HIGHWAY RESEARCH RECORD

Number 130

Shopping Centers and Parking

3 Reports

Subject Classification

53 Traffic Control and Operations
55 Traffic Measurements

HIGHWAY RESEARCH BOARD

DIVISION OF ENGINEERING NATIONAL RESEARCH COUNCIL
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Foreword

In recent years, there have been but few papers on shopping centers and parking problems among the deliberations of the Highway Research Board. The three papers presented in this Record represent the re-entry of research reporting on this demanding phase of transportation.

Two of the papers are concerned with parking and traffic requirements at large planned shopping centers. The other is an interesting look at fringe parking usage for transit riders using studies conducted in Washington, D. C., as a basis.

Deen's paper on fringe parking usage focuses on the feasibility of extended use of parking facilities for transit users in Washington, D. C., utilizing data in that area, and arrives at conclusions which could be influential in the success or failure of fringe parking in cities generally. The many transit systems in the planning stage in various cities could take advantage of this research to plan more effectively their parking areas for the transit user.

Voorhees and Crow's paper on shopping center parking requirements presents research derived from some 270 centers throughout the United States and Canada and recommends appropriate standards for application to zoning ordinances for new centers. Discussions of the paper are also presented.

Dickey and Shuldiner have applied mathematical modeling to calculate maximum generation of traffic to planned shopping centers. The model derived in this paper using trips/sales ratios presents a means of arriving at traffic generation figures which are safely on the high side as far as future traffic is concerned but not unreasonably high.

This Record should be of prime interest to land developers of shopping centers, planning and zoning officials, traffic forecasters, and transit planners. Planning and traffic engineers should find immediate use of the findings presented in some of the papers.

Contents

A Study of Transit Fringe Parking Usage

THOMAS B. DEEN, Associate, Alan M. Voorhees & Associates, Washington, D. C.

Transit fringe parking (or park-and-ride) facilities are valuable to the city because use of them removes peak-hour traffic from the streets and decreases downtown parking demand. Not all attempts at the promotion of fringe parking have been successful, however.

This study, which focuses mainly on the feasibility of extended use of fringe parking facilities in the Washington, D. C. area, presents data and draws conclusions on factors which influence the success or failure of fringe parking in cities generally.

•SINCE World War II, the concept of transit fringe parking, that is, parking a car at some distance from one's ultimate destination and then riding mass transit the rest of the way to it, has been proclaimed by many as at least a partial solution to the urban transportation problem; and it has been tried, with varied results, in cities throughout the country. If commuters can be induced to park-and-ride, the following advantages accrue to the community:

1. Automobiles are taken off the road in and near the central city area, where transportation problems are most acute.
2. Cars are taken off the road during the peak traffic hours.
3. The addition of the new passengers strengthens transit service and allows increased frequency of service. This, in turn, tends to draw even more transit riders and thus further reduces auto congestion.
4. Downtown parking problems are eased, and more space remains available for the shopper and other people desiring short-time downtown parking. The reduction in demand for downtown parking has secondary benefits in that more space is then available for primary land uses, with resultant efficiencies in intradowntown accessibilities, higher tax yields, etc.

This paper contains some of the findings that resulted from a study of fringe parking feasibilities for the Washington, D. C. area (1). The study examined the experience of fringe parking in a number of cities, although Washington was the focus of special analysis. Although the results are not conclusive, the frequency of fringe parking proposals, as contrasted with the scarity of definitive material in the literature on the subject, would seem to make many of the findings useful to other areas.

That commuters can be induced to park-and-ride is amply demonstrated by the fact that thousands do it daily throughout the nation. On the other hand, the number of fringe parking lots that have been abandoned for lack of use is evidence that certain conditions must obtain before park-and-ride is a preferred choice for the commuter.

Fringe parking facilities can be developed in connection with either rail or bus transit systems. While this report presents an inventory of rail fringe parking experience throughout the nation, the main thrust of the study is toward determining the feasibility of fringe parking related to bus transit, that is, bus fringe parking to be used in corridors where rail service is not planned or while the rail system is being constructed.

Paper sponsored by Committee on Parking and presented at the 45th Annual Meeting.

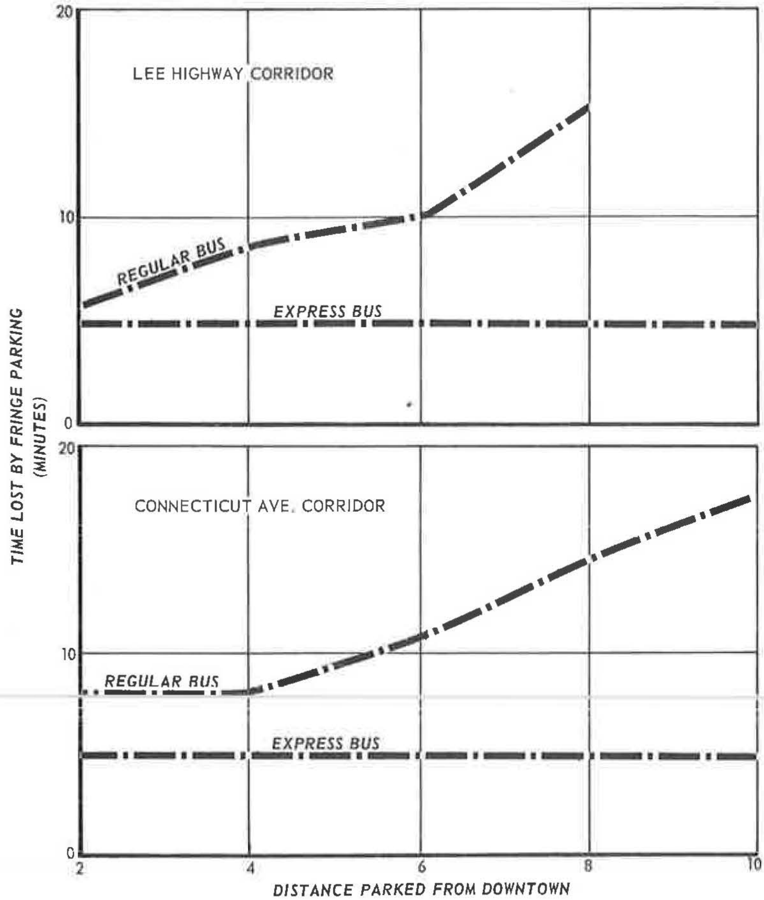


Figure 1. Time lost by fringe parking at various distances from downtown. (Assumes 2-min walk and 3-min wait at fringe parking bus stop; travel times as reported by 1959 Federal employee parking study.)

The purpose of this study is to investigate the bus park-and-ride phenomenon with the objective of discovering those factors which tend to induce more fringe parking and, conversely, those factors which tend to discourage it. An understanding of such factors can be used to evaluate the need for, the best location for, and the fiscal relationships related to additional fringe parking facilities for a city.

In an effort to avoid downtown parking costs and congested driving conditions, the fringe parker must accept (a) the inconvenience of interrupting his drive to downtown, parking, walking to the transit stop, and waiting for the bus or train; and (b) increased travel time. In the case of rapid transit this latter item is not necessarily a factor; but, where the transfer is made to buses operating with other traffic, the trip will almost always be slower for the park-and-rider than if he drives downtown. Even where non-stop buses direct from the fringe lot to downtown are used, the bus can at best only match the auto time; the time required to park and transfer is lost. Figure 1 illustrates this time loss in two Washington corridors, based on travel times reported by downtown commuters.

The decision to park-and-ride is determined by the trade-off the commuter makes in his own mind between the inconvenience and lost time of fringe parking and the high parking costs and congested traffic involved in driving all the way. One purpose of this study is to examine the relative importance of pertinent factors that determine this trade-off.

TABLE 1

USAGE OF PARK-AND-RIDE LOTS AT RAIL RAPID TRANSIT STATIONS

City	Parking Spaces	Cars Parked	Percent Filled	Typical Parking Fee	No. of Lots
New York	4518	2775	61	0.45	6
Chicago	2217	2032	92	0.25	11
Philadelphia	1835	1880	102	0.25	5
Boston	6209	3750[a]	61	0.35	29
Cleveland[b]	7256	7443	103	0	20
Toronto	0[c]	0	—	—	0
Pittsburgh	395[d]	190	84	0.35	3
Ft. Worth	5000	4200	84	0	1
Total	27,430	22,270	81		75

[a]Estimated Boston usage based on the 61 percent usage obtained from Mass Transportation Commission survey of 4490 Boston rail transit parking spaces.
[b]Includes Shaker Heights Rapid Transit Line.
[c]Some park-and-ride reported at private parking facilities located near transit stations. No fringe parking owned or operated by Toronto Transit Commission.
[d]Streetcars operating on their own rights-of-way.

EXPERIENCES WITH FRINGE PARKING LOTS

As noted earlier, the obvious advantages of fringe parking to the transportation efficiency of the community have been recognized for many years. As a result, many cities have attempted to increase the incidence of park-and-ride by the establishment of outlying parking lots expressly for this purpose. Some of these lots have been fully used; others have failed.

In an effort to profit from these experiments, questionnaires were sent to some 36 cities that were known to have experimented with fringe parking. Twenty-eight cities responded and the results have been tabulated.

Fringe Parking and Rail Transit

Table 1 summarizes the results of a survey of parking lots located at rail rapid transit stations in North America. Some 22,000 cars are parked in 27,000 spaces located in 75 individual parking lots each day. These figures do not include park-and-ride associated with commuter railroads. An average of 81 percent of these spaces is used each day, even though parking fees running as high as 60 cents are charged. Cleveland provides the most parking in relation to transit system size (excepting Ft. Worth, which is noted below) and operates under a policy of providing the spaces free to commuters. Plans for extension of the system call for additional parking at outlying stations. Philadelphia also gets full utilization of its smaller number of available spaces, in spite of a 25-cent parking fee in addition to the transit fare.

Only two systems, Boston and New York, experience a significant amount of unused parking space, about 40 percent in each case.

The explanation for this lies partially in the fact that, in each of these two cities, a large portion of the total fringe spaces are located in one lot which is less than half filled.

In Boston, 1600, or 26 percent, of the total of 6200 fringe spaces are located in one lot that is less than one-third filled. This particular lot is located 11 miles out from downtown on the end of a streetcar-subway line with critical speed restrictions that

TABLE 2

FRINGE LOTS USED FOR PARK-AND-RIDE IN CONNECTION WITH RAIL RAPID TRANSIT SYSTEMS IN NORTH AMERICA

Location of Lot	No. of Spaces	Cars Parked Daily	All Day Parking Fee ($)	Distance to Downtown (mi)	Transit Time to Downtown (min)	Transit Fare to Downtown ($)	Trains per Hour		Hours of Transit Service	Self Park	Guard on Duty	Lot Owned by	Lot Operated by	Remarks	Transit Speed (mph)
							Peak	Off-Peak							
New York City:															
Long Island Expressway & 92nd St.; Rego Park	1148	860	0.30	10.0	30	0.15	25	10	24	x	x	City of N. Y.	N. Y. C. Dept. of Traffic		20.0
Westchester & Zerago Ave.; Bronx, N. Y.	59	59	0.40	12.0	40	0.15	14	6	24	x		City of N. Y.	N.Y.C. Dept. of Traffic	Parking meters used	18.0
Grant & Pitkin Aves.; Brooklyn, N. Y.	200	195	0.50	12.0	35	0.15	15	4	24	x		City of N. Y.	N.Y.C. Dept. of Traffic	Metered operation	20.6
Astoria Blvd. & Hoyt Ave.; South Queens, N.Y.	114	114	0.50	6.0	25	0.15	17	5	24	x		City of N. Y.	N.Y.C. Dept. of Traffic	Meters	14.4
Queens Blvd., 32nd Pl., 48th St.; (Sunnyside) Queens, N. Y.	447	447	0.60	4.0	15	0.15	35	12	24	x	x	City of N. Y.	N.Y.C. Dept. of Traffic	Meters	16.0
Willets Point Station of IRT Line	2550	1100	0.50	7.0	19	0.15	36	10	24	x	x	N.Y.C. Dept. of Parks	N.Y.C. Dept. of Parks	2550 of 7225 set aside for commuter parking	16.0
	4518	2775													
Philadelphia:															
Nedro Ave., 9th to 11th Sts.; Fern Rock, Phila.	675	675	0.25	6.5	21	0.24	20	7	24	x		City of Phila.	½ Transit operator & ½ Dept. of Public Prop.	2 areas	18.5
Bustleton & Bridge Sts; Phila.	650	675	0.25	7.0	22	0.24	20	7	24	x		City of Phila.	Transit operator		19.1
69th St. & West Chester Pike; Upper Darby	330	400	0.25	6.0	15	0.24	20	7	24	x		Transit operator	Transit operator		24.0
46th & Market Sts.; Phila.	150	130	0.25	2.5	8	0.24	20	7	24			City of Phila.	Private operator		18.7
	1835	1880													
Chicago:															
Linden Ave. at 4th Ave.; Wilmette (East Lot)	224	219	0.25	14.03	39	0.40	14	7	24	x		Transit operator	Transit operator	Coin-operated gates	21.6
4th Ave. at Laurel Ave.; Wilmette (West Lot)	242	146	0.25	14.03	39	0.40	14	7	24	x		Transit operator	Transit operator	Coin-operated gates	21.6
Howard St. at Hermitage Ave.; Howard Terminal (North Lot)	140	133	0.25	10.57	27	0.25	39	14	24	x		Transit operator	Transit operator	Non-CTA patrons pay additional $0.10	23.5
Hermitage Ave. at Rodgers Ave. Howard Term. (South Lot)	146	131	0.25	10.57	27.0	0.25	39	14	24	x		Transit operator	Transit operator	Non-CTA patrons pay add. $0.10	23.5
Lawrence Ave. at Kimball Ave.; Kimball Terminal	211	169	0.25	9.10	27.0	0.25	16	9	24	x		Transit operator	Transit operator	Non-CTA patrons pay add. $0.10	20.2
Congress Terminal Main Lot Forest Pk.	550	350	Free	9.61	24.5	0.25	11	8	24	x	x	Transit operator	Transit operator	Lot to be converted to fee lot upon completion of terminal	23.5
Congress Terminal Aux. Lot Forest Pk.	70	70	0.25	9.61	24.5	0.25	11	8	24	x		Transit operator	Transit operator	Coin gates	23.5
21st St. Pl. at Central Ave. 54th Terminal Cicero	50	50	0.25	8.09	23.0	0.25	11	8	24	x		Transit operator	Transit operator		21.1
Dempster Terminal Skokie Swift	419	419	0.25	15.66	33.5	0.45	13	4	6 a.m. -11 p.m.	x		CTA & Public Service Co.	Village of Skokie	2-Stage trip	28.1
Lavergne Ave. at Congress Pkwy.	80	60	Free	5.15	13.5	0.25	12	8	24	x		Transit operator	Transit operator	Inconvenient to transit station	22.8
54th Ave. at 21st Pl. Cicero	285	285	Free	8.09	2.3	0.25	11	8	24	x		Transit operator	Transit operator	To be converted to fee lot	21.1

CTS West 117 Rapid Transit Station	560	500	Free	5.24	10.0	0.29	10			x		Transit operator	Transit operator		
CTS Triskett Rapid Station	1300	1600	Free	6.3	12.0	0.29	20			x		Transit operator	Transit operator		
CTS West Park Rapid Station	2096	2400	Free	7.08	14.0	0.29	20			x		Transit operator	Transit operator		
CTS West 98 Rapid Station	329	250	Free	4.28	8.0	0.29	10			x		Transit operator	Transit operator		
CTS East 55	86	105	Free	2.55	5.0	0.29	10			x		Transit operator	Transit operator		
CTS Superior	295	300	Free	7.18	15.0	0.29	10			x		Transit operator	Transit operator		
CTS Windermere	982	600	Free	7.85	17.0	0.29	10			x		Transit operator	Transit operator	75 spaces metered	
	5648	5755													
Cleveland, Shaker Heights System:															
Green Road	570	559	Free	9.8	23.0	0.30	40	8	5:20 a.m. -1:10 a.m.	x		Transit operator	Transit operator		26
Warrensville Ctr. Rd.	95	102	Free	8.8	20.4	0.30	40	8		x		Transit operator	Transit operator		26
Farnsleigh Dr.	316	351	Free	9.1	22.8	0.30	40	8		x		Transit operator	Transit operator		24
Blair House	30	32	Free	9.0	22.5	0.30	40	8		x		Transit operator	Transit operator		24
Lynnfield Rd.	105	101	Free	8.8	22.0	0.30	40	8		x		Transit operator	Transit operator		24
Kenmore Rd.	90	71	Free	8.5	21.2	0.30	40	8		x		Transit operator	Transit operator		24
Avalon Rd.	108	113	Free	8.2	20.5	0.30	40	8		x		Transit operator	Transit operator		24
Ashby	36	34	Free	7.9	19.7	0.30	40	8		x		Transit operator	Transit operator		24
Onaway Rd.	36	39	Free	7.6	19.0	0.30	40	8		x		Transit operator	Transit operator		24
Southington Rd.	28	25	Free	7.2	18.0	0.30	40	8		x		Transit operator	Transit operator		24
South Woodland Rd.	35	30	Free	6.9	17.2	0.30	40	8		x		Transit operator	Transit operator		24
Drexmore Rd.	118	166	Free	6.6	16.3	0.30	40	8		x		Transit operator	Transit operator		24
Woodhill Rd.	41	63	Free	6.3	15.6	0.30	40	8		x		Transit operator	Transit operator		33
	1608	1686													
Pittsburgh:															
Linden Grove	225	190	0.35	5.0	20.0	0.29	25	4	24	x	x	Privately owned	Private operator	Streetcar line on separate R/W	
Drake Leap	50	50	0	11.0	40.0	0.44	8	2	24	x		Transit operator	Transit operator	Streetcar line on separate R/W	17
Castle Shannon	120	120	0	6.0	25.0	0.29	25	4	24	x		Borough of Castle Shannon	Transit operator	Streetcar line on separate R/W	14
	395	360													
Boston:															
Riverside	1600	514	0.10	11.5	38.0	0.40	15	15				Metro Transit[a] Authority			16.5
Woodland	353	360	0.10	10.7	36.0	0.30	15	15							16.5
Waban	42	51	0.35	9.7	33.0	0.30	15	15							16.5
Eliot	57	62	0.35	9.0	31.0	0.30	15	15							16.5
Chestnut Hill	55	46	0.35	6.0	23.0	0.30	15	15							16.5
Brookline Village	130	160	0.10	3.5	15.0	0.30	15	15							16.5
Wonderland	480	290	0.35	5.3	11.5	0.20	10	5.5							24
Ocean Ave.	175	85	0.35	5.0	11.0	0.20	10	5.5							24
Beachmont	150	198	0.10	4.3	10.0	0.20	10	5.5							24
Suffolk Downs	185	112	0.10	3.8	9.0	0.20	10	5.5							24
Orient Heights	209	216	0.10	3.2	7.5	0.20	18	11							24
Wood Island Park	540	162	0.10	2.2	6.0	0.20	18	11							24
Butler Street	285	322	0.10	6.3	17.3	0.30	10	7.5							21
Milton	32	28	0.35	6.5	18.5	0.30	10	7.5							21
Mattapan	200	157	0.35	8.0	23.5	0.30	10	7.5							21
Lechmere	385	-b	0.50	1.3	10.0	0.30	15	15				Metro Transit[a] Authority			16.5
Sullivan Square	200	-b	0.50	2.1	8.0	0.20	17	10							18.1
Cedar Grove	29	-b	0.35	5.7	15.0	0.30	10	7.5							21
Forest Hills	126	-b	0.40	4.7	14.0	0.20	17	10							18.1
Arlington Heights	60	-b	0.35	0.5	3.0	0.30	15	15							16.5
Central Avenue	29	-b	0.35	7.0	20.0	0.30	20	10							21
Beaconsfield	20	-b	—	5.0	20.0	0.30	15	15							16.5
Brookline Hills	12	-b	—	4.3	17.0	0.30	15	15							16.5
Longwood	18	-b	—	3.5	13.0	0.30	15	15							16.5
Everett Station	400	-b	0.35	3.4	11.5	0.20	8.5	10							18.1
Everett Station	80	-b	0.35	3.4	11.5	0.20	8.5	10							18.1
Kendall Square	100	-b	0.50	1.3	4.5	0.20	20	10							29.5
Ashmont Station	140	-b	0.50	5.1	13.5	0.20	20	10							29.5
Forest Hills, Walk Hill St.	120	-b	0.35	5.0		0.30	17	10							16.5
	6209	3750													
Ft. Worth:															
Leonards Fringe Lot	5000	4200	0	0.3	3.0	0	3	4	7:30 - 6:30 p.m.			Leonard's Dept. Store	Leonard's Dept. Store	Streetcar subway	25

[a] Figures from MTC Demonstration Project Progress Report #5, p. 49.
[b] Usage estimated at 61% capacity based on Mass Transportation Commission survey of 4490 rail transit parking spaces.

TABLE

FRINGE LOTS USED FOR PARK-AND-RIDE

City	Location of Lot	No. of Spaces	Cars Parked Daily	All Day Parking Fee ($)	Distance to Downtown (mi)	Transit Time to Downtown (min)	Transit Fare to Downtown ($)	Buses per Hour: Peak	Buses per Hour: Off Peak	Hours of Bus Service
										(a) Existing Lots Which
Cleveland	Lakeshore at 9th	2252	2200	0. 25	0. 25	4	0. 10	—	—	—
	E. 22nd at Seaville	1600	500	0. 25	1. 0	8	0. 10	—	—	—
	E. 22nd at Euclid	1000	—	0. 50	1. 0	6	0. 10	—	—	—
Chicago	Soldiers Field - 14th & Outer Dr.	1200	1000	0. 25	2. 0	12	0. 15	10	10	7:30 a. m. - 6:30 p. m.
New York	W. of Lincoln Tunnel	1600	1650	0. 30	4. 0	12	0. 35	15	4	6:00 p. m. - 2:00 a. m.
										(b) Existing Lots
Pittsburgh	South Hills Jct. (upper & lower lots)	270	150	0	2. 0	7	0. 29	66	18	24 hr
Providence	Broad & Washington Park	125	65	0	3. 0	11	0. 30	8	4	6:00 a. m. - 1:00 p. m.
Washington	Carter Barron	625	615	0	3. 2	24	0. 25	16	9	
	Soldiers Home	290	220	0	3. 1	25	0. 25	15	6	
	Columbia Island	250	200	0	2. 5	16	0. 25	9	1	
	S. Capitol Street	260	200	0	3. 1	21	0. 25	6	1	
	Fairfax, Virginia	50	15	0	15. 0	60	0. 50	2	0	
St. Louis	Municipal Opera (Forest Park)	1200	750	0	5. 0	21	0. 30	6	3	7:00 a. m. - 6:30 p. m.
Seattle	5th Ave. & Republican Street	300	125	0	1. 1	6	0. 25	16	12	
Miami	Orange Bowl Stadium	300	40	0	2. 2	13.0	0. 20	6	15	6:00 a. m. -
	Central Shopping Plaza	300	50	0	4. 2	18.0	0. 20	6	15	6:30 p. m.
Atlanta	Broadview Shopping Center	200	40	0	5. 0	15.0	0. 25	4	2	7:15 a. m. - 6:15 p. m.
	Toco Hills Shopping Center	20	10	0	6. 5	30.0	0. 30	6	2	6:45 a. m. - 7:00 p. m.
Milwaukee	Mayfair Shopping Center	400	90	0	8. 5	22. 5	0. 33	3	—	6:30-8:30 a. m. 4:15-5:45 p. m.
Cincinnati	36 gasoline stations	603	30-100	0	variable	variable	variable	—	—	
Washington	Marlow Ht. Shop. Ctr.	150	30	0	7. 0	30.0	0. 50	3	1	

necessitate a long travel time to downtown. Recent HHFA demonstration projects in Boston have also indicated that substantial increases in lot usage can be induced by reducing parking fees.

