FORECASTING IMPACTS OF TRANSIT IMPROVEMENTS AND FRINGE PARKING DEVELOPMENTS ON DOWNTOWN PARKING NEEDS

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The changing economic role of most downtown areas, with employment becoming the major growth factor, has resulted in a rapid rise in peak-period automobile trips and all-day parking demands and a lower growth rate for short-term (under 3 hours) parking. Few CBD core areas can accommodate all current parking demands or the expected higher demands of the next decade. This paper reviews techniques used in a recent Baltimore study to forecast the number of long-term CBD work-trip parkers who can be diverted to a planned new rapid transit system and to CBD fringe and outlying parking locations, linked to the CBD by improved transit and other people-mover systems. Without these developments, a core-area deficiency of 15,700 spaces is estimated for 1985—double the 1969 deficiency. Recommended programs to divert some long-term work-trip parkers to fringe and outlying locations can reduce the core-area deficit to 10,900 spaces. Also, if the rapid transit system is operational in 1985, most CBD sectors will have surplus parking space. The core area will need only 4,500 more spaces. These needs can be met by recommended 1975-1985 CBD parking programs. This paper explains the parking demand forecasting model and suggests methods for future refinement of the model.

•THIS PAPER reviews techniques used in a recent Baltimore study (1) to forecast the amount of downtown parking that can be eliminated by a planned new rapid transit system and by diverting some CBD parkers to fringe and outlying locations linked to the CBD core area by improved transit and other people-mover systems (1).

The Baltimore study was structured to take into account three transportation trends that have emerged in downtown areas of most large and medium-sized cities over the last 2 decades. These trends create a need to reappraise parking survey techniques with respect to the role of public transit and to provision of new parking facilities. The three trends are as follows.

1. The changing land-use patterns and shifting economic base of downtown areas have produced a sharp increase in morning and afternoon peak work trips, as downtown areas continue to grow in importance as employment centers for financial, governmental, and specialized professional services. They also have caused a reduction in the growth rate (and, in some cases, an actual decline) of midday and evening trips for shopping, entertainment, and other personal and business purposes.
2. Continually but gradually, the proportion of CBD trips made by automobile, for all trip purposes, has increased, and the share of CBD trips made by transit has declined.
3. From the combined effect of these two trends, recent survey findings show an accelerated growth in peak traffic flow within the CBD and in major access corridors and increased demand for more off-street parking spaces within the CBD. Contributing to pressures for more parking spaces is the fact that a higher proportion of existing spaces are occupied by all day work-trip parkers, which reduces turnover.

FOCUS OF PAST CBD PARKING PROGRAMS

Techniques for studying CBD parking supply-demand and for projecting space requirements to a study target year have improved steadily over recent decades, largely because, with the passage of time, projected demands could be checked against actual demands, and refinements could be made in forecast methodology. Survey findings normally are converted into parking programs involving municipal policy decisions that result in more parking spaces being added downtown.

Almost without exception, parking studies in recent years have concluded that the CBD core area, that portion of downtown most intensely developed, has a deficiency in parking supply as measured against demand and that this deficiency would increase in the future. The studies also usually conclude that a parking space surplus exists in fringe areas of the CBD and that a surplus would continue to exist in the study target year.

Although these studies often made reference to the desirability of reducing core-area parking space deficiencies by diversion of some automobile drivers to improved public transit systems and by diversion of some core-area parkers to CBD fringe locations, no methodology existed for quantifying potential effects of improved transit and fringe parking programs in terms of reduced parking demands in the CBD core.

POLICY IMPLICATIONS OF CHANGING CBD FUNCTIONS

The changing role of downtown areas, which has caused a rapid rise in all-day parking and a lower growth rate for short-term parking (under 3 hours), indicates that new techniques aimed at implementing new urban development objectives should be used in CBD parking studies.

The hard fact is that most CBD core areas simply cannot be structured to accommodate all of today's parking demands and the increased demands of the next 10 to 15 years. Even if parking space requirements could be met, the CBD street network and corridor-approach capacity would be limiting factors, as they already are in some large cities.

These remarks are not intended to imply that cities should adopt a policy of banning cars arbitrarily from downtown areas or of prohibiting development of more off-street parking spaces in the CBD core. Such policies would have a negative effect. Downtown areas could not continue to expand as major employment centers, and other CBD growth potentials, primarily as cultural and convention activity centers, would be similarly stifled.

