# Applying Transportation System Management Techniques to Downtown Washington, D.C.

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**For a period of 18 months, the District of Columbia Department of Transportation has been actively involved in developing the transportation element of the Master Plan for Downtown Washington. The transportation element relies heavily on the transportation system management (TSM) philosophy and includes transit enhancement, ridesharing incentives, and pedestrian improvements that work together to create a better-functioning environment for all modes and for all activities vital to a successful downtown. In addition, it complements and is dependent on transportation actions occurring in other sections of the District. These include the growing Metrorail system, the parking enforcement program, and the neighborhood TSM program. An analysis was conducted to determine the transportation impacts of the proposed land use changes for the year 2000. This included an assessment of the Metrorail and road system capacities, parking levels needed to ensure mode-split objectives, and an identification of and a plan to reduce conflicts between pedestrians, automobiles, transit services, and delivery vehicles. This effort has produced a plan that is currently being implemented. Elements of the plan include a street classification system, pedestrian enhancements, streetscape design guidelines, sidewalk cafe legislation, public transit and ridesharing enhancement and promotion, a parking management program, and regulations covering the movement of goods.**

For a period of 18 months, the District of Columbia Department of Transportation (DOT) has been actively involved in developing the transportation element of the Master Plan for Downtown Washington. The transportation element relies heavily on the transportation system management (TSM) philosophy and includes pedestrian improvements, transit enhancement, and ridesharing incentives that work together to create a better-functioning environment for all modes and activities vital to a successful downtown. In addition, it complements and is dependent on transportation actions occurring in other sections of the District. These include the growing Metrorail system, the parking enforcement program, and the neighborhood TSM program.

The goal of the transportation element of the downtown plan is to develop a balanced transportation system for the downtown and make optimal use of the road network, mass transit, and public space. This goal is being accomplished with the following objectives in mind:

1. Meet the transportation needs of all users of the downtown;
2. Reduce conflicts between competing uses for street space--pedestrian, transit, automobile, truck, and bicycle;
3. Promote traffic safety;
4. Enhance the pedestrian circulation network and offer maximum accommodation to walking in the downtown;
5. Ensure the attractive and functional design of public space;
6. Promote the use of ridesharing and transit for the journey to work;
7. Give priority to public transit and ensure that it is an attractive alternative;
8. Minimize the use of the automobile for travel within and into the downtown, especially during peak hours;
9. Provide a supply of long- and short-term parking that is consistent with the goals of the downtown plan;
10. Promote the efficient and convenient movement of goods and services within the downtown; and
11. Allow for the safe and utilitarian use of the bicycle within the downtown.

The first part of this paper describes downtown Washington and discusses current and projected land use and the transportation system. Next, the study methodology is outlined and the results are presented. The final portion of the paper outlines the TSM actions that are being taken in response to these findings.

## DOWNTOWN CHARACTERISTICS

### Project Area

Downtown Washington, D.C., is bounded by Pennsylvania Avenue on the south, M Street on the north, 15th Street on the west, and 2nd Street on the east (see Figure 1). Historically, the downtown had been the major retail and employment center for the District and for the region. Following a significant decline in activity and relative importance in the 1960s and 1970s, the downtown is poised for enormous economic revitalization within the next 10 years. This growth will be due to the following factors:

1. Direct access from the expanding Metrorail system, tying outlying geographic areas to the downtown's six Metrorail stations,
2. The recent opening of the 16 000-seat Washington Convention Center located within the project area,
3. The near completion of the Pennsylvania Avenue Development Program, and
4. A recent surge of private investment in development throughout the project area, which is reflected in the following data on expected increases in land use:

| Land Use | Existing | Year 2000 | Change (%) |
|---|---|---|---|
| Retail (ft² 000 000s) | 5.7 | 5.9 | 4 |
| Office (ft² 000 000s) | 14.5 | 38.1 | 163 |
| Apartments (ft² 000 000s) | 0.46 | 0.89 | 239 |
| No. of hotel rooms | 3250 | 11 010 | 204 |
| No. of residential units | 4080 | 12 410 | 93 |

