transit and other modes by using the Urban Mass Transportation Administration's Urban Transportation Planning System

computer models or modifications thereof. The travel forecasting models incorporate "modal-choice" procedures that relate trip time and cost values to each of several alternative modes of travel and apportion travel between pairs of traffic zones according to empirically derived relations. The models show that some potential Metrorail riders find that their best choice would be to drive to a Metro station and leave their cars there. A decision to make this choice implies that there will be a place to leave the car. If there is no place to park, this constraint can be incorporated into the modal-choice formula, which may then show that the motorist will avoid Metrorail and drive all the way to the trip destination; alternatively, some tripmakers may find that another mode (walk, bus, or kiss-and-ride) would be appropriate or that the trip should be cancelled. In the modeling process, whenever insufficient parking capacity is encountered, the constraint formula requires that potential Metrorail riders will be diverted away from rail to some degree. It is against this background that an attempt is being made to understand how parking space at New Carrollton is being used, who the users are, and something about how parking fees affect the demand for (or level of use of) parking at this location.

PARKING-SPACE SUPPLY

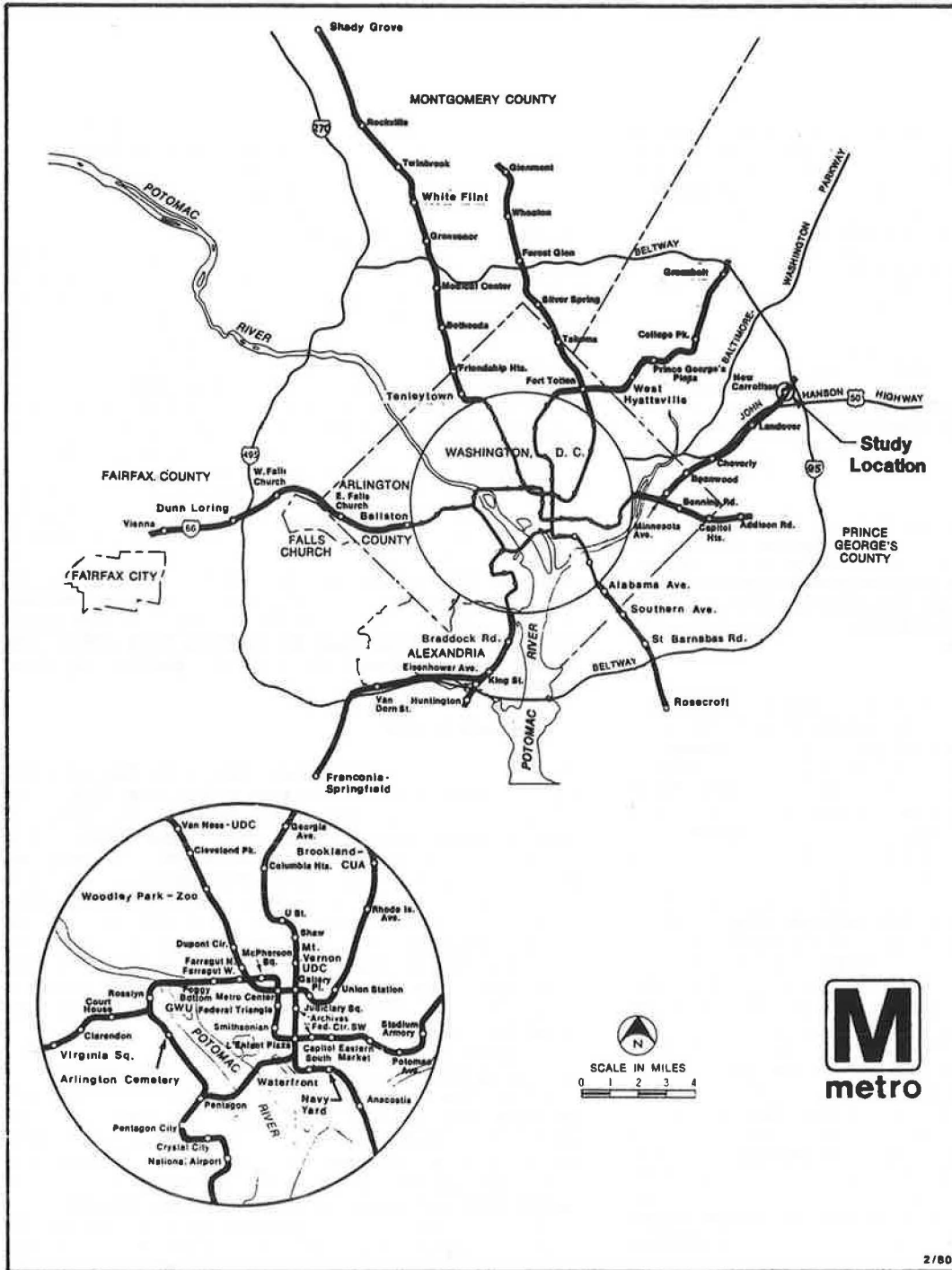
The Metrorail route-terminal station at New Carrollton, 10 miles east of downtown Washington, D.C., was opened to passenger traffic on November 20, 1978. A parking-space inventory at that time found 1971 marked parking spaces in the Metro parking lots, of which 97 were for short-term (kiss-and-ride) use and 1874 were provided for all-day (commuter) parking. Another 280 spaces were made available to all-day parkers late in 1979, and one of the all-day lots was converted to monthly-permit parking at about the same time. The lot layout in early 1980 is shown in Figure 2, and details on allocation of spaces are given in Table 1.