The Willets Point fringe lot in New York contains 2550, or 56 percent, of that city's total of 4518 fringe spaces and is utilized to less than half its capacity.

Leonards Department Store in downtown Ft. Worth, Texas, recently opened a short subway line connecting the store to a large parking lot located on the edge of the central business district. The parking and the 3-min transit ride are free to all, whether one is a Leonards customer or not. The lot operates near capacity.

Table 2 gives the details of fringe lots at rapid transit stations. It is interesting to note that, except for Cleveland, most lots charge for parking, with fees ranging from 10 to 60 cents. Distances from downtown vary from 0. 3 to 16 miles. On the average, trains serve the lots at intervals of 2 to 6 minutes, with schedule speeds of 20 to 25 mph.

Considerable variation is observed in ownership of lots and operating procedures. In Cleveland, the transit operator builds and operates the lots. In New York City, the lots generally are constructed and operated by the City. Fees are collected in some instances by attendants, in others by meters, and in others by automatic parking gates.

The relative success of rail park-and-ride lots can probably be attributed to:

1. The high peak-hour speeds of rail rapid transit operating on its own right-of-way, as compared to those of buses, which are restricted by traffic congestion and greater number of stops.

2. The fact that opportunity for rail park-and-ride is limited to the relatively small area near the rapid transit station, which is usually also the site of intensive land development with a parking space demand of its own. Thus, the opportunities for "on

3

IN CONNECTION WITH BUS TRANSIT

Self Park	Guard on Duty	Lot Owned by	Lot Operated by	Financial Source For Lot Construction	Remarks
Charge for Parking					
x	x	City of Cleveland	City	Gen. obligation bonds-City	Some walk to destination; D. T. loop bus
x	x	City of Cleveland	City	Gen. obligation bonds-City	T. V. lot surveillance; some walk to dest.; D. T. loop bus
x	x	Private	Private		Some walk to destination; D. T. loop bus
x	x	Chicago Park Dist.	C. P. C.	General funds	Regular bus fare is $0. 25 for this area
x	x	New York Port Authority	Public Service Coordinated Transport	Revenue bonds	Downtown parking cost $1. 50 - 3. 75 per day; tunnel toll $0. 25 each way if car drives into downtown
With Free Parking					
x		Transit operator	Transit operator	Revenue bonds	Served by surface streetcars
x	x	Transit operator	Transit operator	Cash reserve	
x	x	Park Service	Parking Agency	Downtown parking meters	Room for expansion
x	x	Dist. of Col.	Parking Agency	Downtown parking meters	Land already owned by D. C.
x	x	Park Service	Parking Agency	Downtown parking meters	
x	x	Park Service	Parking Agency	Downtown parking meters	Land already owned by D. C.
x		City of Fairfax	City of Fairfax	General funds	Room to expand to 600 spaces
x		City of St. Louis	Transit operator		
x		Transit operator	Transit operator	Transit renewal fund	Lot available for park-and-ride only during past year Downtown parking cost $2. 00
x		City of Miami	City of Miami	City	Downtown parking cost $0. 50 - 0. 60
x		shopping center	shopping center	Private	Downtown parking cost $0. 50 - 0. 60
x		Shopping center	Shopping center	Private	Downtown parking cost $0. 50 - 0. 60
x		Shopping center	Shopping center	Private	Downtown parking cost $0. 75
x		Shopping center	Shopping center	Private	Freeway express buses; 22 mph average speed; downtown parking $1. 00
x		Oil companies	Oil companies		Began in 1955; some discontinued
x		Shopping center	Shopping center	Shopping center	Drug store used for shelter

street" park-and-ride are substantially less than with buses; and, if park-and-ride is to take place at all on rapid transit, it must take place in established fringe parking facilities.

Fringe Parking and Bus Transit

To understand fully the experience of fringe parking related to bus transit, consideration must be given to the ubiquitous opportunities for park-and-ride afforded by bus transit. The number of stops in a bus network in a large city may exceed many hundreds, and a significant number of these will almost certainly be located in areas where there is ample opportunity for all-day curb parking. As shown later, drivers take advantage of these opportunities for park-and-ride, often to the consternation of people residing near the bus stops and desirous of places to park near their homes. The important element here is that fringe parking is, to a large degree, already inherently available in a city with bus transit. As a result, efforts to induce the commuter to park in a fringe lot may fail, particularly if a fee is charged for the parking.

Table 3 indicates the effect of parking fees. In the 36 cities surveyed only three cases of successful bus fringe parking were found where a parking fee was levied. All are somewhat special cases. In Cleveland, three free lots are operated, all within one mile of the downtown, where on-street parking is unavailable and where many of the parkers do not use transit, but walk to their destinations.

At the Lincoln Tunnel lot just west of New York City, drivers are induced to park-and-ride by tunnel toll fees (50 cents round trip), lack of Manhattan parking space, and the fact that the buses connect with the New York subway system for distribution throughout Manhattan. Chicago's Soldiers Field charges 25 cents for parking but reduces

TABLE 4

BUS PARK-AND-RIDE LOTS WHICH HAVE BEEN DISCONTINUED DUE TO LACK OF PATRONAGE

City	Location of Lot	No. of Spaces	Cars Parking Daily	All Day Parking Fee ($)	Distance to Downtown (mi)	Transit Time to Downtown (min)	Transit Fare to Downtown ($)	Busses per Hour		Date Discontinued	Remarks	Factors Believed Contributing to Low Usage
								Peak	Off Peak			
Harrisburg, Pa.		225	Few							About 1955	No lots now operating	Low downtown parking costs; easy drive
Ft. Wayne, Ind.	Transit shop	25	6	0		11.0						Low downtown parking costs; easy drive
Richmond, Va.	30 filling stations										Gradually abandoned	Low downtown parking costs; easy drive
Cincinnati, O.	Public Landing	1400	1400	0.25	0.6	4.0	0.10	10	0	1955	Parking still provided; bus service discontinued	Drivers within walking distance of destination
San Diego, Calif.	Balboa Park	900	10	0	2.0	8.0	0.17	4	0	1955		Low downtown parking costs; no off-peak service
Louisville, Ky.	Bowman Field	500	35	0	6.0	26-30	0.15	6	—	1955		Low downtown parking costs; no off-peak service
St. Louis, Mo.	Texas Street									1955	No other information available	
	O'Fallon Park									1955	No other information available	
	Willow Wood St.									1955	No other information available	
Los Angeles, Calif.	Hollywood Bowl		130	0.15	7.0	25.0	0.25	6	3	1957		Parking fee charged
Baltimore, Md.	Pier C, Pratt St.	200	Few	0.30	1.5	—	0.10	7	0	1949		Parking fee charged
Washington, D. C.	Eastover Shopping Ctr.	150	10-15	0	5.5	25.0	0.30	3	½	1/64		On-street fringe parking near with lower transit fare
	Pen Mar Shopping Ctr.	150	5	0	6.5	35.0	0.50	2	1	1962	Lasted about one month	On-street fringe parking near with lower transit fare
	Gregory Estates	—	—	0	7.0	—	0.30	On-street parking only; apartment house owners in area objected to cars parking on street, so discontinued				On-street fringe parking near with lower transit fare
Boston, Mass.	Neposet Drive-In Theater	1500	25-30	See tr. fare	5.5		1.00[a]	12	0	1963	Demonstration project; rail fringe parking nearby	Rapid transit fringe parking nearby
Boston, Mass.	Revere Drive-In	1500	10	See tr. fare	5.0		1.00[a]	5	-	1963	Demonstration project; rail fringe parking nearby	Rapid transit fringe parking nearby

[a]Round trip, including parking.

bus fare from the lot to 15 cents (total daily cost 15 cents + 15 cents + 25 cents = 55 cents). Normal bus fare is 50 cents round trip. Thus the net fee is 5 cents per day above costs of parking on the street and riding a regular bus. This lot is only two miles or a 12-min bus ride from downtown.

Even where no fee is charged, the fringe lot must offer something better than is available on the street if it is to be used. A well-located and designed fringe parking lot can sometimes offer these advantages over on-street park-and-ride:

1. Better bus service. If a lot is large and sufficiently used, extra express bus service, which offers superior frequency and travel times compared to regular bus service, can be provided.

2. A safe place to leave the car and catch the bus. Parking on the street in some areas exposes the commuter's car to vandals. In addition, he may feel personally unsafe while waiting for the transit. Some lots provide guards to protect the cars during working hours. Safety in numbers is provided in any case where larger numbers of commuters gather to catch the bus at the lot.

3. The assurance of a place to park. Some otherwise-good park-and-ride locations are short of street parking space. Space hunting may discourage the commuter, while the assurance of space in a lot would encourage park-and-ride.

4. Shelter while waiting for transit.

Table 4 gives information on bus fringe lots which have been closed, in most cases from lack of patronage. In some cases, details of the operation are no longer available; and it is difficult to determine the cause of the lack of usage. This table provides evidence, however, that a successful fringe parking operation requires some ingredients other than a paved lot, bus service, and a sign announcing the availability of fringe parking. San Diego's 900-space Balboa Park lot attracted only 10 cars, Louisville's Bowman Field Lot with 500 spaces attracted 35, and two large 1500-space drive-in theaters in Boston attracted about 10 and 25 each. Cincinnati's Public Landing is still parking cars, but apparently so many drivers could walk to their destinations that the bus service could not be supported.

Failure of fringe parking in such small and medium-sized cities as Harrisburg, Ft. Wayne, Richmond, Louisville, and even San Diego can probably be explained by the relatively low average downtown parking costs in such cities. As discussed later, avoidance of downtown parking costs is one of the prime motivations of fringe parkers; and, when this element is not present, park-and-ride is not likely to be popular.

The levy of fringe parking fees can probably be blamed for the low usage of the Los Angeles and Baltimore lots.

Discussion of bus fringe parking cannot be complete without noting the recent HHFA Demonstration Experiment in Boston (Table 4). The Neponset and the Revere Drive-In Theaters, each with 1500 spaces, were opened to commuters for fringe parking. The round trip bus fare was set at $1.00 and bus headways were established at five minutes during peak hours. The average number of cars parked in Neponset was 25; Revere attracted 10. The drive-in theaters are located on major arteries. Inbound traffic moves quite freely beyond the theaters; but, between the theaters and downtown Boston, traffic congestion is extremely heavy during peak hours and heavy during other daylight hours. The minor response at these drive-in theaters can only be attributed to the availability of fringe parking at nearby rapid transit stations which are heavily used and offer faster transit service. The drive-in lots have since been discontinued.

The Washington area has had significant experience with fringe park-and-ride lots in recent years. Both successful and unsuccessful experiments have been conducted by both private and public agencies. A brief description of this experience follows.

D. C. Motor Vehicle Parking Agency

One of the most successful fringe parking programs found anywhere in the nation is conducted by the D. C. Motor Vehicle Parking Agency in cooperation with local bus companies. Four lots are currently in operation and another is being planned. These facilities have experienced a steady growth in patronage since their opening several years ago and today serve more than 1200 vehicles daily (Fig. 2). Each lot is well-paved, lighted, and signed, with comfortable shelters, seats, and even heat and telephones for passengers waiting for buses.

Carter Barron.—The largest and most used fringe lot operated by MVPA is located at the Carter Barron Amphitheater. The lot was constructed to accommodate patrons attending performances at the amphitheater and is still used for that purpose. In early 1955, however, the MVPA made an agreement with the National Capital Park Service which provided for commuter use of 625 car spaces during weekdays. The MVPA provided a bus roadway, passenger shelters, and signs and, in addition, agreed to pay for maintenance, snow removal, and lighting costs associated with the lot. MVPA also provides a guard during weekday hours. Excellent bus service to most of the downtown employment area is provided by D. C. Transit Company. In addition to 11 regular buses, 16 special express buses originate at the lot each morning. Still more bus service is provided on the regular nearby routes, although passengers must walk several hundred feet to 16th Street to use it. Lot usage has steadily grown to the point that capacity use is being approached.

Soldiers Home.—In 1959, the MVPA utilized a piece of property left over from highway right-of-way acquisition to construct a fringe lot near the Soldiers Home with a capacity of 290 cars and expansion space for 200 more. Paving, lighting, shelter with heat and telephone service, as well as a guard are provided. Excellent accessibility from major arterial streets is afforded. Bus service is provided direct to downtown at 4-min headways in the peak hours and 10-min headways during off-peak hours. Patronage has steadily grown; recent counts show 220 to 225 cars.

Columbia Island Marina.—The Columbia Island fringe lot was established in 1955 in a manner similar to that at Carter Barron. The existing lot, which served the Columbia Island Marina mainly on holidays and weekends, was, through agreement with the Park Service, made available to park-and-ride commuters. The MVPA provided lights, built a special bus roadway, platform, and shelter, and provided for an attendant. Usage of this lot is also growing, with an average of about 200 cars parked and capacity for 250.

South Capitol Street.—Utilizing property already owned by the District of Columbia, MVPA graded, paved, and provided lights, shelter, and signs to create a facility which

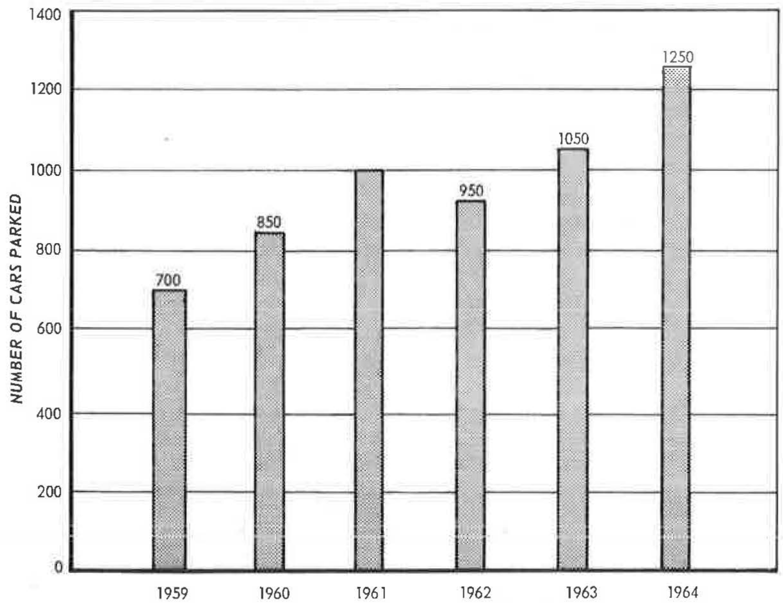


Figure 2. Usage of fringe parking lots operated by D. C. Motor Vehicle Parking Agency (Carter Barron, Soldiers Home, S. Capitol Street, and Columbia Island Marina).

was parking more than 250 cars by 1961. This lot was removed during construction of the Anacostia Freeway, and a temporary lot with a capacity of 250 cars was put into operation. This temporary lot is parking about 200 cars during the construction period, even though it is unpaved and somewhat inaccessible to both buses and autos. A new lot with a capacity of 291 cars is planned for this location.

W. M. A. Transit Company

As part of a general service improvement project in 1962, the W. M. A Transit Company established four fringe park-and-ride facilities in suburban Prince Georges County, Maryland. Three of the four have since been abandoned, and the fourth is being used only by a few persons. This experience warrants careful examination to determine the factors that separate the successful MVPA experience from the relatively unsuccessful W. M. A. experience.

Eastover Shopping Center.--Signs were erected to advertise the availability of free parking on a portion of the lot during weekday working hours and of eight special express buses running direct to downtown. Other details are given in Table 4. Only 10 or 15 cars used this lot for commuting park-and-ride, and the bus service was finally terminated in late 1963. Several factors were involved in this low usage:

1. The lot was located near the edge of the then-developed urban area. This meant that most of the potential users of park-and-ride began their trips between the lot and downtown and thus had to drive away from town to use it.
2. It was located in the same traffic corridor as the South Capitol Street fringe lot operated by MVPA.
3. Bus service was at 20-min (peak) and 2-hr (off-peak) intervals. Such headways are generally unacceptable, especially when potential customers all have automobiles available.
4. Potential customers had only to drive a few more blocks to reach the service area of D. C. Transit buses, which cost 10 cents less and offered more frequent service.
5. Buses serving the lot penetrated downtown Washington only partially (to 10th Street). Commuters working beyond this terminal had to transfer.

Penn Mar Shopping Center.—This park-and-ride lot was similar to Eastover; but peak-hour bus service was at 30-min intervals, and the number of cars parked was about five. The extra bus service was stopped after the first month. Reasons for the limited usage are the same as for Eastover.

Gregory Estates.—Gregory Estates is an apartment area near the District of Columbia eastern extremity. No off-street fringe lot was provided here, but signs were erected advertising the fact that on-street, all-day parking was permitted and that express buses would operate from the area. This experiment was barely underway when objections from apartment owners required its cancellation. It is unlikely that it would have been successful in any case, however, since a 10-cent saving in fare and ample street parking were available just a few blocks away.

Marlow Heights Shopping Center.—This lot was arranged in a manner similar to the aforementioned shopping centers. However, this one is still in operation, and about 30 motorists use it each day. Although it has the same basic disadvantages as Eastover and Penn Mar facilities, there are these differences:

1. It requires a drive of a mile or more to reach the lower fares and more frequent service of D. C. Transit.

2. Even though patronage is too low to support the bus service, this lot is located along a regular W. M. A. route which was operating before the lot was established. Lot patronage is not increasing; but the service can continue, since bus service costs are shared with regular riders.

The many variables affecting the usage of fringe facilities are difficult to isolate, since in each case several factors operate simultaneously to determine the outcome. However, examination of Tables 3 and 4 and other items noted above reveals several important points:

1. The majority of fringe bus lots are provided free to the commuter. The three cities where substantial numbers of park-and-riders are attracted to lots where parking fees are levied have special conditions that do not exist in most cities. While a number of cities have tried to charge, only the three examples noted above have been successful.

2. Most bus fringe lots are located on land that was either already used for parking or was otherwise available for public use. Existing parking space associated with shopping centers, stadiums, auditoriums, and service stations has been reserved during weekday hours for fringe use. In most cases, this in no way interferes with the activities of these enterprises, since their peak demand for parking space occurs during evenings or weekends, when fringe parking is nonoperative. For example, 750 cars are parked daily in St. Louis Forest Park; 625 cars in Washington's Carter Barron Theater in Rock Creek Park; and 90 in Milwaukee's Mayfair Shopping Center. The 5th Avenue and Republican Street lot in Seattle was built for the Seattle Worlds Fair. Today it is partially used to park transit company employees, and the remaining space is being promoted for fringe parking. Washington's Soldiers Home and South Capitol Street lots were built on land already owned by the District of Columbia government.

3. Successful fringe lots seem to be located within a circle extending out to 5.0 miles from downtown; and the chance of success, except for very small lots, seems smaller beyond the 5-mi limit. Washington's successful lots are all located from 2.5 to 3.5 miles from the core, and the Forest Park lot in St. Louis is 5 miles out. Milwaukee's Mayfair Shopping Center (8.5 miles out) is an exception, but it has unusually fast bus service that makes the trip to downtown in about 22 minutes. Twenty-five minutes seems to be the upper limit on bus time for lots of significant size.

4. All lots are operated on a self-park basis. Guards are used on some lots and not on others. There seems to be no pattern here.

5. Proper location of bus fringe lots must give consideration to the financial alternatives open to the potential customer. A lot located just upstream from a bus fare zone is unlikely to be successful even if no fee is charged.

TABLE 5

WORK TRIPS TO DOWNTOWN WASHINGTON BY MODE OF ARRIVAL

(1955 O & D Survey)

Mode	Number	Percent
Auto driver	91,818	34
Auto passenger	51,162	19
Subtotal auto	142,980	53
Transit passengers	115,981	43
Other	10,893	4
Total	269,854	100

TABLE 6

WORK TRIPS ARRIVING IN DOWNTOWN WASHINGTON, 6:00 AM—12 NOON

(1955 O & D Survey)

Mode	Number	Percent
Auto driver	71,028	31
Auto passenger	47,236	21
Subtotal auto	118,264	52
Transit passengers	102,160	45
Other	7,675	3
Total	228,108	100

TABLE 7

FEDERAL EMPLOYEE DAY-SHIFT WORK TRIPS TO DOWNTOWN WASHINGTON BY MODE OF ARRIVAL[a]

Mode	Number	Percent
Auto drivers	26,454	29
Auto passengers	23,650	26
Subtotal auto	50,104	55
Transit	34,918	38
Other	6,559	7
Total	91,581	100

[a] 1961 Federal Employee Parking and Transportation Survey.

FRINGE PARKING HABITS

Work Travel to Downtown Washington

Two large-scale surveys of intraurban travel have been conducted within the Washington area during the past nine years. In 1955, a home-interview origin-and-destination survey was made in which about five percent of the households in the area were questioned concerning their travel habits. In 1961, questionnaires were distributed to approximately 100,000 Federal employees who work in downtown Washington. These questionnaires related to the travel to work of these employees and provided detailed data on their travel habits.

Table 5 indicates the mode of travel of all downtown workers in 1955. (Downtown here refers to the area designated as "Sector O" in recent travel analyses.) Of a total of 270,000 trips to work in downtown, 43 percent used transit and 53 percent used autos. Table 6 gives the same information for day-shift workers—those arriving between 6 AM and noon. Transit passengers constitute about 45 percent of this group. The 71,000 cars arriving during this period carried about 118,000 persons. This average occupancy of almost 1.7 persons per vehicle is significantly higher than that observed for non-downtown work trips.

Downtown Federal employees exhibit similar travel habits (Table 7). The 92,000 day-shift Federal employee trip polled represents about 39 percent of the total downtown work trips. (These comparisons disregard changes in travel habits and downtown employment distribution that have taken place between 1955-1961. A less extensive 1959 survey of downtown Federal employees indicated about the same travel habits as the 1961 survey.)

The proportion of Federal employees using transit (38 percent) is below the 45 percent figure for all employees, although some of this difference is due to the reduction in downtown transit usage since 1955 by all employees. Car pooling is much heavier by government employees, however, with the average Federal employee's car carrying 1.9 persons. Only 29 percent of Federal employees drive their cars to work, as compared to 31 percent for all employees.

TABLE 8

DAY-SHIFT FEDERAL EMPLOYEE WORK TRIPS WHICH BEGIN BY AUTO

Mode	Number	Percent of Total	Percent of Auto Vehicle Trips
Auto drivers all the way	26,454	47	84
Auto passengers all the way	23,650	42	—
Auto drivers transferring to bus	3,474	—	11
Auto passengers transferring to bus[a]	1,447	—	—
Auto drivers transferring to car pool as passengers	1,447	—	5
Subtotal: Auto then change mode	6,368	11	—
Subtotal: Auto vehicle trips	31,375	—	100
Total	56,472	100	—

[a]Includes those drivers from cars parked (park-and-riders) and from cars not parked—these transit riders driven to the transit stop by their wives are sometimes referred to as "kiss-and-riders."