### Project Area Population

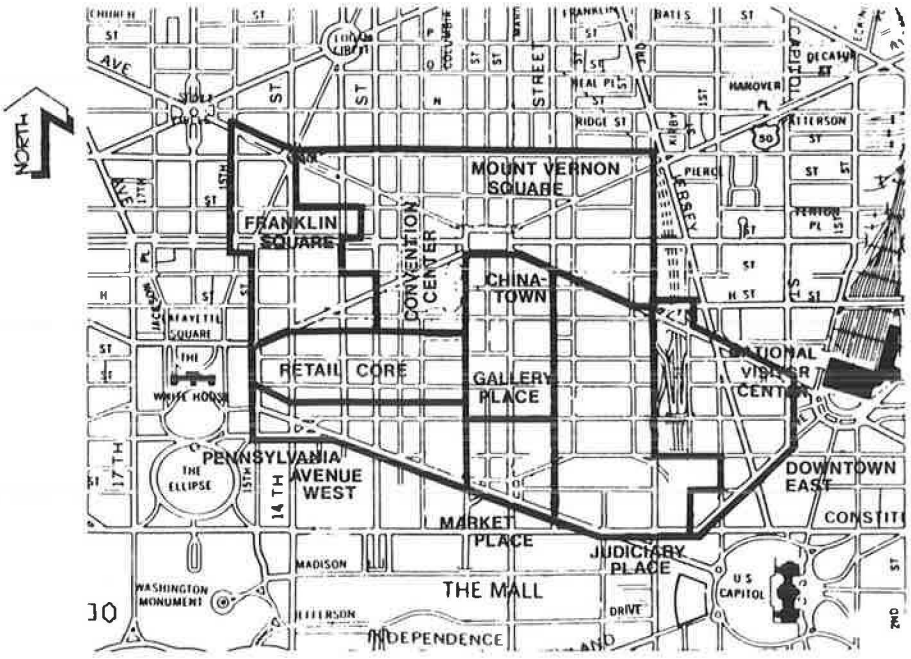
#### Work Force

An estimated 129 000 persons currently work in the downtown. By the year 2000, the downtown will employ nearly 224 000 persons, an increase of 74 percent. The greatest increases are anticipated in office employment, followed by the hotel and retail industries. Employment in the retail core of the downtown is expected to increase by 100 percent, from 16 000 today to 32 000 in the year 2000.

#### Shoppers

The downtown has traditionally contained the city's retail core. The Metrorail system has had a positive impact on the area by making it more competitive with the suburban shopping malls. Clientele

Figure 1. Downtown Washington, D.C.




has increased substantially since 1979. By the year 2000, the regional retail center is programmed to include five active department stores. Adjacent activity areas, such as Chinatown and Gallery Place, will extend shopper activity into the evening hours. Shopper volumes are expected to more than double during the downtown growth years.

### Visitors

Approximately 17 million tourists, business travelers, and convention delegates visit Washington each year. The revitalization of the downtown retail center, the development of the Convention Center, and the completion of several hotels promise to bring many more tourists into downtown.

### Residents

The downtown residential population has declined steadily over the past three decades. Today, fewer than 6000 persons live in the project area. However, 450 new housing units are now under construction and over 9000 units are planned.

## Street System

The downtown street system is in the form of a grid with three major diagonal streets superimposed: Pennsylvania, Massachusetts, and New York Avenues. Blocks vary in length from 300 to 500 ft. The avenues are eight lanes wide. The letter and number streets, which form the grid, are between 45 and 70 ft wide and allow for four to six lanes. The curb lanes are typically reserved for parking, loading, and bus stopping and waiting areas during most hours of the day. On many streets, parking is prohibited during rush hours and some curb lanes are reserved for buses and vehicles turning right.