A low-budget, in-house investigation of parking-lot users and parking practices was initiated at the New Carrollton facility in March 1979 and continued at intervals through the summer and fall of that year. The study was limited to parking activities in the 1874 all-day spaces, and data collection was completed before the 280 new spaces were open or spaces were set aside for monthly-permit parkers.

A three-week study of parking-space occupancy was made from March 26 to April 13 (15 weekdays), a second three-week survey was conducted from June 12 to July 2, and a four-week survey was carried out from October 2 to November 2. Other surveys consisted of one-week "time of arrival" and "car occupancy" studies in April. Very briefly, those surveys found that all lots were filled to capacity before 8:00 a.m. each day and that cars averaged only 1.13 occupants. Use of the all-day lots by short-term parkers resulted in some parking turnover and an average daily space use of about 1.1 cars. Combined with average occupancy, each parking space accounted for about 1.25 round-trip Metrorail passengers each day.

The three surveys of parking-space occupancy produced 10 weeks (50 days) of daily license-plate numbers, recorded by survey personnel who passed "once

Figure 1. Washington, D.C., regional rail rapid transit system.



through the lot" each morning (9:00-10:00 a.m.) after the lots were full. The recorded numbers provide comprehensive coverage of all-day commuters but also include some early parkers who return for their cars in late morning and early afternoon. Some of these are replaced by drivers who arrive at random throughout the day; other drivers enter and park for a few hours after the main body of commuters has departed in the afternoon. Although such "turnover parkers" were not listed, their origins and frequencies of appearance in the lots were probably much like those of the recorded vehicles, as discussed later.

PARKING-LOT SURVEY

Each day during the 10 weeks of survey, recorders listed the license numbers and states of registration of all cars parked. Between 1750 and 1850 license numbers were recorded each morning. The variation in numbers parked from day to day was not due to lack of patrons but to peculiarities of the automatic gates, which were programmed to bar entry to each lot when the number of cars entering was equal to the number of spaces in the lot. Erratic behavior of the counting mechanism sometimes caused gates to lock before lots were completely filled.

Figure 2. Final site plan for New Carrollton Station.

