Evaluating the Requirements for a Downtown Circulation System

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• PLANNING for metropolitan area transportation systems in recent years has involved many millions of dollars and billions of words of print. Knowledge in this field has grown rapidly. Indeed, so much has been learned so quickly that today's sophisticated techniques will be too crude for tomorrow's problems. There is surely nothing lamentable about this situation; it is a sign of healthy progress. One element of the transportation system, however, that is consistently ignored or glossed over in all such studies concerns the circulation within the central business districts. Downtown's problems are inevitably lumped in with those of the rest of the city, even though the respective needs are quite at variance. Within downtown, the dominant mode of transportation is the foot. Pedestrian trips exceed all other modes combined, principally because the intense concentrations of people, with an incredibly complex system of interrelationships among the various functions of the heart of a city, require trips that are too short for existing vehicles and systems, and further require the highest degree of flexibility in transportation. If these trips must or should be made by foot, the subject is strictly an academic one. However, if a satisfactory system of facilitating this basic movement could be developed, that would provide relief for the local transportation system, increase the effectiveness of rapid transit by increasing the basic area of service of stations, provide for higher efficiency of business activity and promote retail sales, it might be well worth the expenditure of a modicum of funds and effort. In the belief that this is true, the following study is offered as a first step toward a sophisticated method of planning for downtown internal circulation systems. It was developed in conjunction with the formulation of a plan for the revitalization of downtown Washington, D.C.

BACKGROUND

The problem of determining local circulation requirements involves the same basic information as is needed in evaluating any other component of a transportation system. The kinds of trips, generations, attractions, origins and destinations, trip lengths, and volumes first had to be determined. A model was then needed that could be readily checked and then used for projection to the target year of 1980.

Four primary categories of trip purpose were tentatively defined:

1. Terminal.—trips to and from parking lots, garages and transit stops.
2. Business.—trips between and among office, bank, doctor, lawyer, government center, etc. Essentially any trip other than terminal which did not involve a purchase (either actual or potential).
3. Shopping.—trips oriented toward purchases, including personal services, eating, and drinking. A special subcategory involved lunch trips of downtown employees.
4. Miscellaneous.—a residue category that included sightseeing, trips to and from residences, hotels, etc.

Necessary limitations on the scope of the study precluded definitive findings in any of these categories, and the latter was generally ignored, then added in as an assumed lump sum percentage at the end.

Four devices were employed for the basic measurements:

1. A series of 1,314 interviews with pedestrians at selected locations within and

adjacent to downtown, including parking facilities, transit stops, office buildings, retail generators. The questions were designed to permit tracing of the entire trip of the interviewee from the time of departure from home until his return, as well as background data on age, sex, residence and employment. Interviews were conducted on a Tuesday, Thursday and Saturday in August, and repeated on a Tuesday, Thursday and Saturday in October.

2. A series of 29,000 questionnaires distributed to employees at selected office buildings to determine lunch and shopping habits, as well as age, sex, income, residence. Sixty-six percent of these questionnaires were completed and returned.

3. Manual counts of people entering and leaving two selected office buildings, with periodic interviews to determine if the entrant was an employee or a visitor. Counts and interviews were conducted on two consecutive days (Wednesday and Thursday) in November.

4. A manual all-day count of pedestrians at four key mid-block downtown locations.

MEASUREMENTS

Terminal Trips

Terminal trips were relatively easy to evaluate. Many studies have been made to determine the distances walked from such points according to purpose and length of stay (see 1). Data obtained from cities the size of Washington were applied without further verification.

Business Trips

Measurement of business trips was determined as follows: Using the counts taken at the entrance to two office buildings, referred to as Buildings A and B, on November 2 and 3, a rough determination of generation factors for office use was made. These counts were taken for periods of five minutes in the following order:
(a) totals in and out at door "I"; (b) interrogation for five minutes at door "I" of incoming and outgoing persons to determine if they worked in the building; (c) repetition of two preceding steps at door "II." This cycle was repeated without interruption, except for necessary breaks.