Sidewalks, measured from building line to curb, are approximately 20 ft on most grid streets. Sidewalk widths on Pennsylvania Avenue have recently been increased to 95 ft. The current sidewalk width on New York Avenue is 20 ft, but plans have been formulated to increase this to 32 ft. In all cases the actual width of sidewalk available for pedestrian circulation is less than the design width due to obstructions built or placed on the sidewalks.

## Public Transit

The downtown public transportation system includes rapid rail, bus, and taxi.

### Metrorail

The 101-mile Metrorail system, now about 39 percent completed, is focused on the downtown. Although only one-third of the regional system is in operation, Metrorail today carries almost one-half of all weekday transit trips and has become an important aspect of the regional transportation network.

There are six Metrorail stations with 13 entrances in the project area. The nearby Federal Triangle and Union Station stops also serve the downtown. According to a 1981 study conducted by the Washington Metropolitan Area Transit Authority (WMATA), 9 out of every 10 trips on the Metrorail system are to or from downtown destinations. Downtown ridership increased from 2.5 percent in 1977 to 34 percent in 1978 and to 44 percent in 1979.

The effect the Metrorail system has had on automobile travel to and from downtown Washington is noteworthy. Between 1977 and 1979, the total number of automobile trips entering downtown decreased by 30 800 and the total number of inbound automobile person travel trips decreased by 48 400. This represents a decrease of 7.6 and 8.3 percent in automobile and automobile person trips, respectively, into the downtown.

### Bus System

Downtown is served by more than 90 bus lines extending to outlying areas within the District, Virginia, and Maryland. During the first quarter of 1982, the system carried 70 million riders, 70 percent of whom traveled to and from the downtown. The bus system provides both local and express service and transfer connections to the six downtown Metrorail stations.

## METHODOLOGY AND ANALYSIS

Motivated by the large amount of growth anticipated

**Table 1. Increase in afternoon peak-hour trips generated by year 2000 office development.**

| Mode Split[a] (%) | Automobile Occupancy (persons/vehicle) | Increase in Trips: 60 Percent Peak-Hour Factor | | 50 Percent Peak-Hour Factor | |
|---|---|---|---|---|---|
| | | Automobile | Transit | Automobile | Transit |
| 40/53/7 | 1.5 | 13 840 | 27 510 | 11 530 | 22 920 |
| | 1.7 | 12 210 | 27 510 | 10 180 | 22 920 |
| | 2.0 | 10 380 | 27 510 | 8 650 | 22 920 |
| 30/63/7 | 1.5 | 10 380 | 32 700 | 8 650 | 27 250 |
| | 1.7 | 9 160 | 32 700 | 7 630 | 27 250 |
| | 2.0 | 7 780 | 32 700 | 6 490 | 27 250 |
| 20/73/7 | 1.5 | 6 920 | 37 890 | 5 770 | 31 570 |
| | 1.7 | 6 110 | 37 890 | 5 090 | 31 570 |
| | 2.0 | 5 190 | 37 890 | 4 325 | 31 570 |

[a]Automobile/transit/walk.

in the downtown by the year 2000, the District of Columbia DOT conducted an analysis both to estimate the impact of this growth on the transportation system and to determine the limits of growth that would be possible, given the goals of the DOT and the constraints of the transportation system both in the downtown and citywide. The analysis addressed the following questions:

1. How can conflicts between pedestrians, vehicles, and transit be reduced, and how can an attractive and safe pedestrian environment be created?
2. What is the capacity of the Metrorail system (stations and trains), and what level of service can it be expected to provide?
3. What is the ability of the major arterials and bridges that serve the downtown to accommodate increased vehicle traffic?
4. What represents an appropriate parking supply, and do commuter and short-term parkers have conflicting needs?

The analysis assumed that the full 101-mile Metro system would be operating by the year 2000. It was also assumed that the road network would be fixed and there would be no future increases in capacity. Residential streets would not be used to accommodate any overflow from the arterial network. Recent actions taken by the DOT support this policy. Thirteenth Street, N.W., is no longer one-way during rush hours; the center reversible lanes on Reno Road, N.W., and Sixteenth Street, N.W., have been eliminated; and a study is being undertaken to determine the feasibility of changing Fifteenth Street, N.W., from one-way to two-way operation. All four streets are residential in nature.