RESTRUCTURING OF CBD PARKING STUDIES

The objective of CBD parking programs should be to encourage maximum person-trip attractions, by all modes of travel. And, because it will not be possible to accommodate all trip-makers who wish to drive to and park within the core area, downtown parking studies should incorporate techniques for exploring alternative methods of serving the trip-makers, alternatives that will not discourage people from making the trip and that may even encourage them to make the trip more often.

Downtown parking programs should be structured to promote urban design objectives that recognize that long-term parking and short-term parking have sharply different impacts on CBD parking needs, its economic growth, its internal streets and approach corridors, and particularly its land use.

For example, long-term parking generates morning and evening travel in peak traffic hours; this means that a parking space is used by only one vehicle for the full business day. Because the long-term parker generally reaches the CBD before short-term parkers arrive, long-term parking conflicts with the objective of the CBD to encourage visits for personal and business purposes. In contrast, short-term parking involves trips made chiefly in off-peak traffic hours when CBD streets and approach corridors normally have surplus capacity; allows each available parking space to accommodate a number of visitors during the business day; and contributes to the economic viability of the CBD inasmuch as short-term parkers are customers rather than employees.

CBD parking studies should include measurement of potentials for some diversion of long-term parkers to fringe and outlying locations, with direct trip linkages and pedestrian connections to the downtown center.

The studies also should quantify anticipated impacts of proposed new or expanded rapid transit systems in terms of reduced CBD parking demands and should emphasize, in developing new CBD parking facilities, provision of short-term parking in buildings that combine multilevel parking with office, hotel, apartment, retailing, and other functions.

FORECASTING CBD PARKING DEMANDS

Because a rising share of downtown trips originate in automobile-oriented suburbs, CBD parking demands will continue to increase in older and newer cities in all population ranges. Even in cities with existing or proposed rapid transit systems, more off-street parking facilities will need to be provided—with emphasis, as stated before, on short-term parking in multiple-use buildings.

Downtown parking demands are a function of desires, needs, and habits of tripmakers. The demands can be related to the number of CBD person-trips made by car, average car occupancy, space availability and cost, and efficiency of parking space usage. These factors are affected by urban population totals, geographical location, and seasonal variations in trip purposes (2, 3).

Steps to Establish Current Parking Needs

Procedures for identifying current parking needs in a particular CBD are relatively standardized. They include a block-by-block inventory of curb and off-street parking facilities; parking accumulation and turnover counts; interviews with parkers to determine trip origin and destination, duration, trip purpose, walking distance to destinations, and other parker characteristics; determination of parking-generation rates (unit demand in spaces per 1,000 sq ft of building floor space) for existing CBD land uses; and, in certain special surveys, determination of the percentage of CBD trips made by automobile and other modes through use of a travel-mode questionnaire survey of persons entering principal trip generators such as large department stores, hotels, government and office buildings, and major banks.

Data from these studies are compiled on a block-by-block basis for the entire CBD and stratified to determine short-term, long-term, and total parking demands.

Demands then are compared with parking supply in each block to determine whether a surplus or deficiency exists. If a parking deficit exists in a specific block but a space surplus exists at a nearby location within an acceptable walking distance and at an acceptable parking cost (which normally are greater for work trips than for other trips), adjustments are made in supply-demand calculations to reduce or eliminate the need for added parking supply at deficiency locations. Techniques for these adjustments range from a parking allocation model to manual clerical data methods.

Surplus spaces also are tabulated for locations beyond acceptable walking distances from space-deficient locations but do not reduce the number of needed additional spaces.

Projecting CBD Parking Demands to 1985

Objectives of the Baltimore CBD parking study were (a) to determine present CBD off-street parking needs and those anticipated in 1975 and 1985, with and without a planned rapid transit system in operation in 1985; (b) to measure the potential for shifting some parking demands to locations outside the core area; and (c) to develop data and recommendations on administrative, legal, and fiscal aspects of the city's parking program.

The study drew on data from previous studies relating to Baltimore-area urban development and transportation planning (4) and various reports and files of the urban design concepts associates who were commissioned in 1967 to develop studies and recommendations on location and engineering design of both the planned rapid transit system and the city's freeway and arterial network, with particular attention to social, economic, and aesthetic effects on the community.