TABLE 9

RESIDENCE OF DOWNTOWN FEDERAL EMPLOYEES USING TRANSIT TO WORK

(Day-Shift Employees Living Within 15 Miles of Downtown)

Area	Total by Transit	Auto and[a] Transit	Percent Auto and Transit	Miles from[b] Center
Alexandria	1,672	140	8	
Fairfax County	1,442	758	52	
Falls Church	146	44	30	
Montgomery County	2,226	1,166	52	5-11
Prince Georges County	2,743	1,179	43	
Subtotal outlying	8,229	3,287	40	
District of Columbia	20,950	1,102	5	—
Arlington County	5,033	336	7	3-6
Subtotal, 10 mi sq	25,983	1,438	6	
Total	34,212	4,725	14	

[a]Includes auto drivers and passengers who transfer.
[b]Range including most of residential area.

Auto-Bus Combination Trips.—Table 8 shows that of all Federal employees beginning their work trip by auto, 11 percent changed mode, either to transit or car pool before completing their journey. Of those who begin their trip as auto drivers, 16 percent change mode before arriving at their destination. Eleven percent park their cars and transfer to buses, either at special fringe parking lots or at the curb on outlying streets. A total of some 3500 cars of government employees are parked while their drivers ride transit to work. This represents about 10 percent of all Federal employees who arrive by transit.

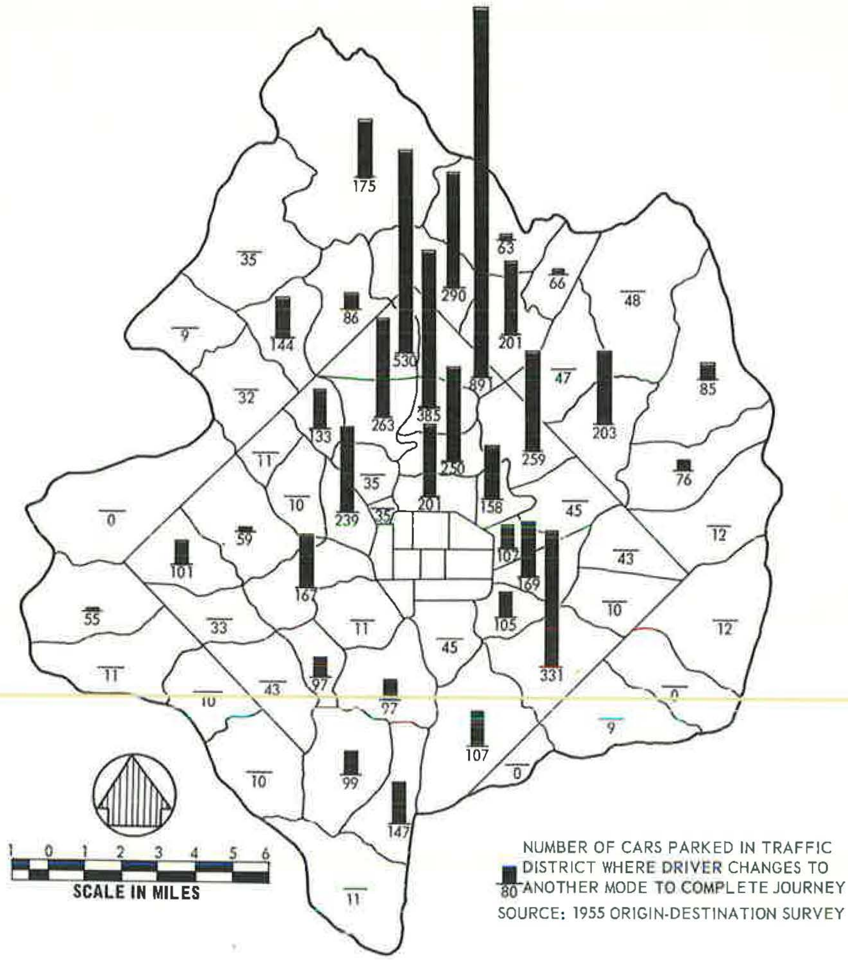


Figure 3. Auto drivers changing to other travel modes, average weekday, 1955.

A rough approximation of the total park-and-riders can be made by expanding the number of government employee park-and-riders by the ratio of government employees to total employees in the downtown. Such an expansion indicates a total of 9500 park-and-riders. A tabulation of the total "auto-driver change-mode" trips from the 1955 survey indicated about 7000 park-and-riders. Considering the probable differences in the habits of the two groups of employees and the difference in the survey year, it is estimated that about 8000 persons drive part way, park near a bus stop, and transfer to transit on their way to work each day. This total represents about eight percent of all persons who arrive at work in the downtown by transit.

The proportion of persons either driving or being driven to bus stops on their way to work in downtown varies substantially with the residential location of the employee. Table 9 indicates that 40 percent of the downtown-transit-using Federal employees living in outlying counties use the auto to get to the bus stop, while only six percent of their counterparts living within the 10-mi square (Arlington County and the District of Columbia) use autos and bus. Fifty-two percent of the employees living in Fairfax and Montgomery that use transit, use auto to get to the transit stop. The significance of these figures is amplified in light of the growing numbers of downtown employees moving to these outlying locations. The relatively thin coverage of outlying communities by bus lines requires the use of auto to get to the locations of frequent bus service.

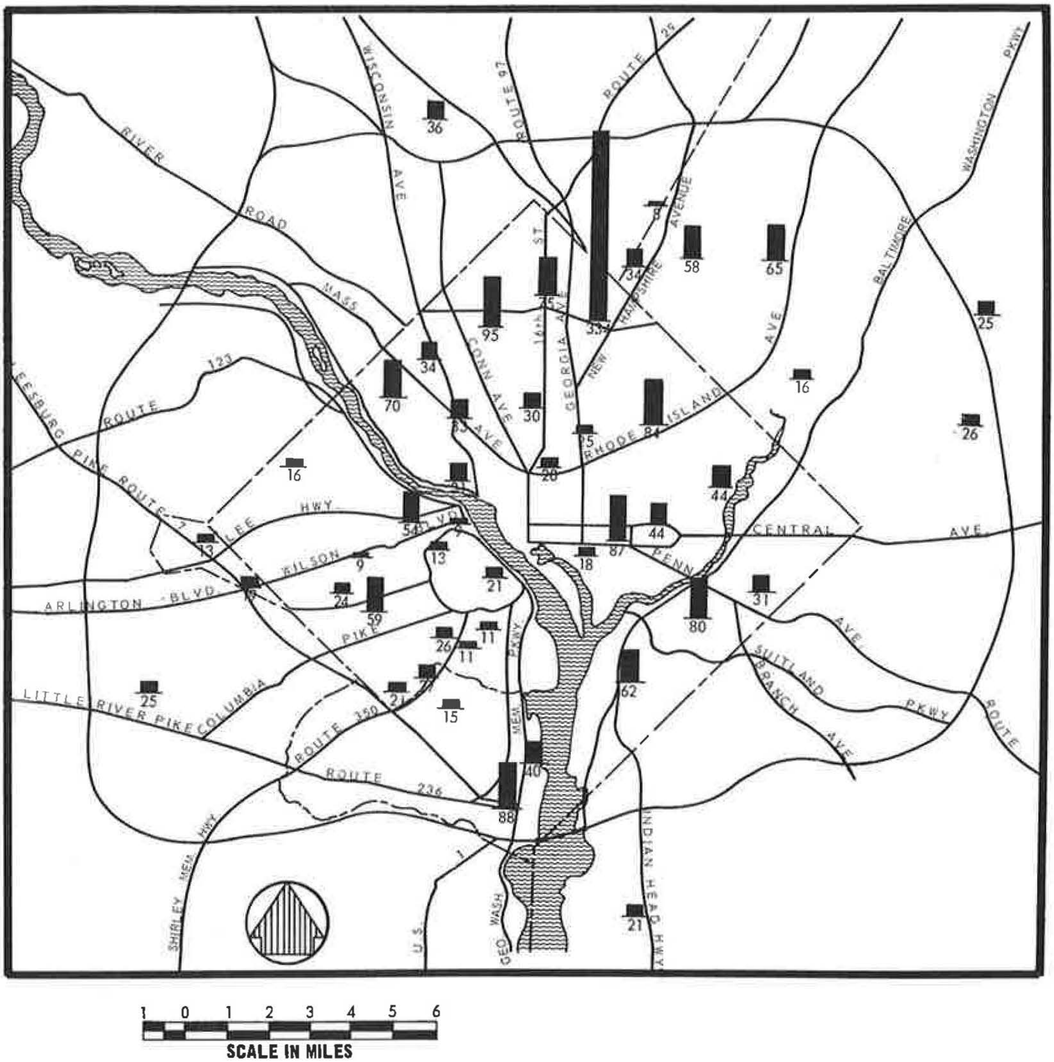


Figure 4. Downtown Federal employees parking and transferring to bus.

One might expect an increasing use of the auto-bus combined ride, particularly if such riding is made more convenient.

Figures 3 and 4 indicate where downtown employees park their cars before boarding transit. Both the 1955 and 1961 surveys clearly show that the heaviest concentrations of park-and-riding are within a 1. 5-mi band running just south of the D. C. line from Massachusetts Avenue eastward to New Hampshire Avenue. Several factors lend to the enhancement of this area for fringe parking:

1. Many of D. C. Transit's routes terminate at the D. C. line. This results in service that is much less frequent just north of the line than south.

2. The flat minimum transit fare begins at the D. C. line. A zone-fare system requiring higher cash outlays is in effect north of this line. Montgomery County drivers can reduce their out-of-pocket expenses by driving the extra distance to D. C.

TABLE 10

RESIDENCE OF DOWNTOWN GOVERNMENT EMPLOYEES WHO BEGIN WORK TRIP BY CAR

(Day-Shift Employees)

Area	Drove All the Way		Drove Part Way—Took Bus		Drove Part Way—Joined Car Pool as Passenger	Total Driving Only Part Way		Total	
	No.	Percent	No.	Percent		No.	Percent	No.	Percent
Alexandria	1,028	86.5	105	8.8	56	161	13.5	1,189	100
Fairfax County	3,760	80.7	570	12.2	331	901	19.3	4,661	100
Falls Church	246	66.2	107	28.8	19	126	33.8	372	100
Montgomery County	4,954	79.7	864	13.8	403	1,267	20.3	6,221	100
Prince Georges County	4,914	79.5	857	13.9	404	1,261	20.5	6,175	100
Subtotal outlying	14,902	80.0	2,503	13.4	1,213	3,716	20.0	18,618	100
District of Columbia	8,326	90.5	740	8.0	136	876	9.5	9,202	100
Arlington County	3,226	90.8	231	6.5	98	329	9.2	3,555	100
Subtotal, 10 mi sq	11,552	90.6	971	7.6	234	1,205	9.4	12,757	100
Total	26,454		3,474	11.0	1,447	5,921	18.8	31,375	100

3. By parking near the D. C. line, drivers can utilize the express or limited-stop bus lines coming in from outlying areas.
4. By parking near the D. C. line drivers are assured of a seat on the bus.
5. It is easier to find a space to park on the street in this area than closer into downtown.

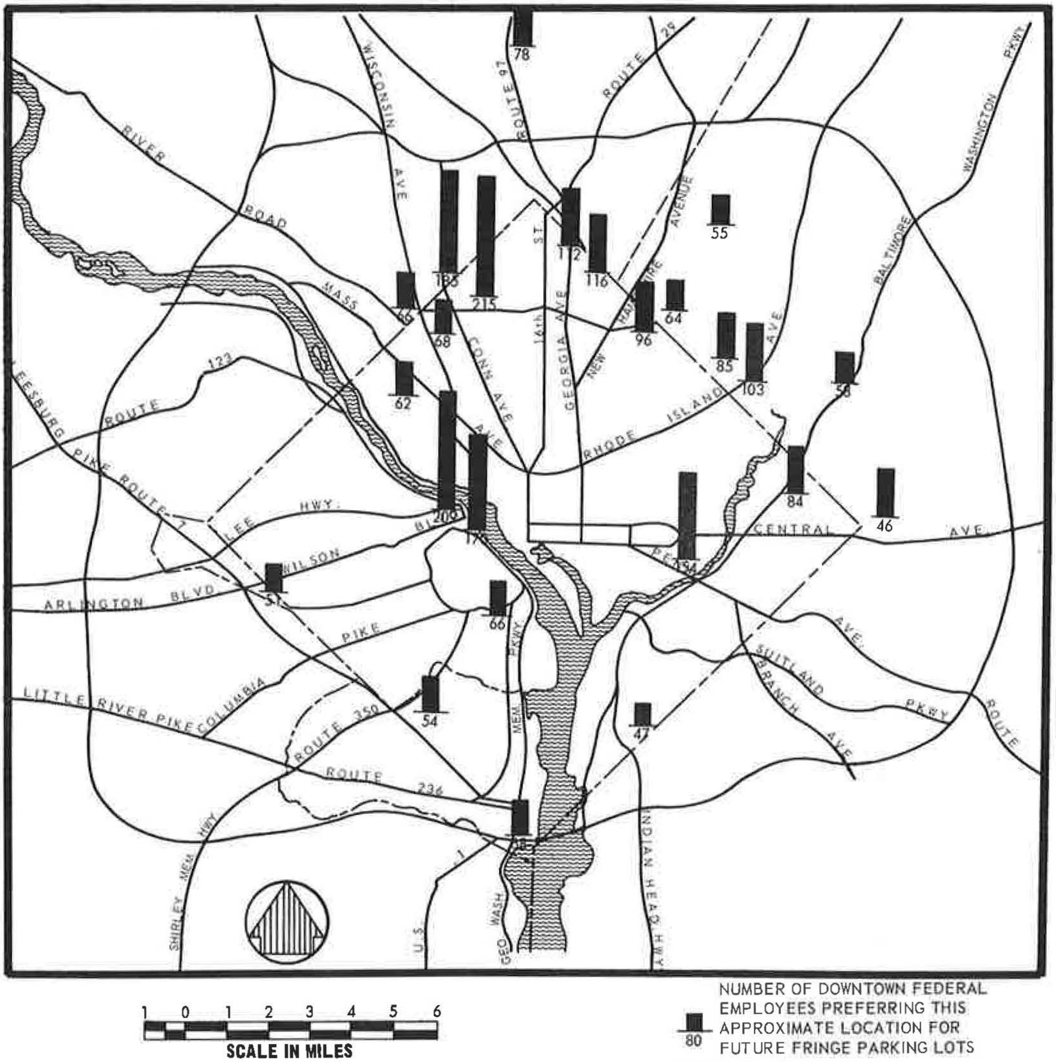
The 1955 survey indicated that significant numbers of fringe parkers park near to the downtown in the north and northwest corridors. Large numbers park in Georgetown and the area to its immediate west. Fringe parkers in the southeast quadrant are distributed at random between downtown and the D. C.-Maryland line.

The 1961 survey indicates that about 1000, or 29 percent, of all park-and-riders live in Virginia (Table 10). Figure 4 does not include any large concentrations of parkers in Virginia, however, as it does for points noted above in the District of Columbia. This is probably due to the zone-fare system which is in effect throughout northern Virginia and to the lack of a sharp cut-off point in transit service such as that which exists at the D. C.-Maryland line.

Virginians who drive to close-in locations to park save travel time and money but are faced with difficulties in finding parking places and bus seats. Drivers parking further out get a seat and can readily find parking space, but they pay more and face infrequent transit service. That drivers from different Virginia communities trade off these factors in different ways results in a general scattering of park-and-ride throughout the area. The 1961 survey indicates some concentrations in north and south Alexandria and in the Clarendon area (about 3.5 miles southwest of downtown Washington).

The 1961 survey asked where drivers would prefer to have fringe parking lots located. Figure 5 presents these data, which must be interpreted in the light of present conditions of bus service, transit fares, etc. Again, the most popular area lies along the D. C. line from Massachusetts Avenue to New Hampshire Avenue. Virginia drivers voted overwhelmingly for parking space close in, especially in the Rosslyn area (about 2 miles southwest of downtown Washington). It must be noted that this is the area of lowest Virginia fare and most frequent bus service. Little fringe parking occurs there today due to a lack of parking space near bus lines. It is likely that these drivers would be willing to park further out if frequent service and/or lower fares could be implemented.

Attitudes, Habits and Preferences of Commuters Currently Using Fringe Lots.—In an effort to dig more deeply into the individual motives of persons who found park-and-ride convenient and to learn something of the characteristics of fringe parkers, personal



SOURCE: 1961 FEDERAL EMPLOYEES PARKING AND TRANSPORTATION SURVEY

Figure 5. Preferred locations for fringe parking lots.

interviews were conducted at three Washington fringe parking lots. A total of about 100 interviews were made. Though the questions asked were not always identical because of the different characteristics of each lot, the same basic information was desired.

Table 11 gives some of the more significant results of the survey. About 85 percent of all persons using the lots came in a car that was parked on the site. On the average, each car parked carried slightly more than 1.1 persons. However, about 1.2 transit trips per car parked originated at the lots, a figure that reflects a number of kiss-and-ride passengers (see note, Table 8). About 96 percent of those who reported the purpose of their trip were persons going to work, and 96 percent of these were employed in downtown Washington. This confirms previous conjecture that fringe parking was related almost completely to travel for downtown workers.

Perhaps the most significant item in Table 11 concerns the mode used in traveling to work before the commuter began using the fringe lot. This item is critical since it

TABLE 11

HABITS AND ATTITUDES OF PARK-AND-RIDERS AT THREE WASHINGTON AREA FRINGE LOTS

(Fairfax, Soldiers Home and Carter Barron)

	All Lots (percent)
Mode of arrival at lot:	
Drove	76
Was driven in car parked here	9
Was driven in car not parked here (kiss-and-ride)	9
Walked	3
Other	3
Purpose of trip:	
Work	92
Other	4
Not reported	4
Job location of persons going to work:	
Downtown Washington	96
Other or no answer	4
Mode to work before began using fringe lot[a]:	
Drove all the way	25
Parked on street and rode bus	14
Walked to bus stop	15
Was driven to bus stop	9
Car pool	18
Other	18
Factors influencing decision to use fringe lot:	
Downtown parking costs	64
Dislike of driving in congested traffic	50
Dislike of parking on the street and riding bus	22
Percentage who would prefer to drive all the way if downtown parking were plentiful and cheap	53
Percentage who normally use lot at least 5 times per week	93
Percent living in Virginia or Maryland	91

[a]These percentages include only those who live and work at the same locations as they did before using lot.

provides the only evidence available as to the ability of fringe lots to generate new park-and-ride traffic as opposed to simply transferring existing street fringe parkers to a lot. Twenty-five percent replied that they formerly drove all the way to their destination. If this proportion is representative, it would imply that for every four spaces provided in a fringe parking lot, one car is removed from the traffic stream.

Downtown parking costs and dislike of driving on congested streets are the most important factors influencing the decision to park-and-ride. However, 23 percent indicated that they liked parking in a fringe lot because they did not like to park on the street and ride the bus.

CONCLUSIONS

A number of factors have been identified as related to the success or failure of fringe parking facilities. Although no quantitative correlation of these independent factors has been attempted, it is believed that significant qualitative evidence has been presented to provide useful conclusions. Highlights of findings and conclusions are as follows:

1. Fringe parking is a relatively small but nevertheless important part of the commuter transportation system, particularly in large cities.
2. Fringe parking associated with rail rapid transit is generally utilized, with an average 81 percent occupancy in U. S. systems.
3. Fringe parking lots associated with bus transit seem to fare less well than those with rail transit, due to: (a) slower speeds on buses which are normally mixed with other traffic, and (b) ability of commuter to park and ride at any bus stop, reducing the need for special fringe lots.
4. Small parking fees can often be charged for rail fringe parking without reducing usage. Fees can be charged for bus fringe parking only on lots located very near the downtown areas of large cities. In general, cost of parking is a very sensitive factor in determining lot usage.
5. Avoidance of downtown parking costs is the main motivation of fringe parkers in the Washington area. A secondary motivation is dislike of driving in congested traffic.
6. Successful existing fringe bus lots tend to be located on parking areas developed for other purposes, which have excess capacity during weekday working hours. These include parking lots for stadiums, parks, and shopping centers.
7. Bus fringe lots can be more successful in attracting patronage if located near to the downtown area. This is due to the fact that facilities near downtown minimize travel time (since most of the trip is made by car), draw from the largest number of potential customers, and take advantage of the lowest fares and most frequent bus service, both peak and off-peak.
8. A substantial number of persons park on the street and ride buses to work. About 10 percent of the downtown Federal workers in Washington who ride transit to work begin their journeys in cars. This figure averages 40 percent for workers living in outlying suburban counties.
9. The incidence of on-street fringe parking is correlated with fare and bus-frequency zone boundaries.
10. When utilized, fringe parking benefits the urban community since it capitalizes on the best features of both auto and transit modes. The flexibility in time and space of the auto is used in outlying areas when transit service is uneconomical. The higher capacity capabilities of transit are harnessed in the closer-in parts of the city where auto capacity is limited.

REFERENCE

1. Fringe Parking, National Capital Region. Alan M. Voorhees & Associates, Washington, D. C., Jan. 1955. (Prepared for the National Capital Planning Commission.)

Shopping Center Parking Requirements

ALAN M. VOORHEES and CAROLYN E. CROW
Alan M. Voorhees and Associates, Washington, D. C.

This paper reports on research work carried out for the Urban Land Institute to establish the parking standards that should be used in the design of shopping centers.

An examination of the demand for parking facilities at 270 centers throughout the United States and Canada was undertaken. The research has shown that there are many factors involved in establishing these standards, such as parking habits, trading area, mode of travel, and the presence of nonretail uses in the shopping centers.

This research pointed out that at a shopping center where there is little walk-in or transit trade 5.5 spaces per 1000 square feet of gross leasable area will accommodate customer and employee parking demands on all but the three highest days of the year, with allowance for parking maneuvering. This is considerably lower than most zoning ordinances in effect throughout the country today.

The purpose of this research project was to investigate the demand for parking facilities at existing shopping centers and, on the basis of these observations to establish parking standards to be used in the design of shopping centers. These standards are to reflect the present consumer shopping habits and owner operational practices at shopping centers in the United States and Canada.

•THE RESEARCH program that was undertaken to evaluate parking standards was done in two phases. A pilot study, completed in 1963, was used to guide the establishment of the technique for a primary survey of 270 shopping centers carried out in 1964. Both of these program phases were undertaken by the Urban Land Institute with the assistance of the International Council of Shopping Centers, Inc. The Council obtained the cooperation of all the centers that were contacted and made it possible to get returns from a wide sample of shopping centers.

THE PILOT STUDY

The pilot study was primarily exploratory in nature and was conducted in 21 centers. Automobile arrivals and departures during every hour at each shopping center were counted by shopping center personnel or by pneumatic counters on a weekday (usually December 14) and on a Saturday (usually December 17). Aerial photographs taken between 11:00 a. m. and 3:00 p. m. provided a check on the reasonableness of peak-hour parking counts. An analysis of accumulation, arrival, and departure patterns of customers that was derived from the pilot study indicated that the peak parking demand occurred at about 2:30 in the afternoon or about 8:00 in the evening. Thus, in designing the primary study, it was decided to limit the counting of cars parked to those two hours on the 12 days before Christmas.