Comparative totals were made of the sample of those persons who worked in the building and those who did not (Table 1).

It was assumed that 80 percent of all workers would be in the building by 11:00 AM. Workers in the building were then determined as 80 percent of total employment:

Building A = 0.80 × 622 = 500
Building B = 0.80 × 941 = 750

TABLE 1

COMPARISON OF PERSONS WORKING IN BUILDING WITH THOSE NOT WORKING IN BUILDING

Persons	Building A		Building B	
	11/2	11/3	11/2	11/3
Working	133	113	466	245
Not working	91	136	156	78
% not working of Total	41	55	25	24
Weighted avg.	48		25	

TABLE 2

Distance (ft)	No. of Trips
0- 500	6
501-1,000	6
1,001-1,500	4
1,501-2,000	8
2,001-2,500	5
2,501-3,000	2
3,001-3,500	3
3,501-4,000	0
4,001-4,500	3
4,501-5,000	11
Over 5,000	4

The total sample of workers in by 11:00 AM was determined:

Date	Building A	Building B
11/2	72	186
11/3	51	83

The difference in Building B resulted from failure to alternate counts between the front and back doors on 11/2.

The total sample of all persons entering by 11:00 AM was determined:

Date	Building A	Building B
11/2	94	355
11/3	107	212

The percent sample was determined by comparing workers counted with actual number of workers:

	Percent Sample	
Date	Building A	Building B
11/2	14.5	25
11/3	10	11

The total number of persons entering the building was determined by applying the sample percentage to the sample total count:

Date	Building A	Building B
11/2	2,000	3,100
11/3	2,830	4,200
Avg.	2,415	3,650

The total persons entering who were not employed in the building was determined by subtracting 90 percent of the total employees (allowing 10 percent for absentees) multiplied by 2 (assuming each worker enters the building an average of 2 times per day) from the total count:

Building A $= 2,415 - 0.90 \times 2 \times 622 = 1,300$
Building B $= 3,650 - 0.90 \times 2 \times 941 = 1,960$

Generation factors (trips produced per employee) resulted from dividing the total visitors by total employees:

Building A = 1,300/622 = 2.1
Building B = 1,960/941 = 2.1

The equivalent value for the two buildings was, of course, something of a coincidence. For the purposes of the model, it was thus assumed that this value was representative. It is obvious that this is not universally true. Each employee in a retail store would not generate the same number of business (not shopping) trips as would his counterpart in a municipal office building. However, with the possibility that such wide variations would tend to balance, a factor of 2 business trips generated per downtown employee was applied across the board.

The mode of transportation employed and the distances covered in these trips were determined by analysis of individual trips obtained from pedestrian interviews at office buildings. Fifty-two separate trips were analyzed, totaling 147,800 ft, for an average trip length of 2,800 ft and a median of 2,100 ft (Tabel 2). Of these 52 trips, 6 used mass transit, 3 used taxicabs, 5 were in private automobiles and 38 walked.

Shopping Trips

There are essentially three categories of shoppers: primary shoppers who come downtown principally to shop; downtown employees who shop during lunch or before or after work; and people who come downtown for other purpses and incidentally shop.

TABLE 3

Stopper	Store	No. of Persons Making Stops										Total Persons	Total Stops
		1	2	3	4	5	6	7	8	9	10		
Shopper	A	20	43	26	8	6	2	1	-	-	-	106	265
	B	12	21	20	4	1	1	-	-	-	-	59	141
	C	12	20	19	12	2	1	-	1	-	-	67	181
	D	25	34	21	10	4	2	-	-	-	1	97	238
	E	6	12	13	11	3	1	-	-	-	-	47	141
	F	34	30	25	13	4	-	-	-	-	-	109	259
	Total											485	1,225
	Avg.											2.5	
Worker	A	20	2	2	1	-						25	34
	B	19	2	1	-	-						22	26
	C	19	11	3	-	-						33	50
	D	10	5	2	-	1						18	31
	E	11	4	2	1	1						19	34
	F	13	3	3	-	-						19	28
	Total											136	203
	Avg.											1.5	
Others	A	15	8	6	2	-						31	57
	B	12	4	2	1	-						19	30
	C	9	8	4	1	1						23	46
	D	13	5	4	2	-						24	43
	E	1	4	5	5	-						15	44
	F	7	3	5	3	-						18	40
	Total											130	260
	Avg.											2.0	