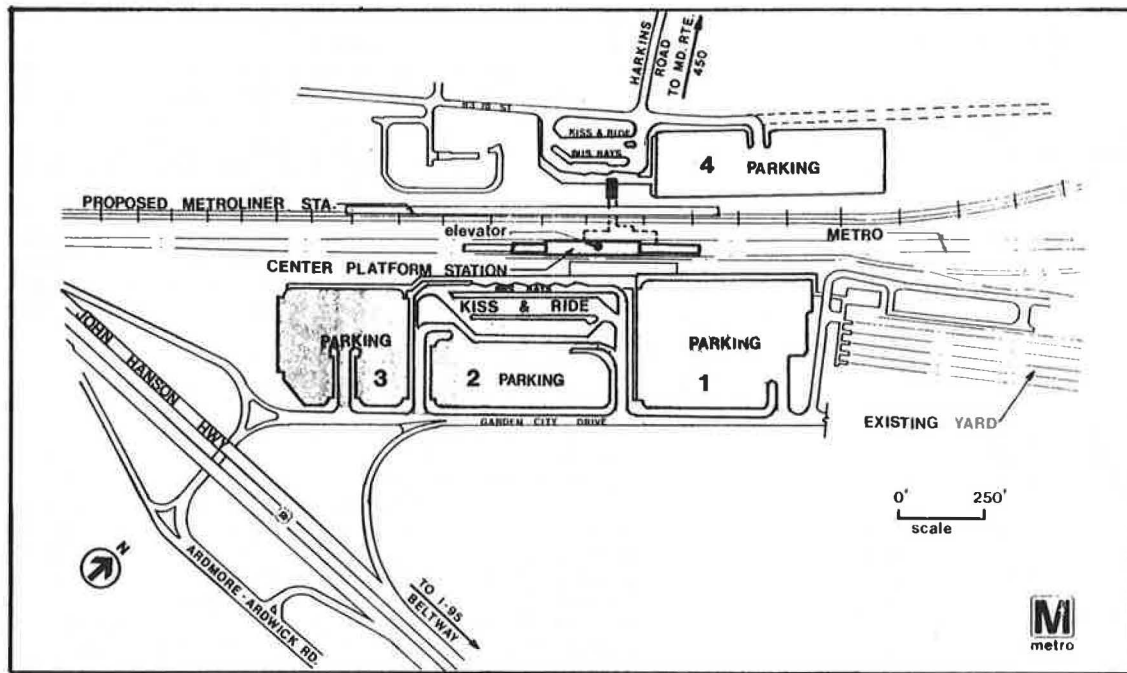


Table 1. Parking-space inventory of New Carrollton Station.

Section of Station	Lot Description	Parking Category	No. of Spaces
East side	Kiss-and-ride	Short term	66
	Long term		
	Lot 1	All-day commuter	626
	Lot 2 ^a	Monthly permit	323
	Lot 3	All-day commuter	522
Total			1537
West side	Kiss-and-ride	Short term	31
	Long term, lot 4	All-day commuter	683
Total			714
Total parking spaces			2251

^aConverted from daily-commuter to monthly-permit lot in November 1979.

About 90 percent of the cars parked at the New Carrollton Station bear Maryland license plates. During each week of the survey, 8000-8200 Maryland license numbers were recorded. Overall, nearly 80 400 Maryland license numbers were listed in the 10 weeks of the survey.

Before the license-plate surveys were made, some WMATA staff were generally of the opinion that the New Carrollton lots were occupied by users (cars) whose identities changed very little from day to day. Comparison of the daily license-number records soon showed that this was not the case. Relatively few of the cars that park in the lots are seen there day after day. During the first week, 8207 Maryland license numbers were listed, representing 4455 different cars. An average of 1641 Maryland plates were seen in the lots each morning, but that number accounts for only 37 percent of all different numbers recorded during the week; on average, more than 700 of the Maryland numbers recorded on each of the other four days of the week were not seen on any other day during the week; these added to the 1641 parked on the first day account for the 4455 different numbers seen during the week. Thus, more than half of all cars recorded during the first week

of the study--54.3 percent--were unduplicated numbers. When data for the first two weeks were combined, the 16 291 records yielded 6699 different numbers, or about 41 percent. Overall, the three-week survey listed 24 535 Maryland numbers, obtained from 8484 different cars--34.6 percent of the total. As data from later surveys were added to these, the number of different cars parked at New Carrollton continued to increase at a slower rate than the gross number of daily records. By the end of the 10 weeks of survey, 14 700 different Maryland cars had been identified, which accounted for 18.3 percent of the 80 400 Maryland license numbers recorded during that time.

Table 2 gives the number of Maryland license tags recorded during each week of the survey, the different cars represented, and the percentage of different cars in the total number of tags recorded weekly.

The proportion of different cars parked in the first week of the study was appreciably larger than in any subsequent week. Several reasons have been suggested, but no one reason may have been the cause. Stormy weather during the last week of March may have reduced the number of regular patrons on some days and allowed more late arrivers to use space not usually available to them. The first week was also a learning period for the survey crew, who may have made an abnormal number of recording errors. (Permanent survey staff did the work, however, and reliability checks at a later date found virtually no recording errors in the daily reports; it is unlikely that recording errors were a significant factor.) In addition, since some drivers who later were regular parkers were not yet established at New Carrollton, more different cars were able to use the lots in the early weeks of station operation; this would be consistent with the steady decrease in the proportion of different cars to all cars parked each week throughout the 10-week study, even though the difference from the first week to the second was much larger than average.