Paper sponsored by Committee on Parking and presented at the 45th Annual Meeting.

TABLE 1

DISTRIBUTION OF SELECTED CENTERS
BY METROPOLITAN POPULATION AND CENTER SIZE

Metropolitan Population	Gross Leasable Area in Thousands of Square Feet						
	Under 100	100-200	200-400	400-600	600-1000	Over 1000	Total
Less than 250,000	9	29	16	3	2	—	59
250,000-500,000	8	12	10	7	2	—	39
500,000-1,000,000	10	10	13	8	2	—	43
1,000,000-2,000,000	18	11	18	5	13	3	68
Over 2,000,000	11	12	21	9	6	2	61
Total number of centers	56	74	78	32	25	5	270
Percent of total	21	27	29	12	9	2	100

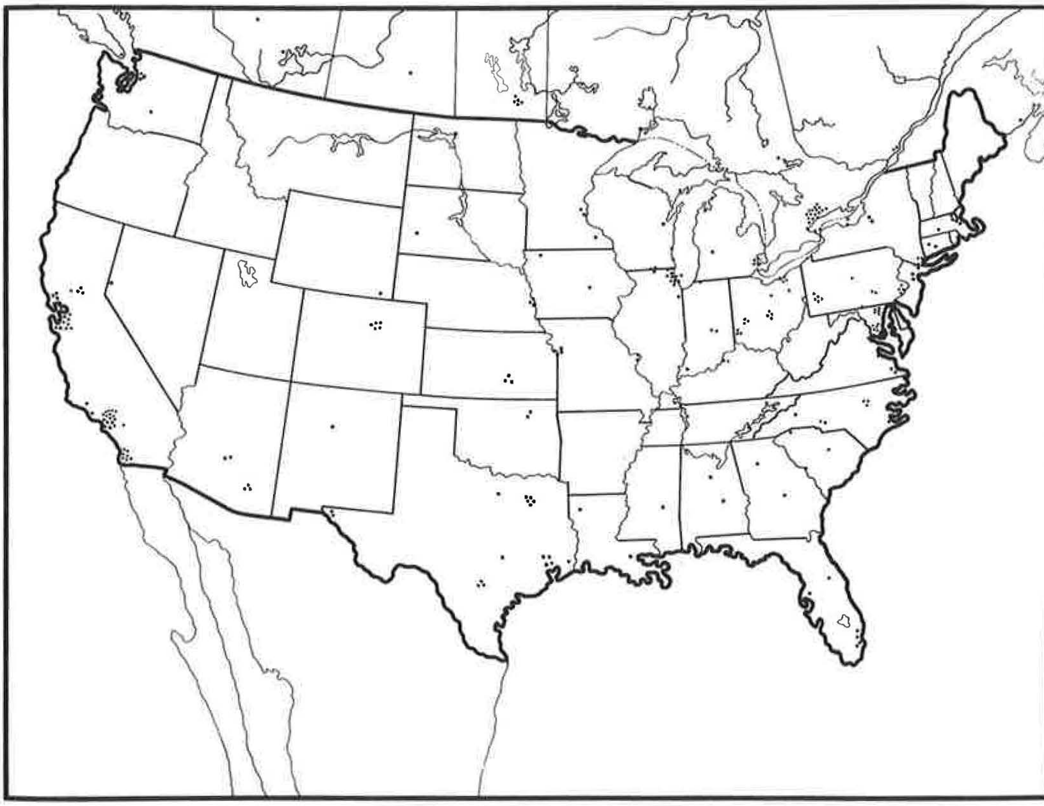


Figure 1. Geographic distribution of shopping centers.

THE PRIMARY SURVEY

A manual was prepared to describe the procedure necessary to systematically count the parked vehicles during the 12 pre-Christmas days (Appendix B). This manual was used to assure that the data would be uniform and comparable. With accompanying questionnaires, it was sent to shopping centers which represented different metropolitan area population sizes, different center sizes, different geographical areas, different consumer incomes, and different shopping center tenants. The larger metropolitan areas to be represented were selected from different geographical areas and climates, and several centers of varying size were contacted in each area. In addition to the numbers of parked vehicles at 2:30 and 8:00, the following information was obtained for each shopping center in the primary study: (a) gross leasable area, (b) occupied floor area, (c) activities in the center, (d) available parking spaces, (e) spaces used by employees, (f) annual sales, (g) type of customers, and (h) age of center.

Sample for Primary Study

Questionnaire returns were obtained from 270 shopping centers. Table 1 summarizes the response on the basis of the population of the metropolitan area and the size of the center. Each population and size class appears well represented.

The 270 shopping centers which responded are widely distributed throughout the United States and Canada (Fig. 1). The San Francisco-Oakland, Chicago, and Toronto metropolitan areas are represented by more than ten centers each; and the Boston, Pittsburgh, Washinton, D. C., San Diego, Baltimore, and Houston metropolitan areas by more than five centers each. There are about 50 metropolitan areas represented in the less-than-250,000 population class, 25 in the 250,000-500,000 population class, 19 in the 500,000-1,000,000 population class, 16 in the 1,000,000-2,000,000 class, and 10 in the over-2,000,000 class.

PARKING PATTERNS AND THEIR IMPLICATIONS FOR A ZONING STANDARD

Daily Parking Patterns

The most important observation made during the pilot study was that, on the busiest day, shoppers tended to spread their shopping trips across the entire day. This is shown in Figure 2, which compares the peak day with a normal day during the Christmas season. Peak day trips are dispersed throughout the day, while on the other day they are concentrated into a shorter period of time. The difference between the peak parking volumes on the two days is very small, even though more than twice as many cars were

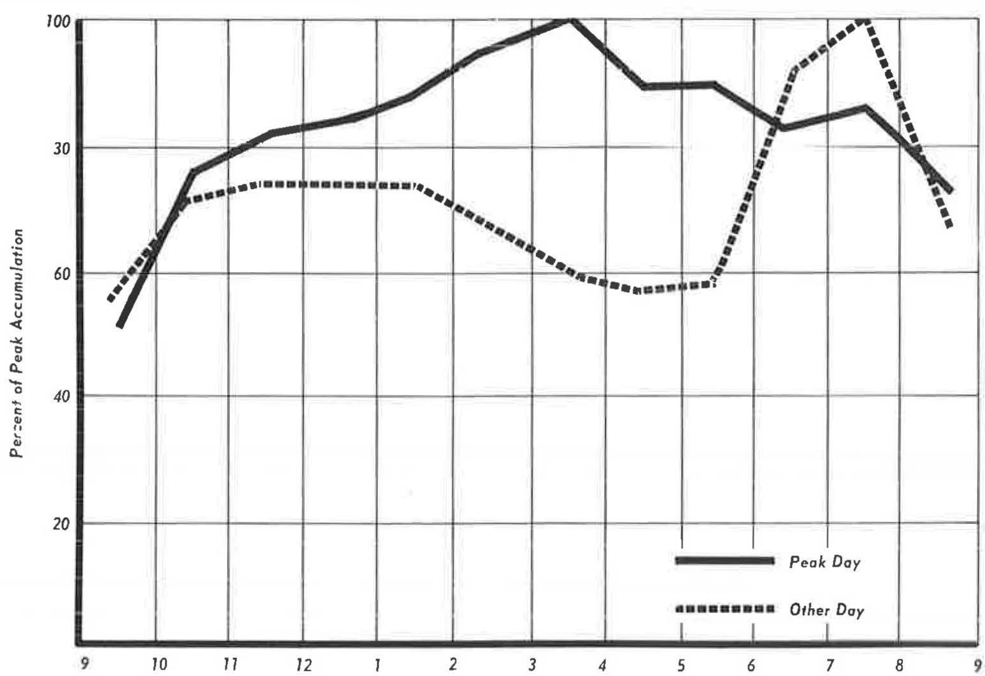


Figure 2. Accumulation pattern on peak and other days at a typical shopping center.

parked on the peak day as on the other. Some of the difference in the shapes of the parking demand curves can be shown to be the result of the normal differences between weekday and Saturday parking patterns; but there is, nonetheless, a consistent pattern of increased dispersion of trips on the peak day. Such a pattern makes it quite apparent that people do adjust their habits to avoid peak conditions and that any reasonable parking standards should take this into consideration.

Derivation of Yearly Parking Patterns

From the survey's data on parking space provision and its usage at peak hours, it was possible to derive the number of days during a year when these levels are apt to reoccur.

1. An analysis of shopping center traffic and parking, using data from eight of the centers in the pilot study, indicated that there is a strong relationship between daily inbound traffic volumes and peak-hour parking accumulation. This finding was confirmed by the study that Cleveland and Mueller had conducted for 14 other centers (1 Appendix, Fig. 40). Investigation of daily inbound traffic volumes and peak-hour parking demands for each of the 12 pre-Christmas days studied, using rank-order correlation techniques, further confirmed this relationship.

2. Recognizing this correlation, an investigation was made of the daily inbound traffic volumes at the same shopping center over a 2-yr period. This investigation indicated that of the 12 shopping days before Christmas, the four highest were never equaled during the entire year. However, each of the fifth- through the eighth-highest days of traffic volume before Christmas was duplicated at other times throughout the year, and each of the ninth- through twelfth-highest days of traffic volume was duplicated twice throughout the year. The same patterns should occur in peak-hour parking demands, since a strong relationship exists between them and daily traffic volumes. Thus, it was possible from this analysis to relate the observations that were made for the peak hours of the peak days in the Christmas period to a yearly pattern.

To estimate the equivalents of the third-highest day or sixth-highest day in the more conventional engineering terminology of highest-hours, additional analysis of the shopping center data on traffic volumes was carried out which indicated that the third-highest day of the year and the tenth-highest hour of the year are approximately equivalent. Similarly, the sixth-highest day was comparable to the thirtieth-highest hour so often used in highway engineering standards. When this pattern was compared to the annual hourly traffic volume pattern at the shopping center described in the Cleveland-Mueller report, the two were found to be very similar (1, Fig. 48).

Determination of Parking Requirements

In establishing a standard to guide the amount of parking to be provided at a shopping center, it must be recognized that, if extremely high peak parking demands occur only two or three days a year, it is unreasonable and uneconomical to provide facilities to fully accommodate them (Fig. 3). Therefore, determination of the number of parking spaces that should be provided by a shopping center is a problem analogous to highway design problems, which are generally solved by the provision of facilities to meet the thirtieth-highest hour of traffic volume (2).

A similar analysis was made of the shopping centers in the sample by estimating the frequency of occurrence of each peak-hour parking demand level in all of the centers combined, during the entire year, as previously described. The parking demand was expressed in "spaces used by customers and employees per 1000 square feet of the gross leasable area that was occupied." By ranking these observations from the highest to the lowest, it was possible to determine the level of parking demands on the second- or fourth- or sixth-highest days of the year at all of these centers combined. The result for 103 centers without theater or office space is shown in Figure 3. The vertical scale in the figure represents use of parking spaces at the various shopping centers. The horizontal scale shows the number of days during the year when the parking demand was greater than that shown by the use curves as derived from the

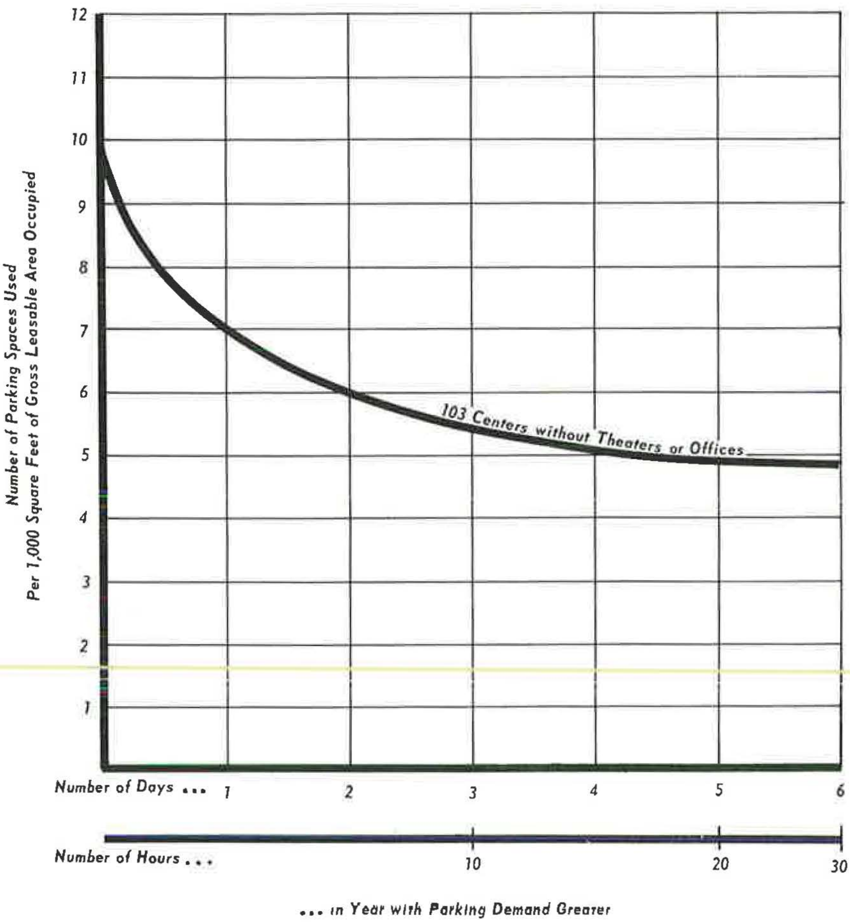


Figure 3. Daily parking requirements.

basic data. The chart shows that parking demand exceeds six spaces per 1000 square feet on only two days of the year and 5. 5 spaces per 1000 square feet on three days of the year.

To the extent that this sample is representative of all shopping centers in the United States and Canada, the same levels of parking usage can be expected at all shopping centers, and the standard described herein will be applicable to them.

If the highway officials' thirtieth-highest hour design criterion were used to determine parking requirements at shopping centers, about 4. 9 spaces per 1000 square feet of gross leasable area would be required. Comparison of hourly and daily parking demands by the special analysis of traffic data for a shopping center (described above) indicates that the thirtieth-highest hour of parking demands is roughly equivalent to the sixth-highest day (Fig. 3).

Perhaps a more realistic standard in light of customers' desires would be the selection of the third-highest day as a basis for a parking standard. This is logical because, as shown by Figure 3, the curve levels off after the third-highest day. Such a standard would eliminate the extremely high peaks which occur on the first-, second-, and third-highest days. This would mean that for each space not provided (between this standard and one which would require an additional space per 1000 square feet) about ten auto customers in a year would be unable to find a parking space immediately, since the third-highest day is approximately equivalent to the tenth-highest hour (the average customer stays at a typical center for about an hour) (1, Figs. 41-43; 3).

From an economic point of view, such a standard is very conservative since the annual cost of providing a parking space in a shopping center greatly exceeds the profit revenue from the sales volume that ten customers would generate.

If the design hour were selected solely from an economic point of view, that is, considering the shopping center developer's annual cost of providing parking ($100 per space) and the possible economic return on such money ($2 to $3 per vehicle parking), the design hour would probably be between the thirtieth- and fiftieth-highest hours. These estimates of the annual cost of providing parking and the economic return per vehicle parking are subject to judgment but, even if the most optimistic cost estimates are used, provision of parking to meet the tenth-highest hour of parking demand will be more than adequate to meet the economic criteria.

The Recommended Standard

As shown by Figure 3, provision of parking spaces at a level which would exclude the third-highest day of demand requires approximately 5.5 spaces per 1000 square feet of gross leasable area (exclusive of theater or office space). This includes parking spaces required by employees, as well as the reserve spaces needed for parking maneuvering. The counting technique took into account the spaces needed for parking maneuvering by: (a) considering a space occupied if a car were pulling in or out of it, (b) considering a car as filling an empty space somewhere else if it were waiting to pull into a space, and (c) considering a car as filling a space somewhere else if it were parked in an illegal space. (See Appendix B for a more detailed description of the counting technique.)

Thus, a total of 5.5 spaces per 1000 square feet of gross leasable area (exclusive of theater and office space) is recommended as the parking standard for the design of shopping centers of all sizes. To the extent that the centers in this sample are like those in the United States as a whole, Figure 3 shows that this standard, on the average, will satisfy the parking demands for all but three days of the year at all of the shopping centers in the United States. This is approximately one percent of the total days these shopping centers are open during a year.

Additional analysis of the 103 centers that had no theater or office space indicates that they had the same demand on the third-highest day regardless of their size. The number of spaces used on the third-highest day by the centers in all size classes actually varied between 5.0 and 6.0, but there was no systematic relationship between the center size and the parking demand; so it is possible to recommend a single standard of 5.5 spaces per 1000 square feet for centers of all sizes. The parking demands of only one size class (composed of those nine centers with between 400,000 and 600,000 square feet of gross leasable area) differed from the recommended standard by more than 0.25 spaces per 1000 square feet, so the variations by size class were generally insignificant. The lack of a systematic relationship between parking demand and shopping center size is shown by the fact that there was only 0.2 spaces difference between the parking demands of the largest and smallest size classes.

The test of any standard is in its application. Of the 103 centers that were studied, eight centers provided spaces at the recommended level of 5.5 spaces per 1000 square feet of gross leasable area. The parking demand at these centers, as shown by Figure 4, exceeds capacity for only three days of the year—that is, during those days cars are parked illegally and queuing occurs within the center. Figure 4 also indicates that at the sixth-highest day (the standard equivalent to that used by highway engineers in the design of highway facilities, as mentioned above) the centers have a parking reserve of at least ten percent.

Parking demands on the third-highest day at those centers providing 6.0 spaces per 1000 square feet of gross leasable area are very little more than at the centers providing 5.5 spaces per 1000 square feet.

Figure 4 also shows the number of spaces used per 1000 square feet of the gross leasable floor area that was occupied at centers that provided, on the average, 8.8

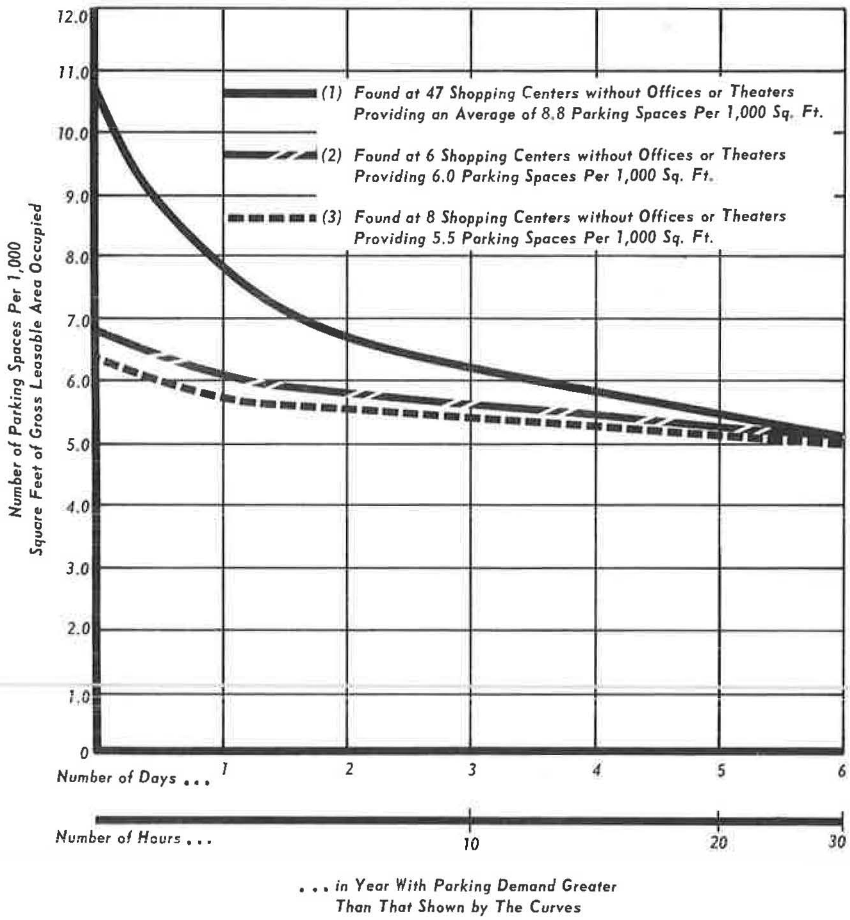


Figure 4. Daily parking requirements.

spaces per 1000 square feet of gross leasable area. In these cases, the additional spaces above the recommended standard were used to some degree for the six highest days, but they only served about 30 extra cars per 1000 square feet, and after the sixth-highest day were not used at all. In other words, when about nine parking spaces per 1000 square feet of gross leasable floor area are provided, the additional spaces over the recommended standard are used only six days a year, mainly on one or two days.

Thus, the recommended standard is one that takes into consideration the customer, but at the same time recognizes that sound planning should not provide for the infrequent extremes in the peaks of parking demand.

Using this technique on data from 103 shopping centers for the 12 days of the pre-Christmas season has probably provided a reliable estimate of parking demand levels and their frequencies during the highest three days of the year (Fig. 3), since the four highest days occur during the Christmas season. This is the portion of the curve which is most reliable and on which the recommended standard for parking space provision is based. Equally reliable estimates of the frequencies of the lower parking demand levels would require more parking counts on more "normal" days, but such estimates are unnecessary for justification of the recommended standard. This, then, is a standard based on observed parking demands at the peak hours of the peak days of the peak season of the year.

SPECIAL CIRCUMSTANCES MODIFYING PARKING REQUIREMENTS

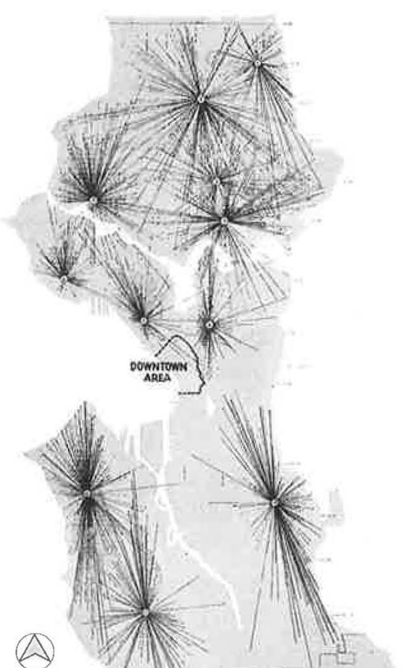
Parking demands are not generated by the building space itself, but by the clientele of the center—which is determined by the location of the center, its competitive advantage, the characteristics of the trading area's population and its mode of transportation, and by the number and types of activities located in the center.

Effects of Shopping Center Location and Trading Area on Parking Requirements

Parking requirements at a shopping center are affected by the location of the center. For example, if a center is located near a physical barrier, such as a body of water or undevelopable open space, fewer shoppers can be attracted from one direction than if the center were located in an area which is easily accessible from all directions. In Figure 5, Shopping Center Number 4 illustrates this. In such cases, the parking requirements probably could be below the recommended standard.