The pedestrian interviews at retail stores were analyzed by trip purpose to determine the number of shopping stops made (Table 3). It was found that where the principal purpose for coming downtown was to shop, an average of 2.5 stores were visited. Where the principal purpose was work or other but shopping was also involved, the corresponding figures were 1.5 and 2.0 respectively.

Mode of travel was again based on analysis of pedestrian interviews. Distance per shopping trip, determined as shown in Table 4, averaged 1,210 ft. Interviews at retail generators indicated a shoppers' composition of 50 percent primary, 25 percent employees, and 25 percent others.

To determine the attraction of workers to shopping, a gravity model formula was tested. It was assumed that the attraction was directly proportional to the size of the retail generator measured by the number of employees in the store (Fig. 1) and inversely proportional to the square of the distance involved. The 6 major generators were used as a combined attractor, and a "retail index" determined as the summation of the 6 individual indices (Table 5). Office buildings in close proximity to each other were combined, resulting in five groupings of employment. The weighted averages of the individual indices gave the group index, which was then plotted against the percent of shoppers as determined from the employee questionnaires on semilogarithmic paper (Fig. 2). With respect to the individual points on this curve, the average income for Group IV was 83 percent of the over-all average, whereas the comparable figure for Group II was 112 percent.

A tangential exploration into the mutual attractions of retail generators yielded the results indicated in Figures 3a and 3b. Figure 3a shows the original plotted points on log - log paper that evolved into the graph shown in Figure 3b. These relative attractions were determined from analysis of interviews with shoppers.

The graph can probably best be explained by an example of two stores with 600,000