Many techniques for projecting parking demands were considered for use in the Baltimore study. Projection methods of recent years have employed a composite factor to forecast base-year demands, derived from growth trends in employment, retail sales, population, disposable income, motor vehicle ownership, and land use, to a future year.

Mathematical Models—Multiple linear regression analyses also have been developed as a projection technique. A mathematical expression is used to project demand based on changes in such parametric values as employment, population, floor space, dwelling units, retail sales, and automobile ownership. The mathematical formula contains both constants and variables and takes a form similar to the following:

$$\text{Demand}_{(\text{year})} = K_1 + K_2\,(\text{employment}) + K_3\,(\text{population})$$

For the base year, the K_i or constants are derived, by use of calculated values for demand, with variables such as employment inserted in the equation, based on known quantities of each parameter. The equation would be solved for demands by using the regression method, and only the statistically stable parameters would remain in the equation.

For a future year, projected values for each significant parameter would be introduced into the formula and the equation solved for demands. This method is frequently referred to as developing a model, inasmuch as the equation generally models a future year based on today's known characteristics. Future demands can be estimated by modifying only the parameters that are based on growth characteristics, and the equation can be solved for future-year demand values.

Generation Rate Model—A projection technique increasingly used today employs parking-generation rates in relation to land use. For example, the generation rate for an office use may be expressed as 1.5 parking spaces per 1,000 sq ft. Mathematical equations can be established as follows:

$$\text{Demand}_{(\text{year})} = (R_1)\,(LU_1) + (R_1)\,(LU_2) \cdots$$

where

R = rate of demand per 1,000 sq ft, and
LU = land use in square feet.

The negative aspects of the regression method thus are reduced because both the rate (unit parking demand) and the land use can be varied independently. An additional advantage lies in the fact that use of constants is minimized. The estimated future parking demand in the Baltimore study was calculated by use of the generation rate method.

A summary of parking-generation rates for existing CBD land uses in a number of large cities is given in Table 1. These figures are estimations based on transportation and land-use studies of various cities from 1964 to 1971. As indicated by the wide variations in generation rates by land use, each CBD has its own parking-generation rates for similar types of buildings, so rates applicable in one CBD may not apply to another.

Method Summary—Four steps were followed to obtain the estimated future parking demands in Baltimore. First, existing parking-generation rates were calculated for core and noncore areas. Rates for older land uses were separated from those for newer developments because parking-generation rates for buildings erected in recent years have been found to differ from those for older buildings.

Additionally, these rates were derived for each land use and reported in parking spaces per 1,000 sq ft of gross floor area, spaces per hospital bed, and spaces per dwelling unit.

All land-use data were furnished by the Baltimore Planning Department for 1969, 1975, and 1985, including announced future parking facilities.

Step two involved a reduction of block demands. Many existing buildings are to be demolished by 1975 or 1985. The 1969 demands from these generators were removed from the data set.

The next step was to add forecasts of new land-use developments and to project demands based on generation rates derived for more modern buildings. The 1969 and 1985 rates used for this projection are given in Table 2. Anticipated changes in Baltimore CBD building floor area between 1969 and 1985 are given in Table 3.

A fourth step involved application of engineering judgment to the values obtained. A high-speed computer was used to tabulate demands. These data were edited and evaluated, and judgment was used to establish final values.

The supply-demand tabulations for 1975 and 1985 were compiled in the same manner as outlined for current parking space needs to produce an estimate of needed additional long-term and short-term parking spaces. These estimated needs can be tabulated on a block-by-block or sector-by-sector basis.

REDUCING CBD PARKING DEMANDS THROUGH TRANSIT IMPROVEMENTS

New methodology was applied in the Baltimore study to develop forecasts of the impact on CBD parking demands in 1985 if a planned new rapid transit system is in operation by that time. Following are the steps involved.

Estimating CBD Trip Diversion to Transit

Travel patterns to downtown Baltimore, both current and projected, have been extensively investigated in recent studies (5, 6). Results are given in Table 4. A total of 253,400 person-trips to the CBD is estimated for 1985. If the rapid transit system is not operational at that time, 65 percent of these CBD trips are expected to be made by nontransit modes, mainly by automobile.