Table 2 also lists all cars and different cars seen in combined data for periods of 2-10 weeks.

Table 2. Summary of license-plate records from 10-week parking survey at New Carrollton Station.

Time Interval (weeks)	Survey Week	Maryland Numbers		
		All Cars	Number	Percent
1	1	8 207	4 455	54.27
	2	8 098	3 793	46.86
	3	8 061	3 894	48.31
	4	8 131	3 800	46.73
	5	7 944	3 718	46.80
	6	8 009	3 688	46.05
	7	7 649	3 281	42.89
	8	8 296	3 362	40.53
	9	8 197	3 293	40.17
	10	7 481	3 037	40.60
2	1+2	16 291	6 699	41.12
	4+5	16 101	5 439	33.78
	7+8	16 022	4 645	28.99
	9+10	15 719	4 399	27.99
3	1 to 3	24 525	8 484	34.59
	4 to 6	24 122	6 745	27.96
	7 to 9	23 427	5 561	23.74
4	1 to 4	32 427	8 645	26.66
	7 to 10	31 798	6 448	20.28
5 ^a	1 to 5	40 524	9 773	24.12
	5 to 9	40 273	9 065	22.51
6 ^b	1 to 6	48 539	10 875	22.40
	5 to 10	47 779	9 748	20.40
7	2 to 8	56 390	12 250	21.72
8	2 to 9	64 653	13 016	20.13
9	2 to 10	72 164	13 643	18.91
10	1 to 10	80 378	14 700	18.29

Note: Survey data are composed of license numbers recorded on weekdays from March 26 to April 13 (three weeks), June 12 to July 2 (three weeks), and October 3 to November 2 (four weeks).

^a Two sets of data are listed for five-week accumulations of Maryland license numbers. Survey week 5 is common to both sets.

^b Two sets of data are listed for six-week accumulation of Maryland license numbers. Note that survey weeks 5 and 6 are common to both sets, which minimizes (partly obscures) differences between nonduplicated portions of the data.

Although the number of Maryland license numbers recorded in each of four different two-week intervals was about the same from one interval to the next, the proportion of different cars in the data compiled each week decreased steadily from just over 41 percent in the first two weeks to only 28 percent in the last two weeks. This is consistent with the decrease in the numbers of different cars in weekly data, noted earlier. Similar ranges were seen when license numbers were combined by 3-, 4-, and 5-week intervals. The vast majority of cars parked at the station during the 10-week period were only occasional lot users. From this, it seems likely that the entire year following initiation of service at the New Carrollton Station saw a gradually changing pattern of use at the parking facilities and a slowly increasing number of regular users.

Table 3 summarizes the use of New Carrollton Station lots by Maryland cars during the 50 weekdays studied. As mentioned earlier, more than a sixth of the nearly 80 400 license numbers recorded (18.3 percent) represented different cars--14 700 separate vehicles. This was more than nine times the number of Maryland cars parked in the lots on the average morning. Almost half of all cars that entered the lots (49.3 percent) were seen there on only one of the 50 days.

Note in column 4 of Table 3 that more than four-fifths (81.8 percent) of the different cars parked at the New Carrollton Station averaged fewer than one appearance weekly (9 or fewer times in the lot in 10 weeks) and, according to the data in column 7, accounted for slightly less than a third (32.7 percent) of the 80 400 parking-space days used by cars with Maryland license plates. About one-eighth

(11.5 percent) of the cars appeared in the lots an average of 1-2 times each week (10-20 times during the period of the survey) and used nearly as many space days (29.5 percent). Fewer than 6 percent (5.9 percent) of the parkers averaged 3-4 days/week but accounted for about the same proportion of the space days (31.3 percent). Fewer than 1 percent (0.82 percent, or 119 cars) were "daily" users, averaging more than four days per week and using nearly 6.5 percent of the space days. (No car was seen on all 50 days of the survey.) Overall, fewer than 5 percent (only 683) of the different cars were each in the lot on more than 25 of the 50 survey days, but this small number occupied nearly 29 percent of the parking spaces used each day (on average) by Maryland cars. In fact, the 172 cars that were parked 39 times or more in 50 days used up as many parking-space days (7283) as all of the one-time parkers (7249).