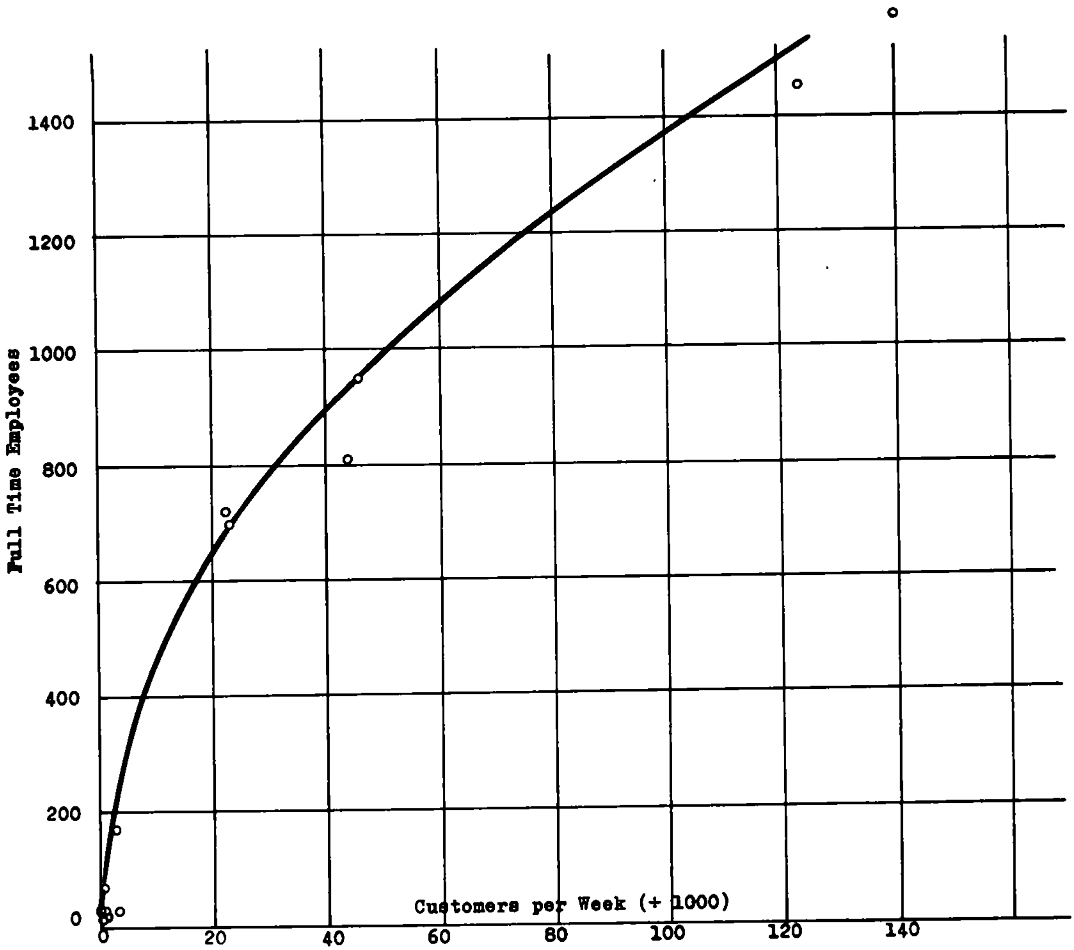

Figure 1.

and 200,000 sq ft of net usable floor area, respectively, that are 1,000 ft (walking distance) apart. One enters the graph at the abscissa representing 600,000 sq ft, goes vertically to the 1,000-ft line, follows this line down to its point of intersection with the 200,000-sq ft abscissa, then reads horizontally to the corresponding ordinate—in this case about 0.21 trips per trip. This indicates that for every 100 persons shopping in the larger store, 21 will go also to the smaller store. Similarly, the impact of the smaller store on the larger can be determined by entering the graph at the 200,000-sq ft point and reversing the procedure with the result of 0.35 trips per trip. That is, of every 100 persons visiting the smaller store, 35 will go on to visit the larger store.

As a further example, there is one large store, A, surrounded by 10 satellite stores B, each equal to 1/10 the size of the larger store and equidistant from it. The figures involved are one at 600,000 sq ft and ten at 60,000 sq ft and 1,000 ft away. Each 100 trips to A will generate 11 trips to each B, for a total of 110 secondary trips generated. Conversely, each 10 trips to each B (again a total of 100 primary trips) will generate 3.5 trips to A, for a total of only 35 secondary trips. The implications, it would seem, are that for maximum commercial intercourse, large concentrations of retailing are preferable to more spread-out areas.

Lunch trips were considered as a special subcategory of shopping trips. The percentage of employees who go out to lunch was determined from the office questionnaires. Where no cafeteria was provided in the building (these are found principally in government buildings outside the downtown area of study), the average figure was 85 percent. Distances covered in the lunch trip, determined from analysis of pedestrian interviews at a typical office building, are shown in Figure 4. The average trip length was 470 ft.

Miscellaneous Trips

As noted previously, study conditions precluded any further breakdown by trip purpose. It was therefore assumed that all other trips within downtown, not specifically evaluated, would comprise approximately 10 percent of the total.

APPLICATION

One of the pedestrian counts at a typical midblock downtown location was used as the control to evaluate the usefulness of the model. Trips within the zone of influence of this point were distributed in the following manner:

1. Terminals.—Cars parked per day at each facility were multiplied by 1.5

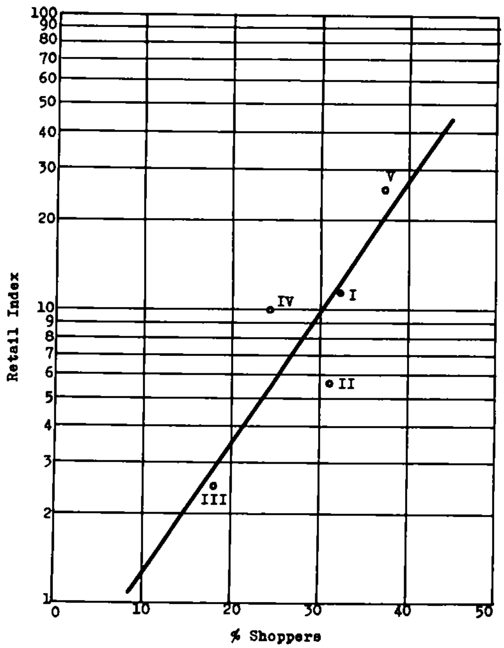

Figure 2.

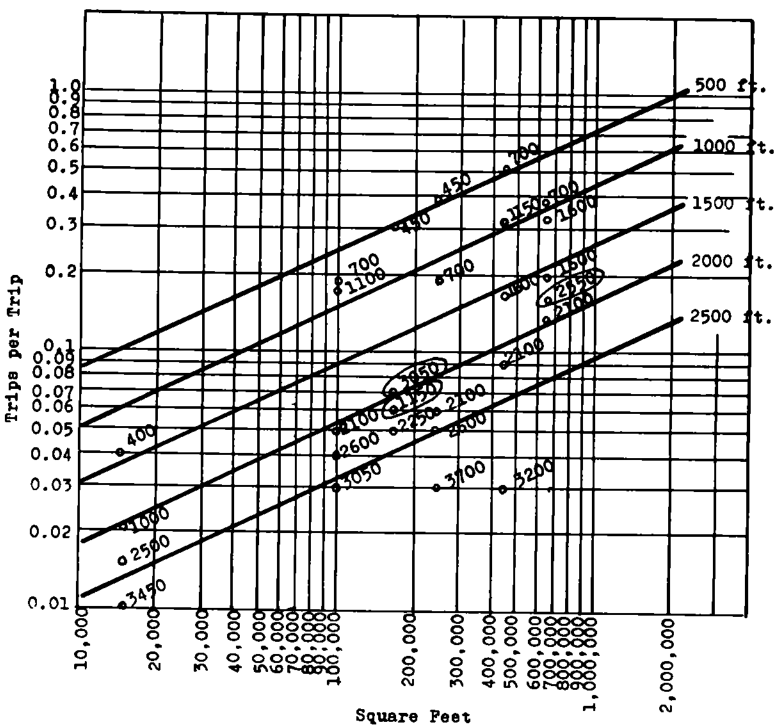

Figure 3a

TABLE 4

Stores	A	B	C	D	E	F	G	Total Trips
A	Trips/Distance	24/1,600	34/700	17/2,550	17/2,100	27/1,600	2/1,100	121
B (Trips x Distance (÷ 1,000))	38.4		15/1,100	1/4,150	2/3,700	3/3,200	0/700	21
C	23.8	16.5		5/3,050	7/2,600	11/2,100	3/400	26
D	43.3	4.2	15.2		62/450	33/1,150	1/3,450	96
E	35.7	7.4	18.2	27.9		62/700	0/3,000	62
F	43.2	9.6	23.1	38.0	43.4		1/2,500	1
G	2.2	0	1.2	3.5	0	2.5		
Total	186.6	37.7	57.7	69.4	43.4	2.5		

Total Trips x Distance (÷ 1,000) = 397.3
Total Trips = 327

$$\frac{397,300}{327} = 1,210 \text{ ft, average distance}$$

occupancy ratio. People were then distributed in proportion to the total employment as follows:

50 percent with 300 ft
25 percent within 300 to 600 ft
15 percent within 600 to 1,200 ft
10 percent within 1,200 to 2,000 ft

Trips were multiplied by two. Buses and streetcars (the only forms of mass transit in Washington) provide stops at every corner in the area, so that the distances involved would be somewhat less. Here the distribution was as follows:

60 percent within 300 ft
30 percent within 300 to 600 ft
10 percent within 600 to 1,200 ft

Again, total trips were multiplied by two.