These data represent person-trip demands, based on trip-generation rates for anticipated CBD land uses. The important question of whether sufficient street and parking capacity can or will be provided to permit the demands to be fully accommodated is now unanswered.

The effect of improved transit facilities anticipated to be operational by 1985 (including a rapid transit system and extensive expansion and upgrading of service on bus routes) also is given in Table 4.

Under these conditions, daily transit trips to the CBD are estimated at 136,500, or 54 percent of total CBD trips, and also 54 percent more trips than would be made by that mode without the transit improvements.

Daily automobile trips to the CBD are estimated to be reduced 22 percent by the transit improvements. This means that CBD automobile trips in 1985 would be below the level expected in 1975.

Parking Demands Without Rapid Transit

The 24-hour trip data in Table 5 were adjusted to the 8 hours (10:00 a.m. to 6:00 p.m.) used in the CBD parking study, based on screen-line checks made by the city and the Maryland State Roads Commission.

Under the process previously described for projecting parking demands to 1985, long-term and short-term space demands, without rapid transit, were aggregated by CBD sectors. These are given in columns 2, 3, and 4 of Table 5.

The ratio of peak demand to total daily parkers was determined by CBD sectors from 1969 parking study data. These ratios, shown in column 5 of Table 5, were assumed to apply for future years. The ratios were used to expand peak demands to total 8-hour demands in 1985.

Parking Demands With Rapid Transit

By using the trip tables from a 1968 Baltimore study (5) modified to reflect the 8-hour parking study day rather than a 24-hour day, we derived the number of automobile drivers (parkers) destined to each sector after diversion to transit. The difference between parking demand with and without rapid transit represented automobile trips diverted to the transit system.

Table 1. CBD parking-generation rates by floor area and land use.

Use	Spaces per 1,000 Sq Ft Average	Range
Floor area		
General office buildings	1.4	0.2 to 5.3
Banks	1.5	0.6 to 6.7
Department stores	1.4	1.1 to 4.7
Hospitals	1.1	0.4 to 4.0
Bus terminals	4.1	1.5 to 7.9
Government offices	1.2	0.3 to 5.1
Courthouses	1.6	1.1 to 3.7
Post offices	1.1	0.8 to 4.5
Colleges	2.1	1.5 to 3.0
Hotels	0.5	0.3 to 1.9
Medical buildings	3.8	1.1 to 8.6
Utility company offices	1.3	0.4 to 5.6
Libraries	1.5	1.1 to 4.3
Manufacturing and wholesale	0.7	0.2 to 1.4
Furniture stores	0.5	0.3 to 1.2
Restaurants	2.1	0.9 to 6.3
Land area[a]		
Residential		
Single family	0.5	0.1 to 2.5
Multiple family	0.3	0.0 to 4.0
Commercial	1.5	0.2 to 9.3
Industrial	0.6	0.1 to 2.7
Public and semipublic	1.0	0.2 to 6.5
Parks and open space	0.1	0.0 to 1.4

[a]Land area is surface occupied and does not include square feet of building above the ground level.

Table 2. Parking-generation rates for Baltimore CBD, 1969 to 1985.

Land Use	1969 Short-Term	1969 Long-Term	1969 Total	1985 Short-Term	1985 Long-Term	1985 Total
Office	0.4	1.0	1.4	0.4	1.3	1.7
Retail	1.2	1.0	2.2	1.1	1.0	2.1
Hotel[a]	0.1	0.2	0.3	0.1	0.3	0.4
Manufacturing and wholesale	0.1	0.3	0.4	0.1	0.5	0.6
Hospital[b]	0.3	0.5	0.8	0.6	1.0	1.6

(Spaces per 1,000 Sq Ft)

[a]Parking spaces per room. [b]Parking spaces per hospital bed.

Table 3. Building floor area use in Baltimore CBD, 1969 and 1985.

Floor Use	1969 (sq ft)	1985 (sq ft)	Change Square Feet	Change Percent
Office	15,205,200	21,059,200	+5,854,000	+38.5
Retail	8,733,300	8,610,400	-122,900	-1.4
Hotel	1,610,300	1,709,100	+98,800	+6.1
Manufacturing and wholesale	10,326,300	6,751,500	-3,574,800	-34.6
Institutional	8,205,200	10,899,300	+2,694,100	+32.8
Other	1,015,300	2,527,600	+1,512,300	+148.9
Total	45,095,600	51,557,100	+6,461,500	+14.3

Table 4. Person-trips per 24 hours to Baltimore CBD with and without rapid transit.