Numerous studies in the past have indicated that the trading area of a shopping center is also affected by the location of competition and the size of the center itself. These factors are also clearly shown by Figure 5, which shows the points from which shoppers came to various shopping centers in Seattle. The size of the trading area of each center varies with the size of the center, but the influence of competing centers modifies these trading areas, as in the case of Shopping Center Number 3.

Thus, there may be instances where a shopping center, because of unique location, would have higher or lower parking requirements than indicated by the recommended standard. Where such conditions are not likely to change with time, modification of the



0 ½ 1 2 miles

Source: CITY PLANNING COMMISSION OF SEATTLE

Each Dot Represents 36 Families

Figure 5. Trading areas of shopping centers in Seattle.

standard is in order. In such circumstances a specialized study should be undertaken to establish the parking requirements. In the case of a proposed center, this would call for the application of a mathematical model that adequately simulates shopping patterns. Where an existing shopping center is to be expanded, analyses of existing parking practices and a study of projected parking requirements should be undertaken before such modifications can be considered.

Effects of Mode of Travel on Parking Requirements

The data for the shopping centers included in this study show the characteristics of their suburban locations and, as is typical of such outlying areas, the elements of walk-in trade and dependence on public transportation are missing. The customers arrive principally by private automobile. Suburban shopping centers have the greatest parking demands per unit of gross leasable floor area. Where a shopping center (or a shopping district) is located in a central city area served by mass transportation and where a high volume of walk-in trade comes from the surrounding neighborhoods, the parking requirements are reduced by as much as two-thirds from those found in suburban areas. This finding comes from a traffic engineering survey of parking demand in the Baltimore metropolitan area. (This information comes from a special investigation of data developed in connection with the market potential and site evaluation studies on multi-purpose centers for the Baltimore region by Alan M. Voorhees and Associates, Inc.) Similar reductions in parking requirements for retail shopping districts have been observed from comparable parking demand studies conducted in Detroit (4).

Since the recommended parking standards are for a center with little walk-in trade or transit usage, an increase in the importance of either of these factors would call for a corresponding reduction in parking requirements.

Effects of Tenant Composition on Parking Requirements

The recommended parking standard might be modified if the array of shopping center tenants were unusual. For example, if the center's tenant composition were to include furniture stores or other such specialty tenant classifications, the parking requirement could be reduced, since such stores generally do not generate the parking requirements that are normally observed at shopping centers with predominantly apparel, drug, variety, hardware, and food stores and services (3, Table 5; 5, Table 14).

Effects of Offices and Theaters on Parking Requirements

The 270 shopping centers in this study reported the floor area, if any, devoted to office use. An analysis was made to determine what impact the office use might have on parking requirements at the peak hours of the third-highest day. It was found that office floor area was not a significant predictor of parking space demand in regression analysis.

Office space does not generally have an impact on peak-hour parking requirements at the third-highest day because when this peak hour occurs offices are not normally open. For example, at the centers in the sample only 13 percent of the peak demands on the third-highest day occurred when the offices were in full operation. These peak demands usually occurred on evenings, Saturdays, or the day before Christmas when, generally, office activities were below normal.

Generally, it was found that normal hours of office operation only began to coincide with the peak hours occurring on the sixth-highest day of parking demand. Figure 3 shows that there is a difference of one-half space per 1000 square feet (of the gross leasable area that was occupied) between the peak parking demands on the third-highest day and the sixth-highest day. This number of spaces would accommodate normally about the parking requirement for 200 square feet of office space, assuming that 2.5 spaces per 1000 square feet of office space use are adequate to satisfy normal office parking requirements in shopping centers. This means that for every 1000 square feet of gross leasable area at a shopping center an additional 200 square feet in office use may exist without increasing parking demand for the third-highest day. Thus, if up to

20 percent of the gross leasable area of the center is in office space the center's parking requirement based solely on gross leasable area is adequate. When more than 20 percent of the gross leasable area of the center is in office use, provision should be made for office parking according to the generally accepted standard of 2. 5 spaces per 1000 square feet in office use.

It is possible that those centers which have large concentrations of offices with tenants such as doctors and dentists, who serve the public directly and may have extra demands during Christmas vacations, would generate enough parking demands at the tenth-highest hour to require more than 5. 5 spaces per 1000 square feet, but these effects were not observed in the present study.

An analysis of the impact that theaters may have on parking requirements at shopping centers was also undertaken. Although statistically significant results were obtained by multiple regression techniques, indicating that the presence of a theater in a shopping center generates additional parking demand, it was felt that in light of the sample size (only 28 shopping centers had theaters) and the dominance of retailing activities at the centers studied, additional research should be undertaken. Appropriate research should analyze the nature of parking demand generated by a theater at a shopping center by determining: (a) the extent to which theaters have a multiplier effect on retail parking demands, (b) the interchange of parking spaces between theater and retail

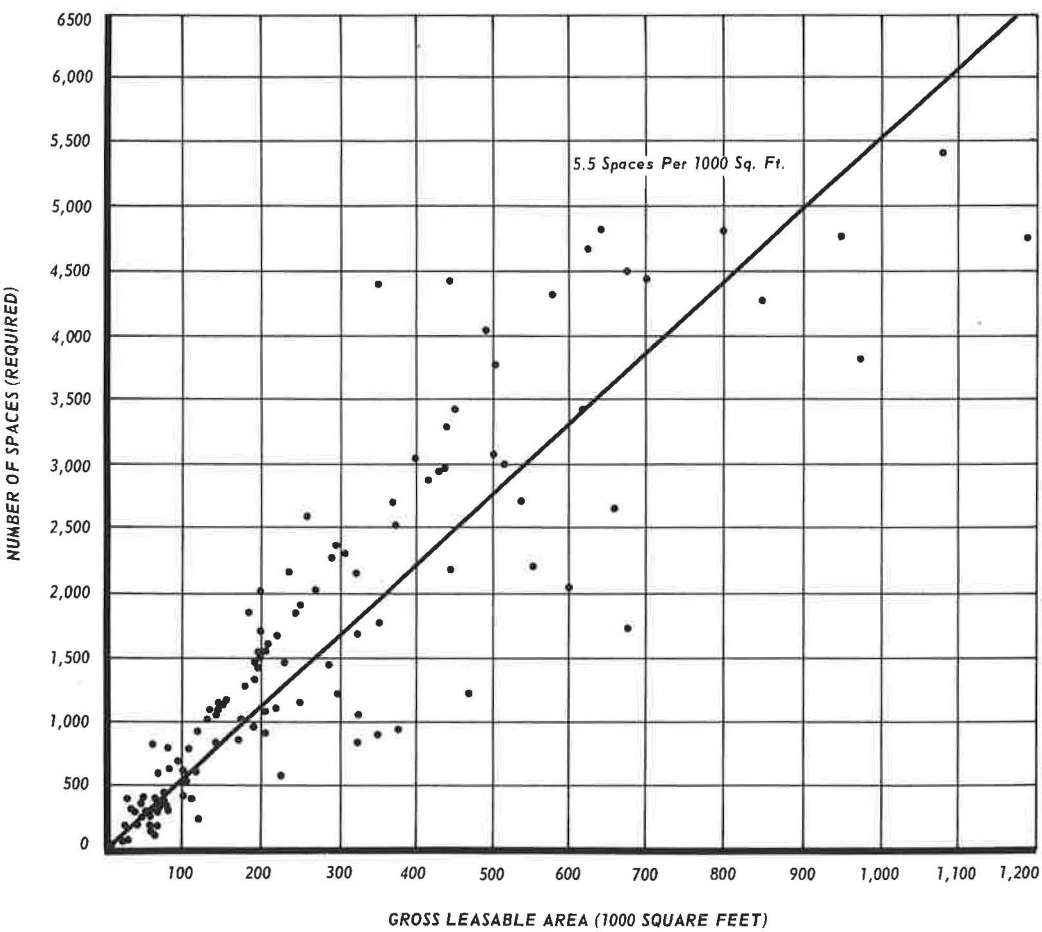


Figure 6. Parking spaces required by existing zoning by gross leasable area in relation to recommended standard.

activities, and (c) the influence that the location of the theater within the shopping center has on parking requirements.

RECOMMENDED STANDARD COMPARED TO EXISTING ZONING REQUIREMENTS

Forty percent of the centers in the survey reported information making possible an accounting of the number of parking spaces required by the provisions of a local zoning ordinance. These parking space requirements are plotted in relation to the gross leasable area of the shopping centers in Figure 6. A line representing the recommended standard of 5. 5 spaces per 1000 square feet of gross leasable area in the center (exclusive of theater and office space) is also shown. This figure shows that the ratios of number-of-spaces-required-by-zoning to center-size vary widely. It also shows that 56 percent of the shopping centers shown were located in areas where the local zoning ordinance parking requirement was higher than the recommended standard.

Since the area required by a parking space varies with a parking lot's layout, this study uses the parking index, or number of car spaces provided per 1000 square feet of gross leasable area, rather than the parking ratio, which relates the area of the parking space to the building area.

Many of the dots above the line representing the recommended standard indicate zoning requirements based on the parking ratio of three-feet-of-parking-area to one-foot-of-building area now in common usage. Assuming 400 square feet per parking space, this is equivalent to 7. 5 spaces per 1000 square feet of floor area. The recommended standard of 5. 5 spaces per 1000 square feet is equivalent to 2. 2 feet of parking area for one foot of floor area. In other words, a 2. 2 to 1 ratio is more appropriate than a 3 to 1 ratio, if the ratio formula is to be used in zoning ordinances.

REFERENCES

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Appendix A

DEFINITIONS

The data collected from the 270 shopping centers which returned questionnaires are tabulated in Appendix C. Some explanation of definitions and methods of derivation of the data shown is necessary to understand the tabulation, but many items are self-explanatory.

Gross Leasable Area—The total floor area designed for tenant occupancy and exclusive use, including basements, mezzanines, and upper floors, if any, as expressed in square feet measured from center lines of joint partitions and exteriors of outside walls. This does not include office buildings in which medical, dental, research, and other kinds of special organizations are housed, nor theaters, although it does include banks and other such activities which are part of the shopping center (6). It should be noted that this definition of gross leasable area does not include space in office or theater use.

Parking Spaces Available—The total parking spaces available within the center provided for all purposes, whether used by employees or customers. They were determined by actual count. (A few centers excluded those spaces for employees which are so located that customers never use them; e.g., in rear service areas.) The number of spaces used by employees was determined by counting the number of cars parked in the lots before the stores opened in the morning. These spaces were then subtracted from the total to get the number of spaces available for customer parking. For the 31 cases in which customers park outside the center the number of parking spaces thus used was estimated, using information provided by the questionnaires.

Peak Parking Demand—The peak customer and employee parking demand for each day at a shopping center shown here as the higher of the afternoon and the evening counts. (The number of customer cars parked is derived by subtracting the number of empty spaces counted from the number of spaces available to customers both inside and outside the center.) The day in the 12-day period which had the highest number of parked cars is shown in the column labeled "Max. Day." The numbers of cars parked at the peak times on the second- and third-highest days are also shown. In some instances the same peak parking demand occurred at a given center on two or three of the top three days, so the first, second or third observation might be the same.

Estimated Parking Spaces Required by Zoning—Several shopping centers gave the actual number of parking spaces required by their zoning ordinances, while others gave only the zoning standards from which the numbers of spaces required were estimated. Since the floor area definitions used by the various ordinances had minor differences, the numbers shown here vary slightly in their degrees of accuracy. (These calculations assumed 400 square feet per parking space.)

Appendix B

SURVEY TECHNIQUE

The following excerpt from the instruction manual sent to all shopping centers participating in the survey describes the counting procedures used (6).

Survey Technique

In setting up the program to count the empty parking spaces, the following steps should be carried out.

1. A person at the management level should be selected to head up this program.
2. He should be assigned a man who is to do the actual counting. This may be a full-time employee or a part-time worker.
3. The manager of this project should go through all the procedures with the counter to be sure he is doing an adequate job to get a good approximation of the number of empty spaces. These would include:
   a. Dividing the area up into clusters or units of about 300 parking spaces and selecting a walking pattern around the Center that will permit one to count all the empty spaces that exist in each cluster around the Center. It might be helpful to first lay out such a pattern on a site plan, like Figure 1, and then go out and actually review it with the counter. At this time it should be possible to determine how long it will take to walk around the Center, thereby making it possible to set up a time schedule for the counter.
   b. The manager should then instruct the counter on what is meant by an empty space. For example, if a car is pulling in or out of a space, that space should

be considered occupied. If a car is waiting to pull into a space that car should be considered as filling an empty space somewhere else. If a car is parked in an illegal space, it should be considered as filling a space somewhere else.

c. After the walking pattern has been determined, a trial run should be made to determine what is the best way to record the empty spaces. If a hand-counter is available, this should be used. In other cases, it may be possible for the man to continually count the number of spaces until he goes all the way around the lot, and then record the number on the form (Table II). Or, you might develop a tally sheet to record empty spaces in each cluster or unit.

d. Once the test program has been set up, the starting times for the count should be the same for each day—2:30 and 8:00 p. m. The counts should be taken each day between December 11 and 24. The counter should always start from the same starting point.

Reference

6. Manual for Developing Parking Data at Shopping Centers in the United States and Canada During the Pre-Christmas Season, 1964.

Appendix C

SHOPPING CENTER CHARACTERISTICS

1

SAMPLE NO.	AGE IN YEARS 1–2	AGE 3–5	AGE 5+	AGE OVER 5 WITH LATER ADDITION	AGE 3–5 WITH LATER ADDITION	RETAIL	OFFICE	OTHER	PARKING SPACES IN CENTER AVAILABLE	PARKING SPACES IN CENTER CUSTOMER	EST OUTSIDE CENTER	FLOOR AREA (100'S SQ. FT.) GROSS LEASABLE	OCCUPIED GROSS LEASABLE	OFFICE	OTHER	OTHER USE MOVIE	REC	CIVIC	LIBRY	OTHER	METRO POP (1000'S)	ANNUAL SALES (1000'S)	CUSTOMER TYPE INCOME LOW	MID	UP	INDUS	OFF	TRAVL	OTHER	EST PKG SPA REQ BY ZON CRD	CUSTOMER AND EMPLOYEE PARKING SPACE USED MAX DAY	2ND DAY	3RD DAY
1	X					X			32	32		109	101								OVER 2000		X			X				27	23	21	16
2				X		X			322	297		259	259								100-250	2500		X		X	X			41	142	132	123
3			X			X			251	233		276	276								500-1000	1800		X		X	X				170	158	152
4		X				X			216	201	5	334	309								OVER 2000	2000	X			X	X			83	86	79	76
5			X			X			240	210		359	304								OVER 2000			X		X					87	83	80
6			X			X			214	214	12	363	363								OVER 2000			X		X					237	212	212
7			X			X			415	390		385	385								1000-2000	4600		X			X			319	285	247	240
8	X					X			220	190		399	384								1000-2000			X			X				119	111	111
9	X					X			296	274		415	415								1000-2000			X			X				176	140	138
10			X			X			296	270		423	423								1000-2000			X			X				191	169	152
11		X				X			250	225		494	494								OVER 2000	2250		X		X	X			247	175	165	145
12			X			X			181	178	58	577	568								1000-2000	3400	X			X				288	233	231	215
13			X			X			185	185		600	600								1-100	2500			X		X			150	160	152	145
14					X	X			343	303	12	611	611								1000-2000	4250		X		X	X			175	313	295	
15			X			X			395	395		630	504								500-1000	2457		X			X				336	292	261
16		X				X			1350	1312		642	642								100-250	3628		X	X	X	X			103	526	365	325
17			X			X			354	319	50	661	661								OVER 2000		X	X		X	X				404	404	404
18			X			X			479	431		662	662								500-1000				X		X			795	385	327	269
19	X					X			474	454	75	700	683								500-1000	4970		X		X	X			600	546	505	498
20			X			X			534	498		715	715								1000-2000			X		X	X			357	411	394	381
21			X			X			276	255		717	717								1-100	4890	X	X	X	X			X		276	276	276
22			X			X			458	429		727	697								100-250	1627		X		X	X				295	238	223
23			X			X			305	279		730	696								1000-2000			X						388	305	237	215
24		X				X			617	577		792	792								500-1000	4249	X	X						316	453	279	278
25		X				X			705	629		800	795								250-500	7250	X	X		X	X				518	505	505
26			X			X			563	514		906	848								500-1000										318	298	293
27			X			X			520	420		930	930								250-500	5441	X			X					455	411	368
28		X				X			825	735		947	932								OVER 2000	8000			X		X			710	523	371	352
29			X			X			700	675		795	795								500-1000	2834		X	X						355	354	268
30	X					X			478	433		1029	979								OVER 2000			X	X			X		412	451	443	438
31		X				X			1000	800	50	1100	1060								1000-2000	2750		X		X	X				602	552	532
32	X					X			850	850		1127	1127								1-100			X		X	X				608	510	506
33			X			X			681	628		1170	1170								250-500	7000		X	X		X				610	592	555
34		X				X			934	909		1229	1229								1-100	10000		X	X						641	569	538
35			X			X			1420	1344		1269	1269								500-1000										1230	1215	1202
36			X			X			815	750		1269	1269								500-1000										611	584	539
37	X					X			823	749		1300	1300								100-250	7000	X	X			X		X	1007	543	506	404
38		X				X			776	683		1356	1316								1-100	4500		X		X	X			814	717	639	585
39	X					X			1110	995		1396	1396								250-500	4000	X	X	X	X	X			1047	667	654	648
40		X				X			1012	911		1402	1366								500-1000		X	X		X	X				759	654	592
41			X			X			700	700		1387	1387								500-1000	7000	X	X							360	302	251
42	X					X			1275	1045		1411	1411								OVER 2000	8000	X				X				965	955	950
43	X					X			887	772		1423	1367								OVER 2000	6250	X	X	X	X	X			1067	595	571	546
44	X					X			875	760		1429	1429								1000-2000			X			X				795	795	785
45		X				X			1150	1070		1473	1473								OVER 2000	10750		X			X			1105	675	636	532
46		X				X			1261	1092		1500	1491								250-500	10000	X	X	X	X	X				878	720	702
47			X			X			1276	1035		1559	1559								1000-2000										1015	950	909
48			X			X			1250	1110		1617	1617								500-1000	8000		X		X					745	719	695
49			X			X			1460	1401		1657	1657								250-500										933	902	862
50			X			X			957	668		1687	1687								500-1000										957	957	953
51	X					X			1100	975		1710	1710								1-100	8500		X						850	1053	1022	934

SAMPLE NO.	AGE IN YEARS 1-2	3-5	5+	OVER 5 WITH LATER ADDITION	3-5 WITH LATER ADDITION	RETAIL	OFFICE	OTHER	PARKING SPACES IN CENTER AVAILABLE	CUSTOMER	EST OUTSIDE CENTER	FLOOR AREA (100'S SQ. FT.) GROSS LEASABLE	OCCUPIED GROSS LEASABLE	OFFICE	OTHER	OTHER USE MOVIE	REC	CIVIC	L I E F Y	OTHER	METRO POP (1000'S)	ANNUAL SALES (1000'S)	CUSTOMER TYPE INCOME LOW	MID	UP	INDUS	OFF	TRAVEL	OTHER	EST PKG SPA REQ BY ZON ORD	CUSTOMER AND EMPLOYEE PARKING SPACE USED MAX DAY	2ND DAY	3RD DAY
52		X				X			2269	2134		1820	1800								100-250	7000		X		X				1274	1310	1027	987
53		X				X			1238	1152		1869	1509								1-100	5000		X	X	X	X			1308	622	559	546
54	X					X			1365	1263		1977	1933								1-100	11300		X	X	X	X		X		1156	1071	1054
55		X				X			865	845		1900	1900								1000-2000	16000		X						950	824	758	753
56		X				X			1339	1194		1950	1890								250-500	7500		X	X					1365	1113	1054	1020
57			X			X			1218	1145		1980	1955								100-250	9000	X	X		X					873	871	795
58			X			X			2000	1750		1997	1997								500-1000		X	X	X	X	X				2000	2000	1990
59			X			X			800	620		1000	1000								1000-2000	5250		X		X					690	680	660
60			X			X			880	880		2000	2000								100-250	8000		X		X	X				792	704	682
61		X				X			2200	1900		2010	2010								250-500	12500		X		X	X				1680	1520	1468
62					X	X			1538	1385		2045	2045								500-1000	13361	X	X	X	X	X			921	1368	1308	1193
63	X					X			1847	1727		2085	2085								1000-2000	13000		X	X	X	X			1564	1514	1405	1373
64		X				X			1593	1273		2250	2120								1000-2000	10000		X			X			563	1256	1231	1147
66	X					X			1584	1364		2293	2257								250-500	11000			X					1432	1224	1180	1154
67	X					X			800	700	100	2350	2134								1-100	12000	X	X	X	X	X	X			859	809	788
68	X					X			1400	1400		2350	2350								100-250	11000		X	X	X	X				1400	1369	1016
69			X			X			1329	1189		2400	2400								1-100			X	X	X	X				1283	1282	1271
70		X				X			1815	1715		2400	2400								OVER 2000	12000		X		X				2250	1430	1418	1093
71		X				X			1745	1503	37	2450	2445								250-500	13000		X	X	X	X				1299	1071	904
72	X					X			1722	1472		2500	2334								OVER 2000	20000		X	X	X				1875	1650	1620	1612
73	X					X			1300	1270		2500	2485								100-250	15000		X							1143	1108	1088
74		X				X			1741	1541		2558	2479								OVER 2000										991	923	764
75		X				X			1760	1530		2656	2656								1000-2000			X		X					1630	1516	1349
77			X			X			1500	1300		2800	2800								500-1000	8000		X		X	X				1311	1264	1122
78			X			X			1280	1200		2806	2801								OVER 2000										1280	1272	1188
79		X				X			1987	1812		2845	2845								500-1000	14000		X			X				1987	1987	1956
80	X					X			1651	1441		2847	2290								OVER 2000	14500		X		X	X				971	959	899
81		X				X			1628	1378	20	2850	2780								OVER 2000	23000		X		X	X			1425	1648	1628	1622
82		X				X			1863	1738		2861	2861								1000-2000			X							1291	1287	1240
83			X			X			1886	1754		2875	2875								OVER 2000	16700		X		X	X				1700	1570	1569
84			X			X			1276	1276		2905	2890								1-100										1276	1111	1048
85			X			X			1800	1675		3062	2825								OVER 2000	13600		X		X	X				1800	1800	1800
86		X				X			3150	2834		3173	3083								250-500		X	X		X	X				2319	2162	2124
87		X				X			2010	1785		3210	3000								OVER 2000			X		X				2140	1843	1757	1618
88			X			X			1593	1463		3237	3237								OVER 2000	12000									1593	1441	1426
89	X					X			2297	1951		3250	2720								250-500		X	X	X		X	X		813	1586	1571	1468
90		X				X			1946	1686		3281	3243								250-500	12000	X	X			X			1640	1566	1491	1273
91		X				X			2263	2163		3283	3283								100-250	14000		X		X	X				2112	2000	1943
92			X			X			1846	1771		3330	3308								500-1000	12000		X		X	X				1431	1227	1204
93		X				X			3404	3219		3501	3073								1000-2000			X						1750	1271	1139	1103
94			X			X			2122	1812		3505	3505								1000-2000										1997	1973	1762
95			X			X			2150	2150		3556	3531								500-1000	22000		X	X		X				2150	2150	2150
96			X			X			2128	1796		3750	3750								OVER 2000	40000		X		X				938	2118	2105	2101
97		X				X			4385	3973		3830	3698								500-1000	12500		X	X		X				3630	3153	3034
98			X			X			1154	1038		2143	1721								500-1000	8500		X	X	X	X				741	728	611
100			X			X			2044	1744		4274	4274								500-1000	25000	X	X		X	X			1069	2012	2005	2005
101	X					X			4040	3727		4350	4346								250-500	18000	X	X	X	X	X			2941	2997	2572	2439
102			X			X			3200	2975		4389	4389								500-1000	21000	X	X		X	X			4389	2146	1864	1828
103			X			X			3047	2887		4394	4284								OVER 2000	20472		X		X	X				2517	2472	2457
104		X				X			3195	2900		4690	4600								500-1000	16000	X	X	X	X	X				2014	1953	1545
105		X				X			3130	2842		4960	4760								250-500	24000	X	X	X	X	X	X			2841	2675	2358