The data compiled in the 50-day survey do not represent all of the Maryland cars (license numbers) parked in the New Carrollton lots during the survey period. Gate fees collected during this time show that about 10 percent more cars were parked in the all-day lots than are accounted for in the daily license-number records; these were the turnover parkers who were able to occupy spaces left open by drivers who returned to the lots during midday, or people who parked in the late afternoon when many commuters had returned from their day's work. There were also many kiss-and-ride drivers who dropped passengers at the station or parked and waited in the short-term lots for passengers returning on Metro. Cars can be left unattended in the metered kiss-and-ride lots after 10:00 a.m. and before 3:00 p.m., and the spaces are used by drivers who expect to make quick return trips on the Metro. Very little information has been assembled on short-term parkers in the above categories, and no license-plate listings have been made to establish the proportion of these parkers who have Maryland plates. How serious is omission of these drivers with respect to the general characteristics developed from the 50-day survey of early morning parkers?

The 50-day survey compiled frequency data on parking in the morning peak. In the absence of direct interviews, it is reasonable to assume that a large proportion of the all-day parkers are bound for full-time work or business activities. Those who leave early may be exceptions. Most of the late arrivals who occupy vacated spaces in midday or evening would seem to be less likely daily users of Metro, but there is little reason to think that a smaller proportion of them are Maryland cars. If they use Metro less frequently than the commuters who park all day, there may be an even larger proportion of low-frequency parkers in their number; the number of different persons using the New Carrollton parking lots during any period of days, weeks, or months would, in that case, appear to be understated in the data presented in Tables 2 and 3, perhaps by an appreciable amount.

To summarize, then, the New Carrollton Station lots were found to accommodate more than 1600 cars with Maryland license plates every day (about 90 percent of the all-day spaces provided by WMATA at this station before the lots were enlarged or restriped). About nine times as many different Maryland drivers (cars) parked in the lots during the 50-day period as could be parked at any one time, which can be interpreted to mean that there is much greater interest in all-day station parking than the lots can handle. The number of one-time parkers was seen to be a diminishing proportion of the cars parked each day throughout the study period; even so, the total number of different cars using the

Table 3. Different cars and their frequency of appearance at New Carrollton Station parking lots over 50 working days.

Times in Lot	No. of Cars	Proportion of Different Cars (%)	Cumulative Percentage		Parking-Space Days Used	
			Increasing	Decreasing	Percentage	Cumulative Percentage
1	7249	49.32	49.32	100.00	9.02	9.02
2	1665	11.33	60.65	50.68	4.14	13.16
3	915	6.23	66.88	39.35	3.43	16.58
4	595	4.06	70.94	33.12	2.96	19.54
5	478	3.25	74.19	29.06	2.97	22.51
6	363	2.47	76.66	25.81	2.71	25.22
7	268	1.82	78.48	23.34	2.88	27.55
8	255	1.73	80.21	21.52	2.54	30.09
9	232	1.58	81.79	19.79	2.60	32.69
10	201	1.37	83.16	18.21	2.50	35.19
11	220	1.50	84.66	16.84	3.01	38.20
12	198	1.35	86.01	15.34	2.96	41.16
13	191	1.30	87.31	13.99	3.09	44.25
14	184	1.25	88.56	12.69	3.20	47.45
15	147	1.00	89.56	11.44	2.74	50.19
16	124	0.84	90.40	10.44	2.47	52.66
17	128	0.87	91.27	9.60	2.71	55.37
18	113	0.77	92.04	8.73	2.53	57.90
19	102	0.69	92.73	7.96	2.41	60.31
20	77	0.52	93.25	7.27	1.92	62.23
21	70	0.47	93.72	6.75	1.83	64.06
22	58	0.39	94.11	6.28	1.59	65.65
23	61	0.41	94.52	5.89	1.75	67.40
24	63	0.43	94.95	5.48	1.88	69.28
25	60	0.41	95.36	5.05	1.87	71.15
26	50	0.34	95.70	4.84	1.62	72.77
27	52	0.35	96.05	4.30	1.75	74.52
28	50	0.34	96.39	3.95	1.74	76.26
29	52	0.35	96.74	3.61	1.88	78.14
30	43	0.29	97.03	3.26	1.60	79.74
31	40	0.27	97.30	2.97	1.54	81.28
32	49	0.33	97.63	2.70	1.95	83.23
33	30	0.20	97.83	2.37	1.23	84.46
34	36	0.24	98.07	2.17	1.52	85.98
35	26	0.18	98.25	1.93	1.13	87.11
36	27	0.18	98.43	1.75	1.21	88.32
37	17	0.12	98.55	1.57	0.78	89.10
38	39	0.27	98.82	1.45	1.84	90.94
39	28	0.19	99.01	1.18	1.36	92.30
40	25	0.17	99.18	0.99	1.24	93.54
41	20	0.14	99.32	0.82	1.02	94.56
42	24	0.16	99.48	0.68	1.25	95.81
43	16	0.11	99.59	0.52	0.86	96.67
44	23	0.16	99.75	0.41	1.26	97.93
45	10	0.07	99.82	0.25	0.56	98.49
46	14	0.10	99.92	0.18	0.80	99.29
47	9	0.06	99.98	0.08	0.53	99.82
48	2	0.01	99.99	0.02	0.12	99.94
49	1	0.01	100.00	0.01	0.06	100.00
50	-	-	-	0.00	0.00	100.00