2. Lunch Trips.—Of the total employment 85 percent was distributed uniformly (there is a wide choice of eating establishments throughout the area) and multiplied by two:

75 percent within 300 ft
15 percent within 300 to 1,000 ft
10 percent within 1,000 to 2,000 ft

3. Business Trips.—Trips generated were two times the total employment. Trips were distributed in proportion to the total employment within 3,000 ft.

4. Shopping Trips.

a. Employees. The percent of total employees per block who shop was de-

TABLE 5

Office Building	Store	A	B	C	D	E	F	Retail Index
	Employees	724	700	1,600	1,400	948	810	
M	(Distance/100)^2	400	961	1,296	2,601	3,265	3,865	
	Employees/D^2	1.8	0.7	1.2	0.5	0.3	0.2	4.7
N	D^2	1,855	1,770	2,170	3,480	2,704	2,220	
	E/D^2	0.4	0.4	0.7	0.4	0.4	0.4	2.7
P	D^2	4,900	3,980	3,480	2,320	1,770	1,370	
	E/D^2	0.1	0.2	0.5	0.6	0.5	0.6	2.5
Q	D^2	2,025	1,370	843	289	576	841	
	E/D^2	0.4	0.5	1.9	4.8	1.6	1.0	10.2
R	D^2	225	100	289	900	529	484	
	E/D^2	3.2	7.0	5.5	1.6	1.8	1.7	20.8
S	D^2	2,500	1,855	1,525	576	343	324	
	E/D^2	0.3	0.4	1.0	2.4	2.8	2.5	9.4
T	D^2	100	196	484	1,195	870	815	
	E/D^2	7.2	3.6	3.3	1.2	1.1	1.0	17.4
U	D^2	169	464	841	1,764	1,370	1,296	
	E/D^2	4.3	1.5	1.9	0.8	0.7	0.6	9.8
V	D^2	72	81	289	872	784	1,089	
	E/D^2	10.0	8.6	5.5	1.6	1.2	0.7	27.6
W	D^2	361	872	1,225	2,500	3,090	3,670	
	E/D^2	2.0	0.8	1.3	0.6	0.3	0.2	5.2

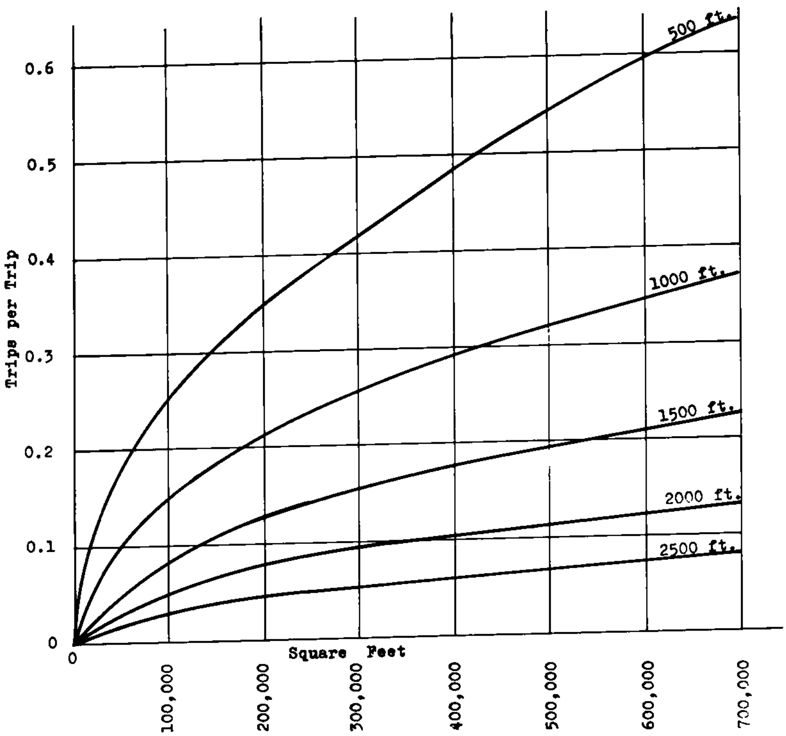

Figure 3b

termined. These shoppers were distributed in proportion to the surrounding retail employment:

50 percent within 500 ft
40 percent within 500 to 1, 500 ft
10 percent within 1, 500 to 2, 500 ft

One-half of these trips were redistributed in the same manner, then returned to the place of employment. The other half of the trips were multiplied by two.

b. Primary shoppers. Each department store employee generates six trips; all other retail employees generate two trips (a necessary oversimplification). These trips were distributed as with employee shoppers. Each of these was redistributed, then one-half were again redistributed.

c. Others. Generation is one-half that for primary shoppers. These were distributed as with employee shoppers, then redistributed once.

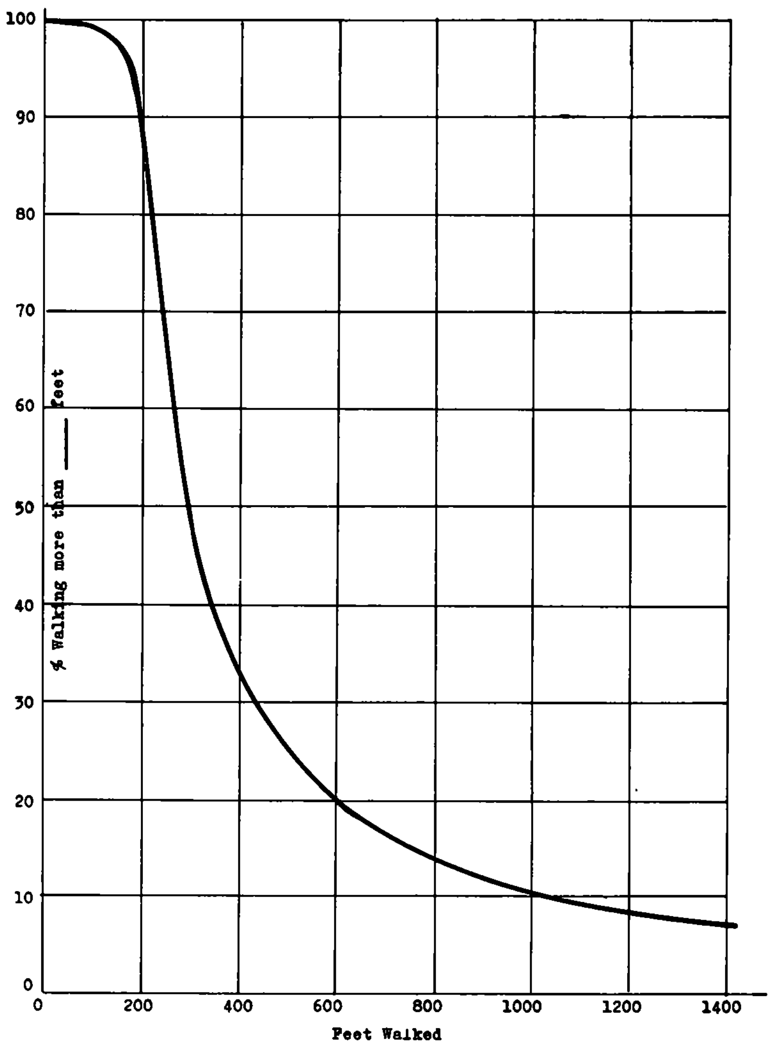

Figure 4.

TABLE 6

Station	1960	1980
A	12,000	18,300
B	13,500	25,300
C	11,500	18,400
D	18,500	19,100

The accumulation of trips across the control block as determined from the model was approximately 16,500. The addition of 10 percent for the miscellaneous trips brought a close correlation to the actual count of 18,500. (Totals in each case refer to "daytime" volumes, from 8:00 AM to 6:00 PM).