SAMPLE NO.	AGE IN YEARS 1-2	3-5	5+	OVER 5 3-5 WITH LATER ADDITION	RETAIL	OFFICE	OTHER	PARKING SPACES IN CENTER AVAILABLE	IN CENTER CUSTOMER	EST OUTSIDE CENTER	FLOOR AREA (100'S SQ. FT.) GROSS LEASABLE	OCCUPIED GROSS LEASABLE	OFFICE	OTHER	OTHER USE MOVIE	REC	CIVIC	LIBRY	OTHER
106	X				X			2818	2471		5000	4950							
107			X		X			3917	3417		5105	5105							
108		X			X			3573	3013		5920	5920							
109		X			X			4325	3950		6127	5876							
110		X			X			4500	4000		6145	6145							
111			X		X			3929	3069		6926	6926							
112		X			X			4425	4015		6192	5404							
113		X			X			3099	2843		6395	6271							
114			X		X			4738	4038		6997	6997							
115			X		X			5000	4700	150	7540	7500							
116	X				X			5400	5050		9680	9080							
117	X				X			250	180		280	280							
118			X		X			518	423		500	500							
119	X				X			1200	1140		1110	1110							
120		X			X	X		287	252		231	216	40						
121	X				X	X		315	225		369	369	33						
122	X				X	X		250	225		399	372	29						
123	X				X	X		235	190		468	468	42						
124			X		X	X		400	375		478	478	5						
125			X		X	X		335	319		526	526	93						
126			X		X	X		196	156		597	441	43						
127	X				X	X		360	315		612	598	32						
128		X			X	X		358	314		656	587	25						
129		X			X	X		325	265		710	634	32						
130			X		X	X		687	625		720	680	24						
131			X		X	X		338	296		732	588	13						
132			X		X	X		412	235		770	770	58						
133			X		X	X		406	324		787	787	100						
134	X				X	X		455	400		792	693	93						
135			X		X	X		371	328	2	820	800	130						
136	X				X	X		714	683		884	776	42						
137			X		X	X		104	82		900	900	69						
140			X		X	X		550	430		1000	1000	8						
141			X		X	X		595	567		1000	928	120						
142			X		X	X		410	380		1008	760	140						
143			X		X	X		1300	1225		1014	1014	55						
144		X			X	X		872	819		1073	910	14						
145			X		X	X		533	508		1102	1080	120						
146		X			X	X		864	806		1134	1032	13						
147	X				X	X		628	523		1143	1143	86						
148	X				X	X		836	781		1158	1158	130						
149		X			X	X		700	615		1177	1177	130		X				
150		X			X	X		716	663		1222	1154	30						
151		X			X	X		1200	1100		1324	1324	61						
152			X		X	X		1000	850		1430	1430	75						
153	X				X	X		1082	1027		1484	1473	12						
154		X			X	X		906	744		1550	1550	18						
155			X		X	X		1500	1375		1612	1564	110						
156			X		X	X		911	694		1650	1560	23						
157			X		X	X		1870	1731		1660	1624	20						
158		X			X	X		1267	1102		1710	1710	60						

SAMPLE NO.	METRO POP (1000'S)	ANNUAL SALES (1000'S)	CUSTOMER TYPE INCOME LOW	MID	UP	INDUS	OFF	TRAVL	OTHER	EST PKG SPA REQ BY ZONORD	CUSTOMER AND EMPLOYEE PARKING SPACE USED MAX DAY	2ND DAY	3RD DAY
106	OVER 2000			X							2198	2190	2168
107	500-1000	30000	X	X	X	X	X	X		3066	3273	3151	2657
108	100-250	75000	X	X	X	X	X			2960	2100	1894	1737
109	1-100			X	X	X	X				2836	2789	2772
110	1000-2000	30000		X	X		X		X	3400	3859	3585	3580
111	250-500	58500		X			X	X			3929	3874	3703
112	1000-2000	20000		X						4644	2638	2625	2282
113	1000-2000				X					4796	2784	2765	2171
114	500-1000		X	X	X	X	X			4373	4135	3977	3484
115	1000-2000			X	X	X	X		X		4275	4248	3508
116	OVER 2000	39000			X		X			3812	5400	5400	5400
117	1000-2000	2300		X			X				213	202	190
118	1000-2000	3400		X			X				393	375	374
119	1-100	6000	X	X		X	X	X			1200	1200	1196
120	500-1000			X			X			185	143	133	130
121	250-500	2100			X		X			300	281	257	249
122	1000-2000	1400		X	X	X	X			185	161	108	93
123	OVER 2000	2500		X			X			351	157	147	143
124	1000-2000	5000			X		X			278	336	300	298
125	1000-2000	2258		X		X	X				335	328	324
126	250-500			X		X	X				184	183	174
127	OVER 2000	3000		X		X	X			306	247	236	235
128	100-250	2025		X			X			218	208	198	190
129	OVER 2000	4500		X		X	X			355	290	266	262
130	250-500	4000		X							375	326	284
131	1-100		X	X		X	X			339	203	189	188
132	500-1000	4239			X					578	412	412	406
133	1000-2000	3100			X		X			787	345	334	319
134	OVER 2000			X			X				273	261	245
135	1-100	3006		X		X	X				209	205	167
136	1000-2000			X		X	X				220	214	186
137	1000-2000	2339		X			X				104	104	104
140	250-500	3000	X	X	X			X			408	346	329
141	OVER 2000	4500		X	X		X			579	308	283	266
142	1-100	1031	X	X		X	X				392	391	383
143	1-100	4100		X		X					731	707	675
144	1-100			X	X	X	X	X			407	385	365
145	OVER 2000		X			X					300	267	250
146	1-100			X	X	X	X				355	344	335
147	100-250	3500		X			X			403	460	448	441
148	1000-2000				X		X				397	354	336
149	OVER 2000	5000		X		X	X			588	585	575	405
150	OVER 2000			X			X			244	585	578	549
151	250-500			X		X	X				812	787	589
152	100-250	10000		X		X		X			831	816	808
153	500-1000	7625		X		X	X				580	532	519
154	1000-2000	12000		X			X			1163	895	881	871
155	250-500	7000		X							1224	911	830
156	1-100	7400		X							802	775	752
157	1-100	6000		X	X	X	X				1069	1068	1037
158	250-500	10000		X		X					891	866	831

4

SAMPLE NO.	AGE IN YEARS 1–2	3–5	5+	OVER 5, 3–5 WITH LATER ADDITION	RETAIL	OFFICE	OTHER	PARKING SPACES IN CENTER AVAILABLE	IN CENTER CUSTOMER	EST OUTSIDE CENTER	FLOOR AREA (100'S SQ. FT.) GROSS LEASABLE	OCCUPIED GROSS LEASABLE	OFFICE	OTHER	OTHER USE MOVIE	REC	CIVIC	LIBRY	OTHER	METRO POP (1000'S)	ANNUAL SALES (1000'S)	CUSTOMER TYPE INCOME LOW	MID	UP	INDUS	OFF	TRAVL	OTHER	EST PKG SPA REQ BY ZON ORD	CUSTOMER AND EMPLOYEE PARKING SPACE USED MAX DAY	2ND DAY	3RD DAY
159	X				X	X		1402	1350		1735	1735	15							100-250	11000		X		X	X				1125	1113	1091
160			X		X	X		501	501		1736	1716	51							1-100	7000	X	X	X	X	X	X		1000	501	425	362
161			X		X	X		780	710	500	1758	1738	64							100-250	7964		X		X					1081	1045	1029
162			X		X	X		1700	1350		1800	1680	21							250-500		X	X		X	X				1480	1480	1465
163		X			X	X		1254	992		1814	1814	130							1-100	6200	X	X	X	X	X				751	713	612
164			X		X	X		1325	1125		1900	1900	4							OVER 2000	11000		X		X	X			1425	1225	1197	1191
165		X			X	X		1706	1640		1945	1945	17							250-500			X			X				1306	1306	1256
166		X			X	X		1300	1190		1955	1755	11							OVER 2000	7900	X	X		X	X			1466	826	687	673
168			X		X	X		1000	839		1614	1503	35							1000-2000			X		X	X				563	508	467
170	X				X	X		1603	1408		2003	1941	135							100-250	6000		X	X	X	X			2003	1334	1178	1045
171			X		X	X		1126	1024		2183	2138	178							250-500			X	X	X	X				993	970	961
172		X			X	X		1279	1137		2190	2117	47							OVER 2000	9750		X		X	X			1643	704	695	624
173			X		X	X		1150	1040		2198	2198	174							1000-2000	10750	X	X		X	X			1099	1119	1109	1051
174			X		X	X		1400	1285		2356	2356	100							500-1000	12899		X			X				1400	1400	1380
175			X		X	X		1549	1227		2500	2500	100							1000-2000	15000			X					1150	1458	1425	1406
176		X			X	X		1316	1185		3000	1700	10							100-250	15000		X			X				1095	1041	952
177			X		X	X		3000	2781		3059	2995	300							1-100	20600	X	X	X	X	X			2294	1793	1790	1679
178			X		X	X		1848	1773	12	3353	3107	60							OVER 2000	23000		X		X					1548	1540	1505
179			X		X	X		1617	1457		3354	3238	54							100-250	12000		X	X	X	X				1505	1441	1427
180			X		X	X		1550	1405		3433	3398	83							OVER 2000	17092		X	X	X	X				1549	1498	1290
181			X		X	X		1739	1639	35	3500	3500	200							1000-2000	15000	X	X		X				875	1287	1258	1119
182			X		X	X		3000	2900		3500	3500	20							1000-2000			X	X						2548	2350	2350
183	X				X	X		3047	2852		3694	3685	12							1000-2000	22700		X		X	X			2509	2556	2323	2242
184		X			X	X		2200	2020	20	3700	3700	125							1000-2000	20000	X	X		X	X			2590	2220	2215	2215
186			X		X	X		4200	3877		3752	3717	59							100-250	16629	X	X	X	X	X	X			3448	3411	3350
187		X			X	X		1859	1659		3973	3930	100							OVER 2000	25000		X	X		X				1856	1833	1822
188			X		X	X		1127	916		2948	2860	29							500-1000	14000			X		X			2358	1101	1096	1080
189			X		X	X		1270	1270		2974	2974	7							OVER 2000	18000	X			X				1201	1242	1241	1178
190			X		X	X		3842	3627		4395	4395	6							OVER 2000	26500		X		X	X			3296	2656	2256	1987
191		X			X	X		2486	2346		4443	4418	280							OVER 2000	26000	X	X	X	X				2222	2395	2369	1974
192	X				X	X		3046	2865		4534	4297	62							250-500			X	X	X	X		X		2868	2631	2457
193	X				X	X		2587	2264		4825	4750	250							250-500			X							2564	2557	2488
194		X			X	X		3032	2584		4875	4800	65							500-1000				X						3562	3332	1850
195			X		X	X		3500	3000	100	5300	5300	350							500-1000	26000	X	X	X						3600	3600	2967
196			X		X	X		2250	2200		5500	5350	120							OVER 2000	29000		X	X		X			2200	2300	2250	2250
197		X			X	X		4351	3764		5090	4896	30							250-500	30000		X	X		X				3353	3323	2998
200			X		X	X		4001	3501		6591	6591	47		X					OVER 2000	36000	X	X		X	X	X		2637	3234	3118	3081
202			X		X	X		3951	3451	75	6736	6736	408							1000-2000	35000		X	X	X	X			4491	4094	3933	3735
203		X			X	X		6492	6080		6902	6858	480		X					1000-2000	35000		X	X						4577	4575	4266
204			X		X	X		5769	5408		8022	7924	50							1000-2000	48300		X	X		X			4812	5472	5291	5276
205			X		X	X		5352	4502		9438	9158	75							OVER 2000	60000		X	X	X	X				4964	4908	4201
206		X			X	X		3800	3500		6000	6000	250							1000-2000	25000		X							2806	2551	2525
209		X			X	X		3000	2700		2440	2440	40							OVER 2000	15000		X	X	X	X	X		1830	3000	3000	3000
210		X			X	X	X	270	260		278	278	13	8				X		250-500	1000	X			X	X			403	48	47	45
211		X			X	X	X	272	260		455	455		16				X		250-500	2200	X	X		X	X				175	145	141
212		X			X	X	X	205	190		509	500	9	46				X		250-500	1250	X	X		X	X			407	160	124	119
213		X			X	X	X	400	350		626	626	58	25					X	500-1000	2435		X			X		X		391	388	384
214			X		X	X	X	437	412		630	630		150		X				OVER 2000	4300			X					313	229	219	196
215		X			X	X	X	353	303		693	693				X				1000-2000			X			X				333	315	311
216	X				X	X	X	983	926		762	588			X					1000-2000			X						381	870	590	590
217		X			X	X	X	446	401	15	873	863		140		X				1-100	4361	X	X	X	X	X				419	404	381

SAMPLE NO.	AGE IN YEARS 1-2	3-5	5+	OVER 5 WITH 3-5 LATER ADDITION	RETAIL	OFFICE	OTHER	PARKING SPACES IN CENTER AVAILABLE	IN CENTER CUSTOMER	EST OUTSIDE CENTER	FLOOR AREA (100'S SQ. FT.) GROSS LEASABLE	OCCUPIED GROSS LEASABLE	OFFICE	OTHER	OTHER USE MOVIE	REC	CIVIC	LIBRY	OTHER	METRO POP (1000'S)	ANNUAL SALES (1000'S)	CUSTOMER TYPE INCOME LOW	MID	UPP	INDUS	OFF	TRAVL	OTHER	EST PKG SPA REQ BY ZON ORD	CUSTOMER AND EMPLOYEE PARKING SPACE USED MAX DAY	2ND DAY	3RD DAY
220		X			X	X	X	474	429		1000	1000		70					X	OVER 2000	5700		X			X				387	384	322
221			X		X	X	X	587	521		1020	1008	12	140			X			250-500	5500		X	X	X	X				396	350	326
222			X		X	X	X	617	537		1060	1060			X					1000-2000	5500			X		X			505	598	582	580
223			X		X	X	X	670	584	22	1093	1078		41					X	500-1000	3299		X	X					765	613	611	606
224		X			X	X	X	566	526		1187	980		78					X	1000-2000		X			X				890	410	263	248
225	X				X	X	X	1251	1217		1260	1260		20		X				100-250	9000	X	X		X	X				903	890	856
226			X		X	X	X	869	741	50	1302	1302			X					100-250										907	907	840
227			X		X	X	X	725	650	30	1350	1339	22	18					X	1-100	7500	X	X		X	X			1000	613	572	554
228	X				X	X	X	996	910		1359	1343		210		X				1-100			X		X				1019	422	405	398
229			X		X	X	X	1700	1660		1455	1455	9	54					X	500-1000	7200		X			X			1091	543	514	493
230			X		X	X	X	1008	924	20	1497	1497	113	143		X				100-250	5212		X		X	X				1028	1028	1028
231				X	X	X	X	1772	1620		1666	1666	142	18					X	1000-2000	7800		X		X	X				1067	1060	1039
232			X		X	X	X	1645	1465		1685	1685	198	141		X				1-100	4524		X		X	X				1513	1475	1475
233		X			X	X	X	1693	1618		1867	1803		188		X				100-250	7700		X		X	X			1867	1490	1370	1322
240			X		X	X	X	1319	1138		2032	1900	221	190		X				1000-2000	8000		X		X	X			1712	1207	1050	851
241			X		X	X	X	2210	1650		2047	1875	350	371		X				250-500	20000		X						1535	2313	1998	1960
242		X			X	X	X	2252	1792		2053	2053	32		X					OVER 2000			X			X				1402	1252	1252
243	X				X	X	X	1368	1097		2100	2050	30	30			X			500-1000	15000		X	X		X	X		1050	1281	1157	1135
244			X		X	X	X	1533	1384	25	2180	2180	730		X					250-500			X	X		X				1558	1546	1544
245		X			X	X	X	1700	1500		2351	2277	85		X					500-1000	10000		X		X	X			2351	1553	1394	1288
246			X		X	X	X	1638	1241	37	2615	2505		28					X	500-1000	11900		X	X					2614	1589	1514	1483
247					X	X	X	1761	1507	10	2707	2681	166	392		X				250-500	9800	X	X	X	X	X			2030	1706	1701	1374
248			X		X	X	X	1632	1380		2714	2714	108		X					1-100	9124		X	X	X	X				1632	1632	1632
249		X			X	X	X	2500	2300		2020	2020		980		X			X	OVER 2000	9800		X		X	X			1515	2500	2500	2500
251			X		X	X	X	1654	1582		2985	2877	384	182		X				100-250	3109		X		X	X				1256	1209	1207
252			X		X	X	X	979	936		3044	2996	353	198		X				1000-2000	5291	X			X					936	830	810
253			X		X	X	X	2170	2020		3059	3059		344					X	OVER 2000	24000		X			X				1995	1985	1919
254	X				X	X	X	3000	2637		3458	3329			X					1000-2000	20000	X	X	X	X	X				2301	2243	2137
255			X		X	X	X	1972	1515		3475	3470	465		X					500-1000		X	X	X	X	X				1651	1638	1607
256			X		X	X	X	1965	1665	50	3500	3500	170		X					1000-2000	17000	X	X		X	X				1915	1847	1819
257			X		X	X	X	2316	2126		3500	3500	70	45			X			100-250	20000		X	X					4375	1759	1563	1383
258			X		X	X	X	937	737	100	3515	3515	295	173	X			X	X	OVER 2000	17479		X							1037	1037	1037
259			X		X	X	X	3600	3280		3839	3282	137	479					X	1000-2000	14144		X			X				1683	1648	1504
260	X				X	X	X	1800	1600	50	3846	3636	18	278		X	X	X	X	100-250	7000	X	X	X	X	X	X			1850	1802	1750
261			X		X	X	X	1200	994		2287	2287	291	181	X	X				1000-2000	4965		X		X	X				984	953	934
270			X		X	X	X	2275	2172		4030	4030			X					500-1000	29000		X	X	X	X			3023	2209	2143	1554
271			X		X	X	X	2181	1805		4207	4207	86	360		X	X			1000-2000			X	X	X	X			2875	1849	1731	1699
272			X		X	X	X	3132	2507		5231	5228	401	218		X				1-100	8316		X		X	X				3118	3110	3089
273		X			X	X	X	3143	2968		4306	4239		175						1000-2000	20000			X					2960	2769	2449	2109
274	X				X	X	X	3500	3250		4500	4446	17	24	X		X			1000-2000	20000		X			X			3375	2558	2520	2444
275	X				X	X	X	2184	1984		4566	4170	70				X			100-250			X			X				1989	1958	1686
276			X		X	X	X	2800	2644		4580	4580	70		X					1000-2000		X	X		X	X				2566	2464	2437
277			X		X	X	X	2825	2185		4597	4179				X			X	OVER 2000			X		X					2206	2200	1606
278			X		X	X	X	3675	3150		4722	4382	279	151	X	X				250-500	25000	X	X	X	X	X			1207	2994	2629	2585
279			X		X	X	X	4514	4244		4859	4859		402	X	X				OVER 2000	38000		X	X	X	X				4514	4514	4514
280			X		X	X	X	1792	1292		4901	4901	39	1132	X	X			X	1000-2000	20000		X			X			4067	2239	2161	2088
281		X			X	X	X	3813	3180		5000	5000	72	100	X		X	X		OVER 2000	21000		X						3750	2937	2924	2863
282			X		X	X	X	4313	3456		5326	5005			X					OVER 2000	30000		X	X	X	X			2663	3629	3570	3445
283		X			X	X	X	3097	3097		5620	5620	30	60			X			250-500	40000	X	X	X	X	X				3297	3256	3165
284			X		X	X	X	4500	3500		5750	5750			X					500-1000	30000	X	X	X	X	X	X		4313	4500	4500	4500
290			X		X	X	X	2675	1905		6000	6000	272		X					100-250	30000		X	X		X			2068	2523	2523	2461

SAMPLE NO.	AGE IN YEARS 1-2	AGE IN YEARS 3-5	AGE IN YEARS 5+	AGE IN YEARS OVER 5 3-5 WITH LATER ADDITION	RETAIL	OFFICE	OTHER	PARKING SPACES IN CENTER AVAILABLE	PARKING SPACES IN CENTER CUSTOMER	PARKING SPACES EST OUTSIDE CENTER	FLOOR AREA (100'S SQ. FT.) GROSS LEASABLE	FLOOR AREA OCCUPIED GROSS LEASABLE	FLOOR AREA OFFICE	FLOOR AREA OTHER	OTHER USE MOVIE	OTHER USE REC	OTHER USE CIVIC	OTHER USE L:R F~	OTHER USE OTHER	METRO POP (1000'S)	ANNUAL SALES (1000'S)	CUSTOMER TYPE INCOME LOW	CUSTOMER TYPE INCOME MID	CUSTOMER TYPE INCOME UP	CUSTOMER TYPE INDUS	CUSTOMER TYPE OFF	CUSTOMER TYPE TRAVEL	CUSTOMER TYPE OTHER	EST PKG SPA REQ BY ZONORD	CUSTOMER AND EMPLOYEE PARKING SPACE USED MAX DAY	2ND DAY	3RD DAY
291			X		X	X	X	4569	3754	100	6287	6251	20	10			X			OVER 2000	40000		X		X	X				4518	4497	4331
292			X		X	X	X	5000	4100		6731	6731	29	512		X			X	250-500	35C00		X		X				1683	4729	4715	4633
293			X		X	X	X	4750	4138		7500	7437	330	142	X				X	1000-20C0			X	X	X	X				4750	4625	4599
294		X			X	X	X	6C00	5521		7827	7827	102	471	X	X			X	OVER 2000	65000		X			X			7827	5497	5323	4394
295			X		X	X	X	4465	3956		7894	7894	500	200	X				X	1000-2000	42000		X		X	X				4132	3652	3506
297		X			X	X	X	6157	5157		9458	9358		275					X	OVER 2000	75000		X		X					6657	6607	6457
298		X			X	X	X	5600	5015		9487	8481	664	52			X			500-1000			X		X	X			4739	4273	4148	4038
299			X		X	X	X	6800	65C0		9500	8700	300		X					1000-2000		X	X	X	X	X	X			5143	5087	5046
300			X		X	X	X	6000	49C0		822C	8200	10		X					1000-2000	60000		X	X	X	X				6000	6000	6000
301			X		X	X	X	4267	3467		8494	8202	544	405	X	X	X			1000-2000	42500		X		X	X			4247	4673	4648	4206
310			X		X	X	X	8C00	6800		10105	10105	21		X					OVER 200C	6C150		X		X	X				7589	7514	6400
311	X				X	X	X	6615	6165		10812	10425	227	71	X		X			1000-2000	77500	X	X	X	X	X			5405	6505	6243	6238
312			X		X	X	X	514C	4740	990	11900	11898	3	7C0					X	OVER 200C	75000	X	X	X	X	X			4760	6130	5880	5695
313		X			X	X	X	5718	4C25		12500	12000	2250		X					1000-2000	7C000			X		X				5306	5289	5253
314		X			X	X	X	6784	6088		12540	12446	271	122		X				1000-2000	53000	X	X	X	X	X				6476	5588	4636

TOTAL RETAIL CNLY 116 TOTAL RETAIL + OFFICE 80 TOTAL RETAIL, OFFICE + OTHER 74

Discussion

A. JAMES BATES Barton-Aschman Associates--The shopping center parking index findings of Mr. Voorhees and Mrs. Crow are very welcome as a standard with which a designer or planner may compare his own recommendations. Data at my disposal for large, regional centers tend to confirm the authors' findings that 5. 5 stalls per 1,000 square feet of leasable retail space will accommodate all but the highest parking peaks.