Note: Total number of different cars = 14 700.

lots during the first year of operation was doubtless much larger than the number seen during the survey.

Figure 3 shows a plot of the numbers of Maryland cars parked (accumulated week by week) versus the number of different cars seen. The plotted points form a line to which an equation has been fitted. The equation shows that if this relation were to hold for a full year, during which time more than 400 000 cars would have used the all-day lots at New Carrollton (52 weeks, with >8000 cars with Maryland license plates entering the lots each week), about 40 000 different Maryland vehicles would have been seen in the lots. If account is also taken of the 15 percent increase in lot capacity and the 10 percent "turnover" experienced in the all-day lots during the study period, assuming continued rates of occupancy, then a somewhat larger number of Maryland cars could be expected to make use of the lot each year.

STATION SERVICE AREA

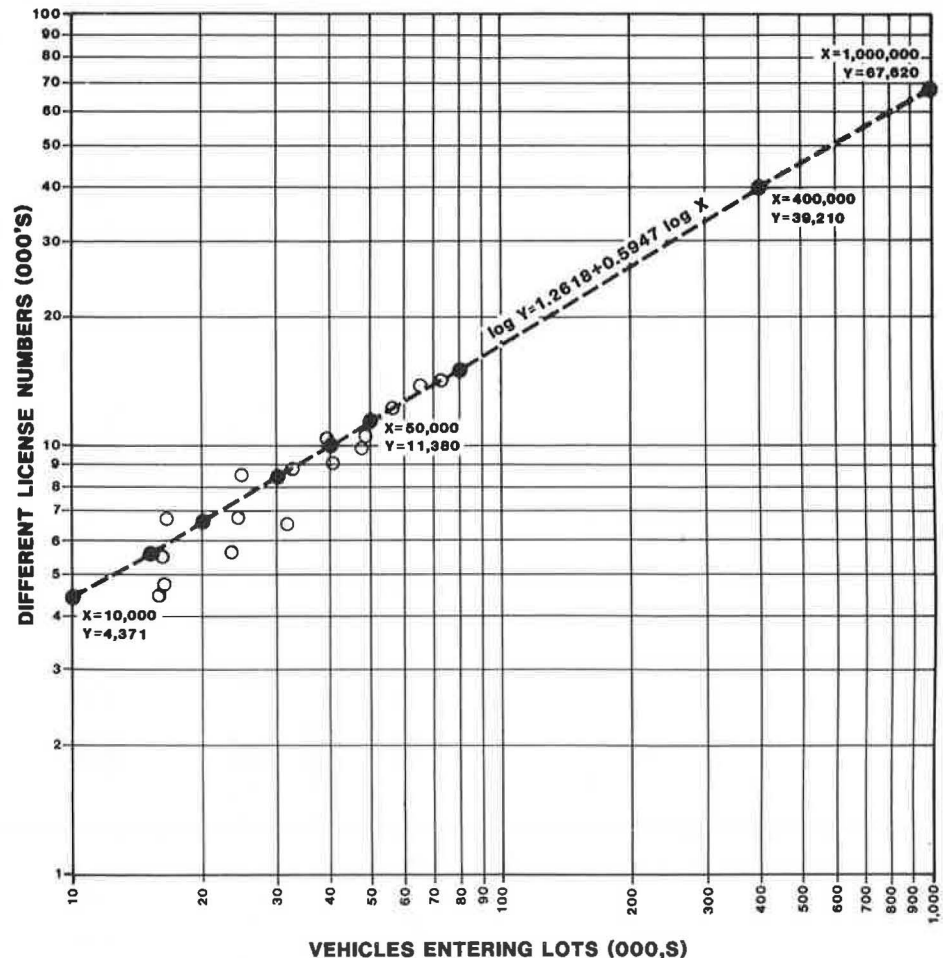
The New Carrollton Station is strategically located to provide access to a considerable portion of