Year	Total Person-Trips	Transit Trips Total	Transit Trips Percent	Automobile Trips Total	Automobile Trips Percent	Other[a] Total	Other[a] Percent
1962	140,000	53,400	38	56,000	40	30,600	22
1969	171,900	63,600	37	70,500	41	37,800	22
1975[b]	202,800	71,000	35	87,200	43	44,600	22
1985[b]	253,400	88,700	35	109,000	43	55,700	22
1985[c]	253,400	136,500	54	85,500	33	34,600	13

[a]Includes automobile passengers, taxi patrons, and pedestrians.
[b]Without rapid transit operation.
[c]With rapid transit operation.

Table 5. Baltimore CBD parking space demand in 1985 with and without rapid transit.

Sector (1)	Space Supply in CBD (2)	Without Transit or Fringe Parking Demand (3)	Without Transit or Fringe Parking Supply (4)	Without Transit, With Fringe Parking Demand (5)	Without Transit, With Fringe Parking Supply (6)	With Transit, Without Fringe Parking Demand (7)	With Transit, Without Fringe Parking Supply (8)	With Transit and Fringe Parking Demand (9)	With Transit and Fringe Parking Supply (10)
1	765	1,464	-699	1,291	-526	893	-128	812	-47
2	499	1,129	-630	996	-497	825	-326	735	-236
3	2,639	1,518	+1,121	1,324	+1,315	1,093	+1,546	967	+1,672
4	1,399	1,656	-257	1,394	+5	1,656	-257	1,394	+5
5	2,137	5,633	-3,496	4,751	-2,614	4,168	-2,031	3,549	-1,412
6[a]	10,560	14,841	-4,281	12,841	-2,281	11,279	-737	9,762	+845
7[a]	3,341	9,601	-6,260	8,155	-4,814	7,297	-3,956	6,173	-2,832
8[a]	4,737	9,899	-5,162	8,529	-3,792	7,424	-2,687	6,401	-1,664
9	4,272	4,878	-606	4,291	-19	3,658	+614	3,266	+1,006
10	4,076	3,381	+695	2,853	+1,223	2,975	+1,101	2,520	+1,556
11	1,200	710	+490	623	+577	582	+618	516	+684
12	2,736	4,149	-1,413	3,600	-864	3,319	-583	2,902	-166
Total	38,361	58,859	-22,804[b]	50,648	-15,407[b]	45,169	-10,705[b]	38,997	-6,357[b]

[a]Core-area sectors. [b]Total for sectors with space deficiencies.

Each sector's peak parking demands then were reduced by the percentage of daily parking demand diverted to the transit system. Distribution of diverted car trips between long-term and short-term parking demands is shown in columns 6 and 7 of Table 5. For example, in sector 1, 80 percent of the diverted parkers would be long-term parkers, and 20 percent would be short-term parkers. These percentages were derived from parking-duration data by CBD sector compiled during the parking study.

Remaining parking demands after diversion to transit are shown in the last three columns of Table 5. These sums were derived by subtracting diverted parking demands from peak demands expected without the rapid transit system in operation, as shown in columns 2 and 3.

The analysis concluded that the rapid transit system would reduce 1985 parking space demands by approximately 24 percent within the entire CBD and the three core-area sectors.

POTENTIAL FOR FRINGE AND OUTLYING PARKING PROGRAMS

Regardless of whether a rapid transit system is operational by 1985, the study report recommended development of new parking facilities along fringes of the CBD and at strategic outlying locations with direct person-trip linkages and special pedestrian connections to the downtown center.

Included would be development of reserved freeway and CBD street lanes for use by buses (7), closing of certain CBD streets to all traffic except buses and taxicabs in peak travel hours, use of electronic controls on buses and at selected traffic signal locations so signals can be adjusted to favor bus movement, and development of people-mover systems (such as elevated and enclosed moving walkways) to interconnect CBD buildings and fringe parking facilities.

Results of Travel-Mode Survey

A special travel-mode survey was conducted, by personal interviews, at 13 major CBD trip-generating locations during the parking study. Responses indicated that 25 percent of long-term work-trip parkers would use fringe or outlying parking locations if direct transit service to the CBD core area were provided and if this service involved lower round-trip costs (for the driver and all passengers in the car) than the cost of parking in or very near the CBD core.