I have never seen year-long data on daily accumulations or traffic movements. However, my observations which were gathered for specific problem analysis and are not directly comparable, one to another or to the authors' findings, bring me (along with the authors of this paper) to the tentative conclusion that the busiest four or five days of the year do occur within the twelve pre-Christmas days. Records of day-to-day sales volumes even more strongly support the dominance of the pre-Christmas shopping season. If one accepts the fact that a regional shopping center will use more than 5. 5 spaces per 1000 only during the pre-Christmas season, then some accumulation curves which were plotted from 1964 and 1965 Christmas seasons counts can be interpreted to support the contention that each 1000 feet of rented space would be only about ten customers a year better off for having 6. 5 rather than 5. 5 parking stalls. For a ½ million-sq ft center, this would mean that 500 additional stalls would accommodate 5000 extra customers.

It might be wise to provide these extra stalls. I was unable to define circumstances so stringent that it could conceivably cost more than $50 per year to provide a parking stall. The authors suggested a figure of $100. Furthermore, marginal stalls need not be as heavily constructed as those which receive daily usage, nor must they be lighted or kept free of snow after the Christmas season. Where these economies are invoked, and land costs and taxes are not excessive, it should be quite possible to own a marginal parking stall for $30 per year.

I do not know exactly what the authors mean by "the possible economic return on such money ($2.00-$3.00 per vehicle parking)." My records suggest that during peaks, other than the Christmas peak, the occupants of each car which is parked spend between $9 and $14. Even if Christmas shoppers do not spend more than other shoppers, there should be a gross mark-up of between $2.00 and $5.00 on the merchandise purchased by each carload of people during the Christmas peak. Because these are "extra" sales, it is realistic not to assign any fixed overhead to them. Therefore, almost the entire gross mark-up can be applied against stall ownership and the balance, if any, be considered profit.

Ten parked cars, each providing a gross mark-up of $2.00 to $5.00, certainly make it feasible to own a $30 per year stall. An interview study conducted concurrently with the authors' study suggested that a staggering $30 to $36 is being spent by Christmas shoppers from each parked car.

How much is a marginal stall worth to a shopping center? Those shopping centers which have ample supplies of parking appear more conspicuously successful than those which are inadequately supplied. I analyzed some of the authors' data in an effort to check out this impression. Those shopping centers in which only retail space was provided, and for which annual sales figures were given, were analyzed in two groups. For the first group, that in which the available parking was not filled, even at the highest observation, it was found that shopping centers which offered more than 5. 5 stalls per 1000 did an annual business of $56 per square foot. On the other hand, those which provided 5. 5 square feet or less, averaged only $44.

Similarly, for the second group, that in which the available parking was saturated during the peak, it was found that centers providing in excess of 5. 5 stalls per 1000 did a $66 annual business, while those providing 5. 5 or less did an annual business of only $60.

Did the provision of additional stalls cause the success or did the success prompt the provision of additional stalls? Perhaps all that can be inferred is that there is a correlation.

In any case, although 5. 5 stalls seem to cover most situations, I would be inclined to recommend the provision of 6 or 6. 5 stalls. After all, the developer who is looking at our recommendations is doing so in hopes of having a "better" shopping center. Why recommend nothing more than an "average" parking supply to him?

The authors categorically state that the parking index is independent of the size of the center. Intuitively I mistrust this. Limited observations suggest that the smaller centers (400,000 square feet and less) are more responsive to sales, special events, and other influences, and that they may hit peaks more frequently. If so, they would utilize a higher parking ratio advantageously.

My studies show that the smaller, convenience-oriented centers attract more cars proportionally per day than the larger ones, but that cars do not remain parked as long at the smaller centers. For instance, my data show that the average parking duration for regional shopping centers is something over 1½ hours. This suggests that the 1-hr average duration, found in the Cleveland-Mueller study, was influenced by a briefer parking period at the smaller centers.

Possibly, the shorter parking durations offset the greater relative automobile attraction of the smaller center and the number of cars parked per 1000 square feet at a given time is irrespective of center size. However, as turnover rates increase, a higher percentage of the total automobiles within the center is circulating in the aisles. For the center to operate safely and smoothly, there should be enough empty spaces available so that this higher proportion of cruising vehicles can come to rest relatively quickly. For this reason alone, a somewhat higher index of parking for the smaller center would appear advisable.

Whether or not 5. 5 stalls per 1000 is the right number, I do not recommend that parking, even for "ordinary" shopping centers, be estimated on a single, rigid index. The varying parking needs of the anticipated tenants should be considered. Among the shopping centers with which I am familiar, those that are more or less dominated by a store with higher prices and a fine quality reputation, seem to do very well financially on substantially fewer parked automobiles than do the centers which are dominated by merchants offering a more competitive line. The convenience center depends on an even greater, relative number of cars per day.

These traffic-generating characteristics of the various tenants proposed for a center should be taken into account and balanced against one another, not only for determining the total amount of parking, but also for distributing this parking about the center and for determining the locational and capacity requirements of the entrances and exits.

A pronounced example of a use which requires special consideration is the tire, battery, and accessory operation. With the reservoir space required for vehicles awaiting service, and for those left outside the service area to be picked up, a much higher parking index than 5. 5 becomes appropriate.

There is a recent trend in larger centers toward the establishment of a convenience goods cluster which is physically removed from the shopping goods area. Where this principle is being employed, a very careful analysis of the relative needs of the two sectors of the center is appropriate.

The authors' conclusions about the provisions of parking for office space (namely, that if the square footage of office space does not exceed 20 percent of the retail space, no special parking need be provided) seems to be applicable to only certain, limited situations.

The 2. 5 parking stalls per 1000 square feet which they recommend will suffice for certain types of decentralized office development; for instance, an insurance company home office. However, shopping center offices, appropriately, have a strong tendency to attract tenants such as doctors and dentists who serve the public directly. Clearly, 2. 5 parking stalls per 1000 square feet will not support a dentist's office on a Saturday afternoon when the usual six patients are in the waiting room. Unfortunately, at this time, his parking demands are in direct conflict with the retail merchant's weekly peak. Similarly, seasonal peaks may conflict; for instance, many school children have dental work done during Christmas vacation. If the general public is to be served, the parking requirements of these offices should be studied carefully.

In summary, it appears that an "ordinary" shopping center will work with 5. 5 stalls per 1000 square feet. Perhaps the authors' earlier recommendation of 7 stalls per 1000 for the first 200,000, and 5. 5 for the balance, better recognizes the special problems of the smaller center.

Some questions still to be answered are these:

1. What is a parked car worth to a merchant during the pre-Christmas peak?
2. Shouldn't our recommendations follow the experience of the successful rather than the average operator?
3. Shouldn't we seek a set of factors which accounts for the differences between centers rather than a standard for all centers?

HENRY K. EVANS, Wilbur Smith and Associates—Mr. Voorhees' conclusion concerning a past tendency to provide too much shopping center parking in many instances is sound, I believe. However a great deal of caution is necessary in using the simple rule of thumb figure he has proposed--5. 5 spaces--and I am sure he will agree on this.

For example, the 115 figures for third-highest day parking (tenth-highest hour) in Appendix C, exhibit a variation between 1. 6 and 10. 8 spaces per 1,000 sq ft and only 29 of the 115 fall between 5 and 6. (Mr. Voorhees' explanation in the Urban Land Institute Bulletin is that "the so-called 'third-highest day' and the 'tenth-highest hour' are approximately equivalent." Thus, it appears that the "3rd day" column shown in Appendix C indicates approximately the tenth-highest hour.) The great majority (74 percent) of the cases average between 3 and 6, with an overall average close to 5. 0. I assume an allocation added as a reserve to enable free movement, as mentioned in the paper, brings the figure up to 5. 5.

This points up the need to evaluate each center according to its own requirements, as it may actually require parking considerably above or below the norm.

The findings shown in Figure 3 of the Urban Land Institute Technical Bulletin 53 version of Voorhees' paper would seem to suggest that if the entire sample had been taken from shopping centers with space ratios of 8. 8 or better, the tenth highest hour would have been higher than that actually found in the study. It is almost as if there were a capacity restraint working on the two lower curves. If all 103 shopping centers had offered unlimited parking, I feel there is a strong likelihood the tenth highest hour would have been at 6. 2 or higher. Perhaps we should be guided more by such an uninhibited assignment of demand which would argue for a ratio higher than 5. 5. More research among centers with space ratios of 10 or more would help answer this question.

As we well know, no two department stores, or banks, or offices generate traffic alike. I would like to refer to a roundup of actual parking demand ratios which I made recently. This appeared in the April 1963 issue of the Eno Foundation Traffic Quarterly with the title "Parking Study Applications." The figures demonstrate clearly the large range of demand ratios. For example, 19 banks' space requirements ranged between a low of 1. 8 and a high of 10. 8 spaces per 1,000 sq ft. Nineteen retail stores we studied showed a smaller range—1. 4 to 5. 1—but still a substantial variation. (These are normal demands, not seasonal peaks.) In planning a given shopping center, separate factors have to be applied to each different building type, employing judgment of course as to whether the figure would be on the low, middle, or high end of the range for any particular building category. I would agree with Mr. Voorhees' rule of thumb index of 2. 5 for offices in general, but in a particular case this may be considerably low, or high, as he has pointed out. The 20 percent additional office usage may or may not be added without noticeable increase in parking demand. At the 2. 5 ratio, the 20 percent office space would bring demand on weekdays up to the tenth highest hour level, according to Voorhees' paper but, not being open on Saturdays, would not add to the retail peaks on Saturdays before Christmas. But a bank, medical center, post office, or some other office use with high generation potential would not fall under this case, and additional parking would certainly be required.

The point is well made that special circumstances will modify parking needs and it is stated that parking requirements are reduced by as much as two-thirds in a central city area where mass transportation and walk-in trade exist. This sounds somewhat extreme, when applied to the recommended 5. 5 index, as this would reduce the design index to 1.8. I can report on a recent study of ours revealing how important the transit and walk-in trade are to an urban center in San Francisco, Calif. The Stonestown center, with 59 stores including the Emporium, City of Paris, a large supermarket, restaurant, post office, beauty parlor, bank, automotive outlet, and five-floor medical-dental office building, totaling 1,040,000 sq ft of floor area, has 3,349 parking stalls. It is well served by a street-car line and two bus companies, and is surrounded by residential apartment buildings. Of all entering persons, 7 percent come by transit and 7 percent walk. The peak parking demand of 2.3 spaces occupied per 1,000 sq ft, which occurred on a Saturday, would have been raised only to 2.7 if all pedestrians and transit riders had used autos instead. Or to put it another way, the effect of walk-in and transit is to reduce parking requirements by only 11 percent at this center.

Mr. Voorhees' paper brings to mind a problem we encounter regularly in making business district parking needs studies. I refer now to the problem of estimating peak demands, or "design demand" figures on the basis of parking studies taken in off-peak seasons. If we find a demand for, say, "X" parking spaces during a study in May of the year, and relate that to capacity "Y" to obtain a deficiency "D," this obviously understates the parking deficiency for some other times of the year, notably Christmas. I have frequently employed historical parking meter revenue data to assist in adjusting a particular month's demand to the peak month, or perhaps the eleventh highest month. This method is admittedly rather unsure, since we do not know for a fact that peak parking accumulations are proportional to parking revenues. In a special study on shopping centers by LARTS ("Preliminary Results 1961 Shopping Center Study—Los Angeles Regional Transportation Study," prepared by California Division of Highways) the variation in retail sales was suggested as a possible means of handling this problem.

For the six centers they studied, the peak month, December, represented 17.6 percent of the total year's total, or slightly over double the average month. Further research work is suggested, perhaps in correlating systematic traffic volume counts from fixed counters with parking demand for a given business district.

It would be desirable to see some further correlations made with the data assembled for the subject paper. How does the tenth highest hour compare with the average annual demand? How does the parking index relate to customer income class, and to annual sales per unit area (it appears logical that there would be a positive correlation)?

And finally, more consideration might well be given to exploring demand ratios where no capacity restraint exists.

ALAN M. VOORHEES and CAROLYN E. CROW, Closure--The authors are in general agreement with the point made by both discussants that unique shopping center characteristics must be considered in determining how many parking spaces a particular shopping center should provide. However, it seems to us that selection of a single standard for parking requirements for all shopping centers is desirable even though it has limitations. Municipalities are presently using such standards in their zoning ordinances, although most of those in use are poorly substantiated and not based on empirical research. It is far better to have a standard based on relationships between parking demands and retail floor area, which have been observed at a broad sampling of shopping centers, recognizing at the same time that there are shopping centers which differ from the "average" center and that there are unique situations which must be provided for.

We explored the possibilities of developing techniques which could be used to modify the basic parking requirements, but found that there were too many variables involved to quantify all of these in light of the data we had obtained. Therefore, in the section on Special Circumstances Modifying Parking Requirements, we have attempted to outline the kinds of factors that create different parking requirements at shopping centers and to give some guidelines regarding the effects of these factors.

The discussants expected that a shopping center's size and the nature of its office activities would influence its parking requirements. Our findings are more explicitly mentioned in this draft of the text than in the earlier drafts seen by the discussants.

As was indicated by the discussants, it was quite clear that the capacity of the lot had some influence on shopping center usage and, therefore, had some influence on parking demand. However, as shown by Figure 4, this impact was greatest at the highest hours of the year, while the parking demands were quite similar at the tenth-highest hour and very comparable at the thirtieth-highest hour, regardless of the capacity of the lot. As described, the economic return for providing a large amount of extra parking certainly is not justified.

A Model of the Maximum Generation of Traffic to Planned Shopping Centers

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•IN STUDIES of people and their behavior the investigator is often faced with the problem of evaluating the myriad variables and factors which, when taken together, account for much of the observed variation in behavior but which individually account for little. The study of shopping center generation reported in this paper is a case in point. Many factors influence the shopping trip behavior of persons and families. Within the market area, consideration must be given to such types of variables as, for instance, household-descriptive factors, including residential density, family income, family size and composition, and level of auto ownership. Factors based on the transportation system include distance and travel times to various shopping places, the availability of public transit, and the amount of traffic congestion. For the class of variables relating to the shopping center itself, there are the number and sizes of stores in the center, the amount of parking available, the type and cost of goods sold, the quality of service, etc.

Yet, even if all the significant variables could be identified and measured, the problem of determining their separate and joint effects on demand would remain. Taken together, these two considerations imply the need for a greatly expanded storehouse of information, to say nothing of the additional effort needed to analyze and evaluate such data.

When considering the interrelatedness of effects, a third problem presents itself. The factors which have been considered so far have only been associated with the dependent variable, generation, yet generation in itself is not disassociated with other parts of the urban planning process. The way in which future trips from the home are distributed, for example, determines the future attraction of nonresidential land uses and, furthermore, the future systems built to serve this demand will themselves affect the number of trips made. Thus, it seems unwise to consider generation without evaluating the system effects.

All transportation studies have had to face these three perplexing problems in order to produce models which would be of value in estimating future travel. Moreover, limitations of time, money, and personnel have often retarded progress toward obtaining adequate solutions. Individual research projects have also been constrained by the same circumstances. To make matters worse, each study and project has usually changed in some manner the definitional base on which the examination of travel is established.

A few examples may help to emphasize the points suggested above. In the six centers studied by LARTS (9), vehicle trips per day per gross acre of center varied from 132 to 545 with an average of 296; vehicle trips per day per square foot of floor space varied from 0.009 to 0.046 with an average of 0.023; and vehicle trips per day per employee varied from 6.8 to 36.7 with an average of 16.9. In another study, Harding (8) found similar variations in daily vehicle trips per gross acre with rates ranging from 263 to 794 trips. Using an "average" rate for any of these three variables of attraction might result in a discrepancy of more than one-half the average in either direction. An over- or underestimation of such magnitude might well produce serious distortions in planning local and regional transportation facilities. Yet, if, in order to be on the "safe" side,

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the maximum observed value of daily generation is used, the actual value could be as little as ⅓ of this maximum number. Overestimation might then lead to significant diseconomies in the system planned to serve a given shopping center. To add to these difficulties there is considerable disagreement among planners and engineers as to the extent to which these variables can be adequately estimated for use in the determination of future shopping center attraction.

In summary, it may be said that some kind of model is needed for furnishing information on centers which have not yet been built, but which are known to be needed in the future. The generation of present-day centers can be found simply by observation, but little is known about these future centers except, perhaps, their locations and probable sizes. It is the job of the transportation planner to estimate future traffic to these centers so that their influence on the transportation system can be measured.

PURPOSE OF THE MODEL

The model discussed herein represents an attempt to overcome or avoid some of the major difficulties outlined in the preceding paragraphs. It has the property that the more information that is known concerning the nature of a particular center, the more accurate will be the forecast of traffic attracted to that center. Yet the model can provide estimates with as little information as just the gross size of the shopping center plot. A second property of the model is that it provides estimates which will almost always be on the high side—i.e., the planner can assume that, in practically every case, the actual generation of a center will not be greater than the predicted generation. This last statement implies, in a sense, that the model predicts some measure of the maximum possible generation of a given plot.

The mechanism which allows results from such simple inputs is the use of the trips/sales ratio. To start with, it seems reasonable that total sales of a center is a logical indicator of the environment in which the center is placed. If there is high density of residential development near the center, all other factors being constant, there should be higher sales at the center. If transportation is readily available to the center, all other factors being constant, there should be higher sales at the center. And if the management of the center is extremely adept, all other factors being constant, there should be higher sales. Therefore, if a hypothetical center were to be created which would combine the highest sales of each type of store found in actual centers across the United States, this center would represent some unknown yet optimal combination of all the factors which influence sales.

The next step in estimating the maximum potential generation of centers is to translate the optimal combination of sales factors into an expected maximum trip potential. This step is accomplished through the trips/sales ratio. (The trips per sales ratio used in this study were derived from data reported in (1).) Although there is considerable variation in the ratio of trips to sales from one center to another, a figure two standard deviations above the mean (assuming normality) would include 97.5 percent of all possible variations of trips over sales and could therefore be used to transform sales to trips and still be on the "safe" side. Thus, the optimum in terms of sales would tend to be optimum for trips.

The resultant generation figure for a given center could then be calculated through the use of the trips/sales ratio. The area of those particular stores which have the highest sales added to the area needed to park the vehicles generated by these stores (calculated with the help of the trips/sales ratio) should sum to the total area of plot on which the center is located. The resulting generation figure would then be safely on the high side, yet not unreasonably high.

PRESENTATION OF THE MODEL

The model may be set up in linear programming format as follows:

maximize

$$T_{VA} = ca\left(\frac{1-t-w}{v}\right) \sum_{i=1}^{n} S_i A_i + e$$

subject to

$$l_i \leq A_i \leq h_i$$

$$\sum_{i=1}^{n} A_i/\sigma_i + \alpha_1 \, dac \left(\frac{1-t-w}{v}\right) \sum_{i=1}^{n} S_i A_i + \alpha_2 e \leq L$$

and delivery trips

$$T_{VT} = f_1 \sum_{i=1}^{n} A_i \text{ or } f_2 \sum_{i=1}^{n} A_i$$

where

L = gross area of center;
α_1 = area of parking needed per vehicle to be parked (this figure also includes the area needed for aisles, access roads, malls, truck zones, etc., per vehicle);
α_2 = area of parking needed per vehicle (for the e vehicles);
A_i = gross leasable area of business i;
σ_i = average number of floors on which business i operates;
T_{VA} = automobile vehicle trips per time period;
T_{VT} = truck vehicle trips per time period;
S_i = sales per unit gross leasable area of business i ;
a = person trips per total center sales;
T_p = person trips per time period;
t = percent of persons coming by public transportation per time period;
w = percent of persons coming by foot per time period;
v - car loading factor—persons per auto vehicle;
c = ratio of maximum trips to average trips per time period;
d = coefficient of accumulation of vehicles in parking lot;
e = constant of accumulation of vehicles in parking lot;
n = number of business types;
f_1 = ratio of truck trips to gross leasable area per time period for centers without supermarkets;
f_2 = ratio of truck trips to gross leasable area per time period for centers with supermarkets;
l_i = lower limit on gross leasable area for business i;
h_i = higher limit on gross leasable area for business i; and
G = total ground floor area.

The criterion function (max T_{VA}) can be explained in the following manner: The S_i are the sales per unit area of a given business. Multiplying the sales per unit area by the area of each type of business and summing over all the business in the center gives the total sales of the center. Multiplying this resultant number by the person trips per sales ratio yields the number of person trips per period. Assuming the percentage of persons walking and coming by public transit to be negligible (in order to obtain the maximum vehicle trips) and dividing the number of person trips by the number of persons per vehicle gives the number of vehicle trips (automobile) per time period. The function is not complete, however, until the ratio of maximum to average trips has been considered. This requirement is taken into account by use of the c ratio. Thus, the final figure is the maximum number of vehicle trips per time period.

The first two constraints are fairly direct—the areas of the stores of various businesses cannot be lower than a certain value or higher than another value. For instance, a supermarket in a neighborhood center is practically never less than 5280 square feet or more than 21,420 square feet. These constraints might be called technological limitations, that is to say that operation of a supermarket of dimensions outside of the range given would probably be infeasible either because the area would be too small for proper marketing of goods or would be too large to control and manage economically.

The third constraint refers to the total area of the center. By definition, the ground area taken up for parking and that used for stores cannot be greater than that area set aside by the planner for the center. The first term on the left of the inequality is the representation of the total ground floor area occupied by the buildings. The second and third terms are the parking requirements. Note that the terms from the criterion function

$$T_{VA} = ca \frac{1-t-w}{v} \sum_{i=1}^{n} S_i A_i + e$$

are included in the second term, which can be reduced to $\alpha_1 d\, T_{VA} + \alpha_2 e$. Multiplying the vehicle trips to the center by the ratio of accumulated cars to entering cars gives the total number of cars accumulated in the parking lots, These are the cars which must be parked, taking up space α_1 per vehicle. The $\alpha_2 e$ term is an adjustment made to the regression equation constant e. The significance of this adjustment is discussed in the following.