Prince Georges County and other, more remote Maryland communities. Five principal highways give access across the I-95 Capital Beltway, as shown in Figure 4. The five roads were carrying a combined peak-period volume (6:30-9:30 a.m.) of more than 27 500 inbound vehicles, about 90 percent of which had Maryland license plates. (Maryland cars bound for the New Carrollton Station parking lots account for less than 7 percent of this traffic.)

Residents of Prince Georges County owned 366 482 cars and taxis in 1977, according to year-end vehicle licensing statistics. Adjusted for duplication, cars in actual use in 1979 are estimated to number about 330 000. Some 100 000 of these were owned by residents of the "primary service area" tributary to the New Carrollton Station.

Not all of the Maryland cars parked at the New Carrollton Station originate in the primary service area, of course. The license-plate numbers recorded for cars parked in station lots on June 27, 1979, were matched with addresses of the owners, as recorded in the files of the Maryland Motor Vehicle Administration, and staff of the Prince Georges County Department of Public Works and Transportation plotted on a large-scale map the place of residence

Figure 3. Number of Maryland cars parking in New Carrollton Station all-day parking lots versus number of different license numbers seen over 50 working days.



for 1439 privately owned cars. Four-fifths of the addresses (79.2 percent) were in Prince Georges County, and most of the rest (16.1 percent) were directly beyond, in Anne Arundel County, and reached by some of the same radial routes used for station access by residents of the Prince Georges County portion of the service area. Fewer than 5 percent (4.7 percent) of the Maryland cars were registered to "nonresidents"--persons with addresses in other than these two counties.

Cars owned by Prince Georges County residents are more likely to make repeat appearances in the New Carrollton Station all-day lots than cars from elsewhere in Maryland. In the course of a year, Maryland cars registered to addresses outside Prince Georges County probably account for as many as 10 000 of the 40 000 different cars estimated to park in the long-term lots. The Prince Georges County cars that use the lots thus represent some 9 percent of the different cars owned by County residents and about 30 percent of the cars registered to residents in that part of the County directly tributary to the New Carrollton Station.

These arguments emphasize the impact of the Washington, D.C., Metro on suburban tripmaking. When the impact on different households is examined, an even greater effect is seen. Car ownership in Prince Georges County, after adjustment for overstatement in year-end car registration statistics, averaged 1.4 cars/household in 1980. If one assumes that residents who drive and park at the Metro station use but one of the family cars for this purpose most of the time, then the households whose members