Because 84 percent of Baltimore CBD long-term parking is for work-trips, a potential exists for diverting 20 percent of long-term CBD parking demands to fringe and outlying locations, assuming that the park-and-ride trip involves little or no increase in trip time and that the cost requirements can be met.

It is recognized that this type of survey produces only "subjective facts" based on opinions people express on how they would react to a new set of conditions. Although such surveys cannot be accepted as a fully accurate indication of how people actually would react to new conditions, it is important that efforts be made to learn public preferences in considering alternative transportation improvements.

It is probable, for example, that many improvements in urban transportation facilities made in recent years would have been made in a somewhat different manner if users of the facilities had been able to express choices among alternative solutions, each of which was acceptable from a technical standpoint.

Following are the steps involved in forecasting 1985 CBD long-term parking demands that can be diverted to fringe and outlying locations served by low-cost transit facilities or other types of people-mover systems.

Parking Diversion Without Rapid Transit

The 20 percent value, representing long-term parkers who stated they would use fringe or outlying locations under the stipulated conditions, was applied to 1985 long-term peak parking demands, shown in column 2 of Table 5, representing demand without a rapid transit system.

The projected reduction in CBD parking space demand attributable to park-and-ride diversion is found for each CBD sector by comparing columns 3 and 5 in Table 6. Space demand in the CBD and in the core area was estimated to drop 14 percent.

Parking Diversion With Rapid Transit

If the planned rapid transit system is operational in 1985, projected use of park-and-ride facilities is lower than it would be without the transit system because more car drivers and passengers would use transit service for all or most of their work trips.

Projected diversion to park-and-ride locations was determined by applying the 20 percent parking diversion factor to long-term parking demands remaining in the CBD after diversion to rapid transit.

The estimated reduction in CBD parking demand is found by comparing columns 7 and 9 in Table 6. The reduction in demand, beyond that due to the rapid transit system, is 14 percent.

Combined Impact of Transit and Fringe Parking

Anticipated effects of improved transit and park-and-ride programs on 1985 parking needs are shown in Figure 1.

The anticipated Baltimore CBD parking space supply in 1985, based on existing and currently planned expansion of parking facilities, totals 38,361 spaces, as shown in column 2 of Table 6.

Without either the rapid transit system or the fringe-parking program, projected demand totals 58,859 spaces, resulting in a deficiency of 22,800 spaces. The most critical space shortage is expected in the core areas (sectors 6, 7, and 8) where demand is projected at 34,341 spaces, resulting in a deficiency of 15,700 spaces, or double the 1969 deficiency.

If the park-and-ride program is in effect in 1985 but no rapid transit system exists, the anticipated CBD space deficiency will be reduced 33 percent to about 15,400. The core-area deficiency will be reduced 31 percent to about 10,890 spaces.

With both the rapid transit system and park-and-ride facilities in use in 1985, the CBD deficiency is projected at 6,360 spaces, or 72 percent below the deficit expected without the two programs.

In core-area 6, which has the heaviest downtown office concentration and is by far the leading person-trip generator of the entire CBD, the transit and park-and-ride programs are expected to change a projected 1985 deficiency of about 4,300 spaces to a surplus of 845 spaces. In the other two core-area sectors, the projected deficiency is reduced 61 percent to 4,500 spaces.

This remaining core-area deficiency is within manageable levels for elimination by 1975-1985 parking programs. Recommended programs include establishing parking rate structures that will encourage some additional long-term parkers to use spaces outside the locations of heaviest demand.

CONCLUSIONS AND RECOMMENDATIONS

This analysis of the impact on 1985 Baltimore CBD parking space demands expected to result from the planned regional rapid transit system, and recommended park-and-ride facilities in CBD fringe and outlying locations, indicates that these developments will reduce the need for more long-term CBD parking spaces by some 13,000 spaces, or 31 percent, and will reduce the need for added short-term spaces by about 3,500, or 20 percent.

Economic Implications

The average recent cost for a long-term parking space in downtown Baltimore is \$3,500 and for a short-term space, \$5,500. Thus, the rapid transit system alone can obviate a need for almost \$50,000,000 in new downtown parking spaces.