The final equation, the one for delivery trips, is simply the product of the empirical coefficients found by Gruen and Smith (7) and the gross leasable area. It was felt that this single product was sufficient to explain delivery trips since these trips represent such a small portion of the total number of trips.

VALUES FOR THE CONSTANTS AND COEFFICIENTS IN THE MODEL

The values used for the constants and coefficients in the model are presented in Table 1 along with the reference numbers of the sources from which they were obtained. It should be noted here that the values which are used have been selected so as to produce the greatest amount of generation. For example, the α_s value (see Table 1 for definition of α_s) of 275 sq ft/veh was found in reference (3) to be the lowest value for the parking space required by one vehicle. The use of the lowest parking space per vehicle means that, for a center of a given size, more cars can be parked and thus the calculated generation rate can be higher.

The e value requires some special explanation. Cleveland and Mueller (4) found that the accumulation of vehicles in a shopping center parking lot is highly correlated with the number of entering vehicles (generated trips in the model). The r value is 0.87. The least squares regression line corresponding to this relationship is $dT_{VA} + e$ or $0.193T_{VA} + 500$. Therefore, the use of e.

One other aspect of the model needs mentioning at this point. Some businesses, despite their lower sales per square feet, appeared in almost every actual center. It was felt that these businesses should definitely be included in the theoretical centers. To accomplish this in the model, it was necessary to set the lower floor area values of all unnecessary businesses to zero, while leaving the corresponding numbers for the necessary business at their previous level. The error in calculations caused by such a procedure would seem to be slight.

A SIMPLER COMPUTATIONAL TECHNIQUE

A hand-workable method has been developed which approximates the linear programming model previously discussed. The computing technique is as follows (for both neighborhood and community combined with regional subclasses):

1. Calculate $ca/v = 4.53\,(1.15 \text{ or } 0.68)/1.90 = (2.75 \text{ or } 1.62)$. Note that $t, w = 0$ for maximum vehicle generation.

TABLE 1

LIMITS ON FLOOR AREAS, SALES, AVERAGE FLOORS PER STORE, AND RANKING OF SALES FOR S. I. C. BUSINESS TYPES (13)

Business S. I. C. [a]	Lower Floor Area Limit, Neigh. Centers (× 10^3ft^2)	Higher Floor Area Limit, Neigh. Centers (× 10^3ft^2)	Lower Floor Area Limit, Comm. Centers (× 10^3ft^2)	Higher Floor Area Limit, Comm. Centers (× 10^3ft^2)	Lower Floor Area Limit, Regional Centers (× 10^3ft^2)	Higher Floor Area Limit, Regional Centers (× 10^3ft^2)	Yearly Sales in Dollars per Sq Ft		Avg. Floor per Store of Business	Rank of Business Acc. to Avg. Sales	Rank of Business Acc. to Max. Sales
							Avg.	Max.			
i	l_{hi}	h_{ni}	l_{ci}	h_{ci}	l_{ri}	h_{ri}	S_{ai}	S_{hi}	σ_i	U_{ai}	U_{hi}
1. 5231	00.00	024.94	00.00	024.94	00.33	024.94	033	067	1	37	38
2. 5311	00.00	022.00	10.16	058.50	73.45	999.90	055	100	3	15	22
3. 5331	00.00	021.42	03.84	029.25	01.04	091.36	034	093	1	36	29
4. 5392	00.00	010.00	00.00	010.00	00.00	010.00	032	092	1	38	30
5. 5411	05.20	043.07	04.40	047.20	08.05	050.63	102	190	1	3	2
6. 5422	00.00	004.89	00.00	004.89	00.44	009.78	075	161	1	5	4
7. 5441	00.00	004.20	00.00	004.20	00.50	004.20	054	104	1	16	18
8. 5462	00.00	006.05	00.00	006.05	00.00	006.05	051	143	1	19	9
9. 5499	00.00	006.35	00.00	006.35	00.00	006.35	063	121	1	10	14
10. 5531	00.00	011.70	00.00	011.70	00.00	011.70	037	068	1	33	37
11. 5541	00.00	020.00	00.00	020.00	00.00	020.00	041	094	1	29	28
12. 5612	00.00	004.05	00.15	012.96	00.42	047.68	059	154	1	11	7
13. 5621	00.00	022.50	01.02	036.32	00.64	144.20	048	128	1	22	11
14. 5631	00.00	015.91	00.24	015.91	00.24	047.73	052	103	1	18	19
15. 5641	00.00	003.15	00.00	004.23	00.79	008.59	040	098	1	30	24
16. 5651	00.00	004.41	00.00	027.90	00.00	027.63	045	075	1	25	35
17. 5662	00.00	003.38	01.32	006.30	00.90	027.00	046	101	1	24	21
18. 5712	00.00	004.03	00.00	021.15	00.00	036.15	026	046	1	42	42
19. 5713	00.00	007.12	00.00	007.12	00.00	007.12	049	097	1	21	25
20. 5719	00.00	003.75	00.00	003.75	00.00	003.75	031	091	1	39	31
21. 5722	00.00	007.51	00.00	007.51	00.00	007.51	065	109	1	8	17
22. 5732	00.00	011.50	00.00	011.50	00.63	011.50	058	118	1	12	15
23. 5812	00.00	008.20	01.20	018.40	01.30	084.00	056	117	1	14	16
24. 5813	00.00	002.79	00.00	002.79	00.00	002.79	053	083	1	17	32
25. 5912	01.28	012.83	01.38	021.06	00.90	044.24	057	122	1	13	13
26. 5921	00.00	007.20	00.00	007.20	00.00	007.20	106	176	1	2	3
27. 5942	00.00	007.10	00.00	007.10	00.00	007.10	043	082	1	27	33
28. 5952	00.00	012.10	00.00	012.10	00.00	012.10	047	074	1	23	36
29. 5971	00.00	002.48	00.00	003.40	00.40	013.28	071	158	1	6	5
30. 5992	00.00	003.96	00.00	003.96	00.00	003.96	035	048	1	35	41
31. 5993	00.00	002.16	00.00	002.16	00.00	002.16	117	151	1	1	8
32. 5996	00.00	002.75	00.00	002.75	00.00	002.75	064	127	1	9	12
33. 5997	00.00	006.15	00.25	006.15	00.25	012.30	039	134	1	31	10
34. 5999	00.00	009.18	00.00	009.18	00.00	009.18	082	198	1	4	1
35. 6000	00.00	009.72	00.40	009.72	00.40	019.44	070	157	1	77	6
36. 6400	00.00	003.56	00.00	003.56	00.00	003.56	042	081	1	28	34
37. 0000	00.00	036.00	00.10	108.00	00.10	216.00	030	095	3	40	27
38. 7211	00.20	007.78	00.20	007.78	00.20	007.78	028	056	1	41	40
39. 7215	00.00	004.50	00.00	004.50	00.00	004.50	015	023	1	44	44
40. 7221	00.00	002.28	00.00	002.28	00.00	002.28	036	063	1	34	39
41. 7231	00.20	011.88	00.20	011.88	00.20	011.88	044	096	1	26	26
42. 7251	00.00	002.15	00.00	002.15	00.00	002.15	038	102	1	32	20
43. 7830	00.00	013.50	00.00	013.50	00.00	013.50	050	099	1	20	23
44. 7911	00.00	002.83	00.00	002.83	09.00	002.83	018	034	1	43	43
45. 7931	00.00	052.20	00.00	052.20	00.00	052.20	010	018	1	45	45

[a]See Appendix A for Standard Industrial Classification of Commercial business types.

Note: α_L = 325 ft^2/veh (3)
α_s = 275 ft^2/veh (3)
α_2 = 144 ft^2/veh (4)
c = 4.53 (10th highest hour) (4)
e = 500 veh(4)
d = 0.193
t = 0
W = 0
v = 1.90 persons/veh
a_L = 0.68 mean ± 0.40 (1)
a_s = 1.15 mean = 0.59 (1)
Rank-correlation of Average Sales & Maximum Sales Rankings = 0.79

Subscripts: n = neighborhood
c = community
r = regional
L = community & regional
a = avg. figure
h = max. figure
i = particular bus. type
s = neighborhood

TABLE 2

VALUES FROM ALGORITHM FOR NEIGHBORHOOD CENTERS USING MAXIMUM SALES FIGURES

①	②	③	④	⑤	⑥	⑦	⑧
Business added	$\sum_i A_i/\sigma_i$	$\sum_i A_i S_i$	146.2 × ③	72,000 + ② + ④	500 + 2.75 × ③	⑤/43,560	⑥/⑦
	Total ground flr area (× 10^3 ft^2)	Total center sales ($)	Parking area needed (ft^2)	Total area of center (ft^2)	Generation (cars)	Gross acreage of center	Generation rate (cars/acre per day)
Necessary businesses	6.96	1,139.7	173,934	252,894	3,270	5.80	650
	+9.18	1,817.6					
	16.14	3,007.3	439,667	527,807	8,775	12.11	722
+ 5999	+43.07						
	- 5.28						
+ 5411	53.93	11,139.3	1,628,565	1,754,495	31,150	40.27	763

2. Calculate α_1 dca/v = (275 or 325) (0.193) (4.53) (1.15 or 68)/1.90 = (142.6 or 101.8).
3. Caluculate α_2e = (144 or 275) (500) = 72,000 sq ft or 162,500 sq ft.
4. Introduce the business that must occur in a center into the model along with their minimum floor areas. The minimum areas are used since these businesses are not necessarily the ones with the highest sales (and thus generation).
5. Find the ground floor area requirements for these businesses, G = $\Sigma A_i/\sigma_i$.
6. Find the total sales of the centers = $\Sigma\ A_iS_i$, i = necessary businesses.
7. Find the area needed for parking, P = (142.6 or 101.8)($\Sigma\ A_iS_i$) + (72,000 or 162,00).
8. Find the total area of the center, L = (G + P) /43,560. L in acres.
9. Find the generation, T_{VA} = (2.75 or 1.62) (ΣA_iS_i) + 500. i = necessary businesses.
10. Calculate the vehicle trips/acre = T_{VA}/L.

This procedure will usually yield an L value close to the minimum for that class of center under consideration. To derive generation rates for other center sizes, add stores in the following manner:

11. Take the business with the highest sales per square feet and put it in the model along with its maximum floor area.
12. Return to steps 5 to 10 to calculate the generation rate. Note that if the store with the highest sales per square feet is also one of the stores that is a necessary store in the center, then the A_iS_i value in the original calculation must be subtracted. The i index for this process now covers the necessary stores and the added one.
13. Continue to add businesses according to their sales rank, taking the highest ones first, subtracting the previous A_iS_i where necessary.
14. Find the generation rate for any size center (any L value) by referring to a graph formed by a smooth curve through the points of acreage and generation rates corresponding to the use of the maximum floor areas of given businesses in the model.

EXAMPLE SOLUTION

The following example illustrates the foregoing procedure: (See Table 2): The attempt here is to create a hypothetical neighborhood center which has the highest generation. First, the constants must be calculated.

$$\frac{ca}{v} = \frac{(4.53)\,(1.15)}{1.90} = 2.75$$

$$\frac{\alpha_1 dca}{v} - \frac{275\ (0.193)\ (4.53)\ (1.15)}{1.90} = 142.6$$

$$\alpha_2 e = 144\ (500) = 72,000 \text{ sq ft}$$

Examination of Table 1 reveals that four businesses have lower limits on their floor area (ln_i) and therefore must be included in the center. They are 5411 (supermarket), 5912 (drug store), 7211 (laundry), and 7231 (barber or beauty shop). These businesses are entered into the model with their lower floor areas since these stores are not necessarily the ones with the highest sales/sq ft. (Yet, despite their lower sales, they seem to be necessary to draw customers to the center.)

The total sales for this group is

$$\sum_{i=1}^{4} A_i S_i = (5.28)\ (190) + 1.28\ (122) + 0.20\ (56) + 0.20\ (96) = 1.1897\ 10^6 \text{ dollars}$$

The ground area requirements are

$$G = \sum_{i=1}^{4} A_i/\sigma_i = \frac{5.28}{1} + \frac{1.28}{1} + \frac{0.20}{1} + \frac{0.20}{1} = 6.96 \text{ thousand sq ft}$$

Tho area needed for parking is

$$P = \frac{\alpha_1 dca}{v} \sum_{i=1}^{4} A_i S_i + \alpha_2 e = 142.6\ (1189.7) + 72,000 = 173,934 + 72,000 \text{ sq ft}$$

This makes the total area needed as

$$G + P = L = 173,934 + 72,000 + 6960 = 252,894 \text{ sq ft or } 5.80 \text{ acres}$$

The generation is

$$T_{VA} = \frac{ca}{v} \sum_{i=1}^{4} A_i S_i + e = 2.75\ (1189.7) + 500 = 3270 \text{ cars}$$

This makes the generation rate of 3270 cars/5.80 acres or 650 cars/gross acre.

Now assume that the generation rate was desired for a plot greater than 5.80 acres. The next store added would be for that business which has the greatest sales/sq ft figure which, in this case, is a miscellaneous retail store (5999) (for example, a trading stamp redemption store). Including this store in the model adds (see Table 1) 9180/1 or 9.18 thousand sq ft to the ground floor area and 9.18 (198) or 1817.6 thousand dollars to the total center sales, thereby causing a total area need of: 6960 + 9180 +(146.2) (1189.7 + 1817.6) + 72,000 = 6960 + 9180 + 439,667 + 72,000 = 527,807 sq ft or 12.11 acres.

The corresponding generation is 2.75 (1189.7 + 1817.6) = 8275 cars.

This makes the generation rate 8275/12.11 = 722 cars/acre.

Note that a 10-acre limit set on the size of neighborhood centers has already been exceeded, so that calculations could stop here, but the addition of another store would help illustrate the problem of subtraction mentioned before.

The business with the next highest sales/sq ft is the supermarket (5411). Notice that a supermarket has already been included as one of the necessary stores so that if it is included again, this time at its maximum floor area, the minimum floor area will be counted twice. To rectify this error, one need only subtract the minimum floor area from the calculations

$$\sum_{i=1}^{5} A_i/\sigma_i = \frac{5.28}{1} + \frac{1.28}{1} + \frac{0.20}{1} + \frac{0.20}{1} +$$

$$\frac{9.18}{1} + \frac{43.07}{1} - \frac{5.28}{1} = 53.93 = 53,930 \text{ sq ft}$$

The total sales for the center is

$$\sum_{i=1}^{5} A_i S_i = (5.28)(190) + 1.28(122) + 0.20(56) + 0.20(96) +$$

$$9.18(198) + 43.07(190) - 5.28(190) = 1.1139 \times 10^7 \text{ dollars}$$

Now multiplying by the constants, the resulting generation rate is

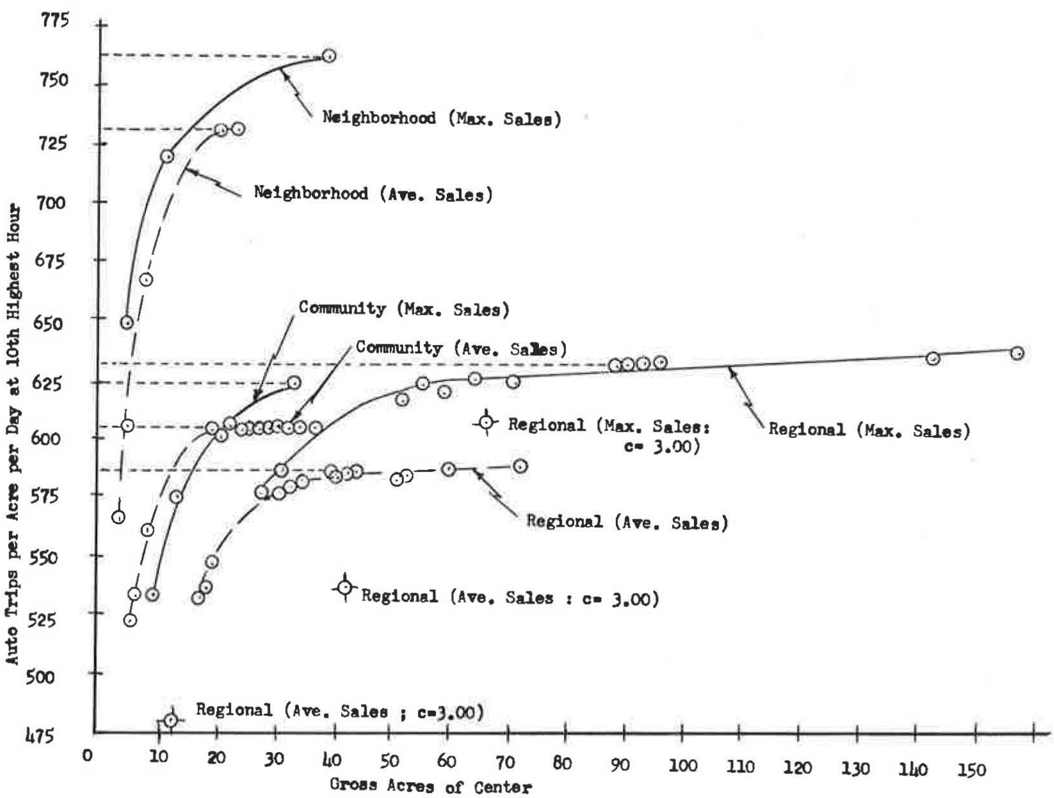

Figure 1. Auto trips generated per acre per day for 10th highest hour for shopping centers of various classes and sizes.

$$763 \; \frac{\text{auto trips}}{\text{gross acre}} \text{ for an area of 40.27 acres}$$

As a final exercise, suppose that the generation rate for a center located on a plot of 9.00 acres is desired. Entering Figure 1, which is a plot of all the results obtained through the model, it is possible to determine the generation rate for any size center. For the case of the 9.00-acre center, an approximate maximum generation rate of 690 cars/gross acre is obtained.

RESULTS

The generation or attraction rates which were obtained from the evaluation of the model are presented graphically in Figure 1. The points plotted represent that stage in the calculations where the maximum area of a given store was absorbed into the center. There are two curves for each class of center, one based on the assumption that all businesses are selling at rates close to their maximum potential, and the other based on the assumption that selling is only at the average rate. There are also a few other example points which indicate the sensitivity of generation rates to the lowering of highest hourly attraction, i.e., if the c value is lowered from 4.53 for the 10th highest hour in the year to 3.00 for the 50th highest hour.

Attention is directed to the shape of the resulting curves. Apparently the curves rise steeply in the beginning because of the influence of the businesses which have been forcefully included because of their presence in almost all actual centers. These businesses do not necessarily have the highest sales. Eventually the influence of their less-than-highest sales is overcome and the curves flatten out. It would seem wise that, in order to use the results of this study, these beginning influences should be neglected, and the model generation values should be obtained by proceeding vertically from the point on the abscissa representing the size of the land plot of the center until the dotted extension line is reached. The ordinate value corresponding to this intersection would then be the desired generation figure.

CONCLUSIONS

On the basis of the model, the maximum expected generation rates for three classes of planned centers of various sizes can be calculated. It should be stressed at this point that, if the only information available is the size of the proposed center, all that is required is to enter Figure 1 in order to obtain an estimate of a reasonable maximum value for the generation of the center. It should be kept in mind that these estimates are based on combinations of factors selected in such a manner as to produce maximal

TABLE 3

Parameters Used in Model	Value Assumed in Simple Maximal Model
Type of store	The store types which have the highest sales plus those commonly found in all centers
Size of store	The greatest floor area for highest sales stores The least floor area for commonly found stores
Sales of store type	Highest sales per square foot
Person trips/sales	Two standard deviations above mean $A_{\Gamma} = 0.68$, $A_S = 1.15$
Car loading factor	A low value 1.90 persons/vehicle
Peak vs average number of trips	Tenth highest hour 4.53
Accumulated vs generated vehicles	Regression line
Parking area per vehicle	A low value $\alpha_L = 325$ ft^2/veh, $\alpha_S = 275$ ft^2/veh
Average number of floors per store type	Assumed equal to one for most all types

generation figures. Examination of Table 3 will reveal, for example, that the lowest value of parking space per vehicle was used so that more cars could be squeezed into the available parking area.

The simple approach is suggested when only the area of the future center is known. If additional information becomes available, the more detailed approach outlined in the sample problem can be used with appropriate values for the known variables in order to achieve a more accurate (and probably lower) value for the expected generation rate. For example, if the actual types of stores and corresponding floor areas were known for a center soon to be placed in operation, these values could be used directly in the detailed technique to obtain a more accurate rate. (In this case, the known businesses would be assigned their highest sales figures along with the higher values of trips/sale and peak to average ratios.) In another case, it might be known that the future owner does not wish to plan for the 10th highest hour but for the 50th instead. Again, this could be incorporated into the procedure by lowering the peak to average ratio from 4.53 to 3.00. The results of such a policy would then be incorporated into the model program.

The advantage of the model (and algorithm), then, is that the more information that is available to the planner, the more he can narrow his calculations toward a reasonable generation rate. Yet, he is assured that his resultant value for generation will be on the high side of the actual value except under the most improbable circumstances. If no information other than plot size is known, the maximum limit presented in Figure 1 can be used.

Added to this advantage is simplicity of calculation. The method of estimation which has been presented does not require a complicated computer program but can be hand-solved for an approximate value in a short period of time.

One shortcoming in the proposed model is the inevitable change in several of the parameters over time. This is especially true of the sales parameter, due to changes in prices of goods and services. Nevertheless, the model has been checked against existing rates found in the available literature (5) and has been found to give good results in practically every case.

To sum up, what has been presented is a procedure rather than an answer. On the other hand, the "grand" maximum values have been calculated for reference in those cases where the planner simply has no basis from which to infer further information concerning the nature and characteristics of the future center other than the gross acreage of the plot.

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Appendix A

SOME CLASSIFICATION OF BUSINESS TYPES[a]

S.I.C. No.	Business Type	S.I.C. No.	Business Type
5231	Paint, glass, & wallpaper	5912	Drugs
5311	Department stores	5921	Liquors
5331	Limited price variety	5942	Books
5392	Dry goods & general merch.	5952	Sporting goods
5411	Grocery—supermarkets	5971	Jewelry
5422	Meat markets	5992	Florists
5441	Candy, nut, and confectionery	5993	Cigar stores
5462	Retail bakeries manufacturing	5996	Camera & photographic supply
5499	Food stores, not elsewhere classified	5997	Gift, novelty, & souvenir
5531	Tire, battery, & accessory dealers	5999	Miscellaneous retail
5541	Gasoline service stations	6000	Banks
5612	Men's & boys' clothing	6400	Insurance agents
5621	Women's ready to wear	7211	Power laundries—family and commercial
5631	Millinery		
5641	Children's and infant's wear	7215	Self service laundries
		7221	Photographic studios
5651	Family clothing	7231	Beauty shops
5662	Men's shoe stores	7251	Shoe repair shops
5712	Furniture stores	7830	Motion picture theatres
5713	Floor covering stores	7911	Dance halls, studios, etc.
5719	Micellaneous home furnishings	7931	Bowling, billiards, etc.
5722	Household appliance		
5732	Radio & television		
5812	Eating places	8000	Offices
5813	Drinking places (alcoholic)		

[a]From: Bureau of the Budget, Standard Industrial Classification Manual (S.I.C.), Washington, D.C. Government Printing Office, 1957.