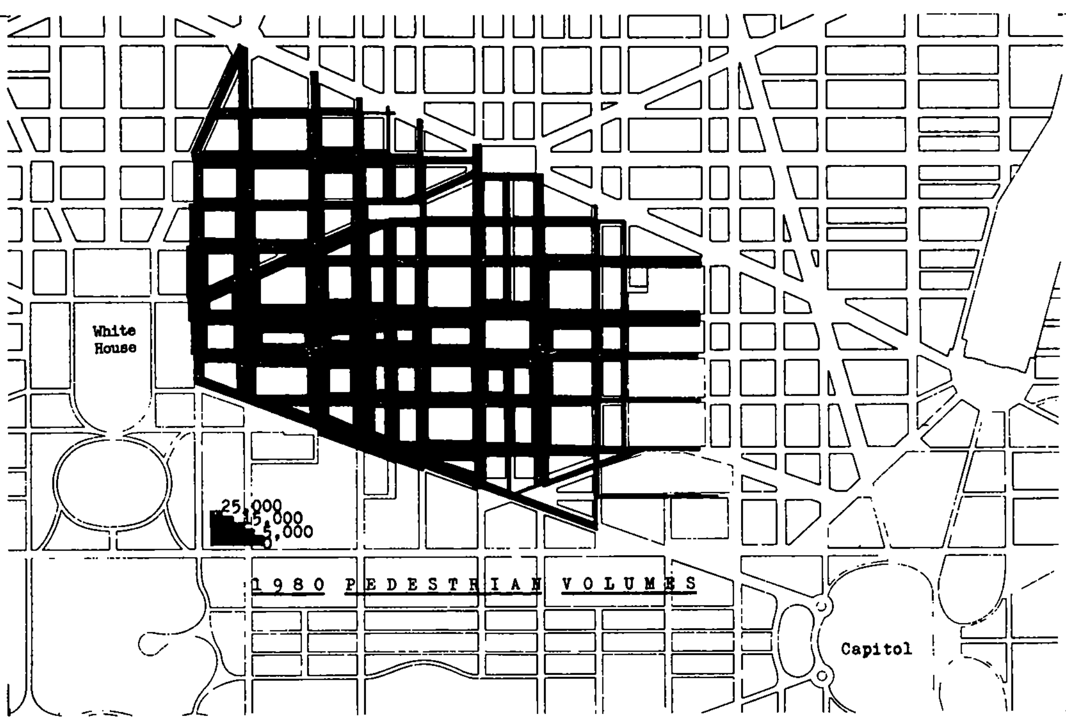

Figure 5.

With confidence that a reasonable approximation of pedestrian volumes can thus be obtained, the model was then applied to the plan for downtown 1980. In addition to changes in land use and employment, a comprehensive rapid transit system was assumed, with bus and subway stations serving downtown, plus a planned parking program integrated with a proposed new traffic plan. These new data were then applied to the model, with the resultant pedestrian traffic flows shown in Figure 5. Comparing existing volumes with projected volumes at the four control stations is shown in Table 6.

In applying the data to the development of an internal circulation system, the composition of the pedestrian volumes can be analyzed by trip purpose to evaluate service requirements. For example, rapid transit stations and long-term facilities would have different requirements for service than would the retail core. The higher the degree of flexibility of vehicles and routing, the better will these individual needs be served.

CONCLUSIONS

The internal circulation model developed for downtown Washington is an admittedly rough tool. It is presented here in the hope that it will stimulate further research. With the growing activity in planning for downtown areas in the U.S., the potential for local circulation systems should not be overlooked. Is it unrealistic to think of a transportation system serving a downtown area that would bring people to a selected number of discharge points, then blanket the central business district with a distribution network composed of vehicles specifically designed for this function, connecting all such points with all prime generators? If such systems are to evolve, means for determining their requirements and demands are essential. It would seem that small effort can bring great rewards in this field.

REFERENCE

1. "Parking." Eno Foundation (1957).