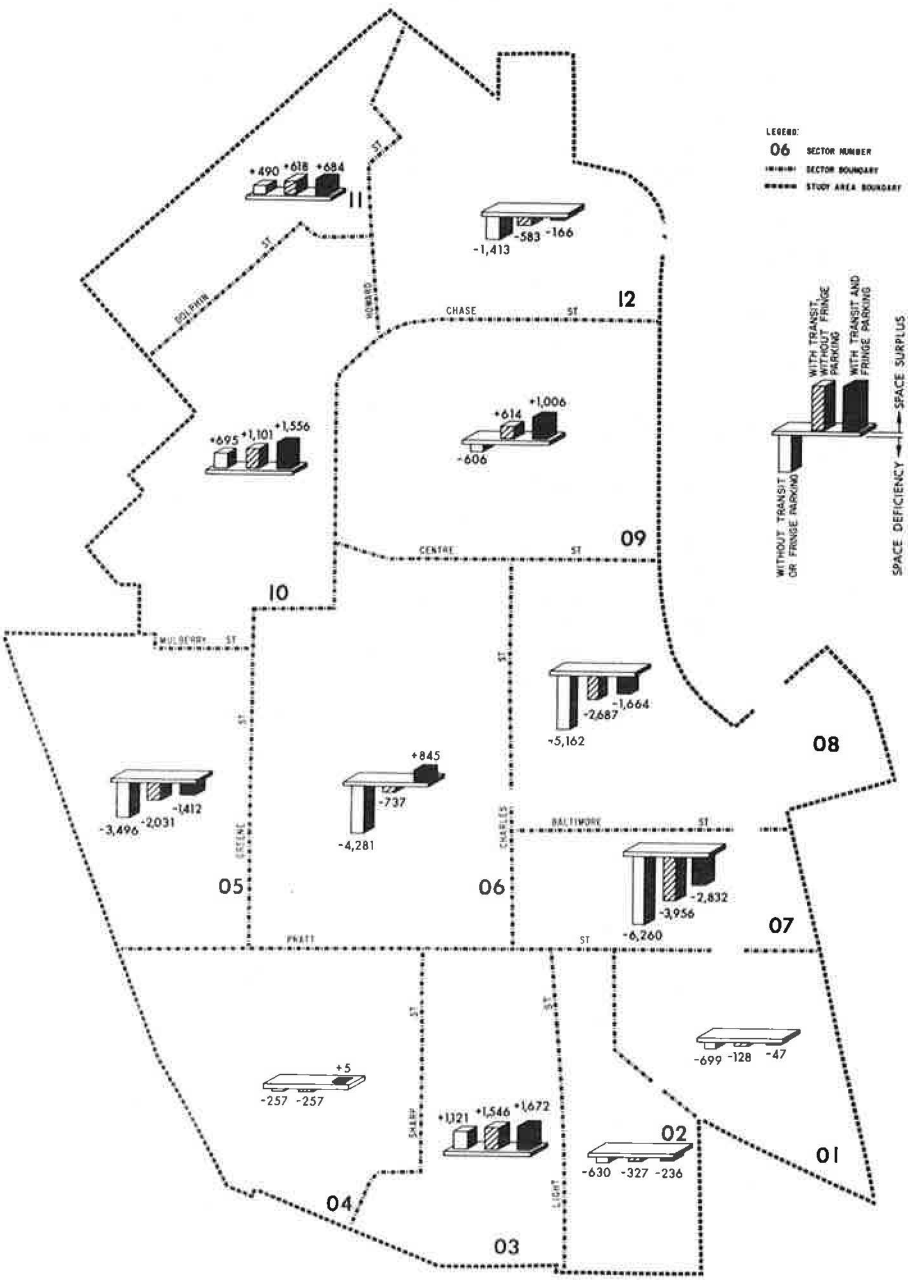
The park-and-ride terminals also will have a substantial impact on capital costs of developing long-term parking spaces. By taking advantage of lower land costs in fringe

Table 6. Baltimore CBD parking supply and demand in 1985 with and without transit and fringe parking.