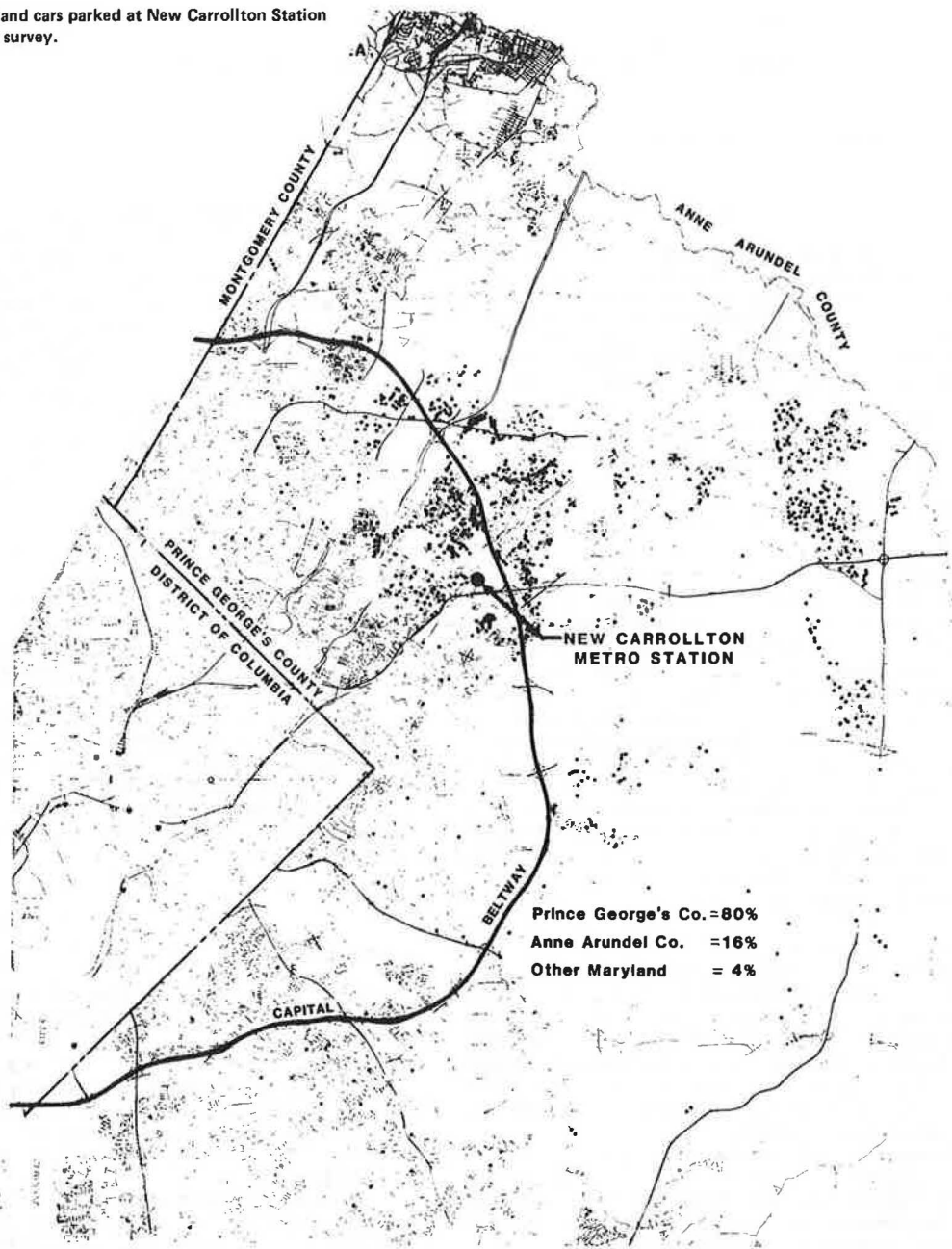
make active use of the parking lots are seen to constitute an even larger proportion, accounting for a third or more of all households in the tributary area served by the five highways that radiate into the County from the vicinity of the Metro station. (Overall, the influence of the rapid transit system is further augmented by patrons who arrive at the New Carrollton Station each day by modes other than private car; these account for more than a third of daily boardings.)

The policy implications of the facts about commuter parking at New Carrollton are especially intriguing. Instead of catering to a group of steady customers who represent a favored fraction of the local electorate, the lots at New Carrollton are being used by a broad cross section of residents throughout a large service area (nearly everyone has need to ride Metro at one time or another). In light of this widespread interest, and the evident inability of the parking-space supply to fully meet demand, the study of parking practices at New Carrollton will continue to command great interest.

SUMMARY

The significance of the commuter parking practices described in this paper extends far beyond the patronage and revenues realized from parking charges and Metro fares. That everyone is affected by and acutely interested in the improved mobility provided by Metro is affirmed by the evidence that in its first full year of operation the New Carrollton Station attracted park-and-ride customers from a third

Figure 4. Origins of Maryland cars parked at New Carrollton Station from one-day license-plate survey.



or more of all Prince Georges County households directly accessible to the station.

The New Carrollton Station is the first of Metro's end-of-route rail stations to begin service. Eventually, nine rapid transit routes will have similar terminals, providing suburban accessibility to rapid transit in most of Washington's principal travel corridors. Early experience at New

Carrollton confirms the appeal that the Metro system was expected to have in attracting former motorists to transit and emphasizes the importance of an adequate supply of commuter parking spaces to accommodate the modal interface.

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