	1985 Peak Demand Without Transit				Diversion to Transit		Remaining CBD Parking Demand		
Sector (1)	Long-Term (2)	Short-Term (3)	Total (4)	Peak-Hour Factor[a] (5)	Long-Term (6)	Short-Term (7)	Long-Term (8)	Short-Term (9)	Total (10)
1	863	601	1,464	0.95	457	114	406	487	893
2	663	466	1,129	0.47	213	91	449	374	825
3	972	546	1,518	0.66	340	85	632	461	1,093
4	1,309	347	1,656	0.83	0	0	1,309	347	1,656
5	4,412	1,221	5,633	0.81	1,319	146	3,093	1,075	4,168
6[b]	10,002	4,839	14,841	0.56	2,137	1,425	7,865	3,414	11,279
7[b]	7,231	2,370	9,601	0.61	1,613	691	5,618	1,679	7,297
8[b]	6,849	3,050	9,899	0.56	1,732	743	5,117	2,307	7,424
9	2,934	1,944	4,878	0.54	976	244	1,958	1,700	3,658
10	2,639	742	3,381	0.76	356	41	2,274	701	2,975
11	434	276	710	0.57	102	26	332	250	582
12	2,747	1,402	4,149	0.61	664	166	2,083	1,236	3,319
Total	41,055	17,804	58,859	0.60	9,918	3,772	31,136	14,031	45,169

[a]Factor is 1969 peak-hour demand divided by total 1969 parkers; the resulting ratio is assumed to apply for 1985.
[b]Core-area sectors.

Figure 1. Impact of rapid transit and fringe parking on 1985 downtown Baltimore parking needs.



and outlying locations and economies of scale in developing large parking areas, we estimate that each parking space in such locations will represent a capital saving of about $2,000.

This indicates that the recommended park-and-ride facilities can mean a savings of another $8,000,000. If federal grants are obtained to cover part of the fringe-parking development costs, as appears possible under current programs of the U. S. Department of Transportation, the savings to the city would be even higher.

Refining Forecast Models

Although the Baltimore parking study was one of the first to use these new techniques for forecasting impacts of planned rapid transit and new park-and-ride facilities on CBD parking demands, similar techniques are being used in several CBD parking and regional rapid transit studies under way in other cities.

It is anticipated that these techniques will become standard elements in urban transportation planning studies and that the methodology will undergo continuing improvement. Progress in that respect can be furthered by the following four developments:

1. Adoption of a standard data set of urban land uses in as much detail as practical (the data set also should be reasonable in perspective with urban design objectives);
2. New systems for testing parking-generation rates for various land uses including park-and-ride terminals;
3. Refinement of "model" techniques for estimating future demands for each mode of transportation, with emphasis on simplicity and ease of application (parking allocation models also can be used or integrated to assist the analysis work effort); and
4. Further testing of the "public preference" phase of transportation planning to find better ways to measure desires of users of the transportation system in order to accommodate them to the degree feasible.

In this connection, the Urban Corridor Demonstration Program, cosponsored by the Federal Highway Administration and the Urban Mass Transportation Administration of the U. S. Department of Transportation, is designed to test, through actual developmental programs, the potentials for diversion of car trips to improved transit systems and public acceptance of park-and-ride facilities. This program should be of tremendous assistance in measuring demands for such facilities.

It will be impossible in coming years to accommodate in CBD core areas everyone who wishes to drive downtown on work trips that involve long-term parking. The future growth of downtown areas as major employment centers and as centers of cultural and convention activities, therefore, will depend heavily on how well our larger cities meet the problem of providing alternative CBD travel choices to the trip-maker while keeping the alternatives sufficiently attractive so that he will continue to make the trip.

ACKNOWLEDGMENT

The study was conducted for the City of Baltimore in cooperation with the Maryland State Roads Commission and the Federal Highway Administration of the U. S. Department of Transportation.

REFERENCES

1. Downtown Baltimore Parking Study. Wilbur Smith and Associates, 1970.
2. Parking in the City Center. Wilbur Smith and Associates, 1965.
3. Transportation and Parking for Tomorrow's Cities. Wilbur Smith and Associates, 1966.
4. MetroCenter/Baltimore. Baltimore City Dept. of Planning, 1970.
5. Baltimore Region Rapid Transit System. Daniel, Mann, Johnson, and Mendenhall and Kaiser Engineers, 1968.
6. Baltimore Metropolitan Area Transportation Study. Wilbur Smith and Associates, 1964.
7. Progress Report: Exclusive Busways. GMC Truck and Coach Div., General Motors Corp., 1971.