Travel demand was estimated for the year 2000 based on a level of development that will completely fill the downtown building envelope. Peak-period trips will increase by 80 000, which is nearly a 100 percent increase over current volumes.

Scenarios assuming various mode splits, automobile occupancies, and peaking characteristics were tested to determine impacts. The "do-nothing" case assumed a 40 percent mode split, an automobile occupancy of 1.5 persons/car, and a 60 percent peak-hour factor. A more optimistic scenario assumed an effective TSM program that would result in a 30 percent automobile mode share, an automobile occupancy of 1.7 persons/car, and a 50 percent peak-hour factor. Under this scenario there would be 45 percent fewer vehicle trips to the downtown than if trip characteristics were to remain the same. Table 1 summarizes the travel demands under the various scenarios.

## Pedestrian Circulation Analysis

The following activities were performed to determine pedestrian circulation conditions and needs in the downtown:

1. Inventory--Twelve-hour weekday pedestrian volume counts taken at 46 downtown locations;
2. Safety evaluation--A review of annual safety statistics, police accident records, and locations of pedestrian-vehicle conflicts in the downtown; and
3. Level-of-service analysis--A review of peak pedestrian flows and sidewalk and crosswalk capacities over time.

### Inventory

Walking is the preferred mode in the retail core. More than 147 000 pedestrians were counted on 15 selected streets during one 12-h weekday period. This pedestrian volume is equivalent to the work force within 183 downtown office buildings or, put another way, the maximum capacity of 12 Convention Center events. The six retail core streets listed in the following table carry 45 percent of weekday pedestrian volumes:

| Location | No. of Pedestrians: Midday Peak | Evening Peak | 12-h Total |
|---|---|---|---|
| 13th Street between F and G | 3810 | 1 880 | 18 100 |
| F Street between 12th and 13th | 3080 | 1 680 | 16 300 |
| F Street between 9th and 10th | 2230 | 1 460 | 13 892 |
| G Street between 13th and 14th | 2190 | 1 750 | 13 400 |
| 11th Street between F and G | 1570 | 1 860 | 13 100 |
| F Street between 14th and 15th | 1980 | 1 350 | 6 600 |
| Total | 9980 | 14 860 | 81 392 |

On these streets, the maximum flow was found to occur between 12:00 noon and 1:00 p.m. Twenty-one percent of the total 12-h flow is within this period. Pedestrian and vehicle volumes are compared below (the data are taken from a field study by JHK and Associates):

| Location | No. of Vehicles | No. of Pedestrians | Ratio |
|---|---|---|---|
| 13th Street between F and G | 1200 | 1880 | 1.6 |
| F Street between 12th and 13th | 500 | 1680 | 3.4 |
| F Street between 9th and 10th | 500 | 1460 | 3.0 |
| G Street between 13th and 14th | 450 | 1750 | 3.9 |
| 11th Street between F and G | 1100 | 1860 | 1.7 |
| F Street between 14th and 15th | 280 | 1350 | 4.8 |

These data indicate that pedestrian volumes exceed vehicle volumes by as much as 75 percent during the evening peak period (3:00-6:30 p.m.).

The Gallery Place and Metro Center Metrorail stations are major generators of pedestrian travel. Figure 2 indicates that 91 percent (1773 users) walk to Gallery Place in the evening peak. Only 5 percent arrive by bus and 1 percent by automobile. At Metro Center, 87 percent (6863 users) access the

station via the walk mode, 6 percent arrive by bus, and only 1 percent by automobile. Land is expected to develop rapidly in the retail core by 1985. As a result, walking trips to Metro Center are projected to increase by 59 percent and to Gallery Place by 52 percent. By the year 2000, when the downtown is fully developed, pedestrian access is expected to increase by 200 percent.

Less pedestrian activity was recorded in other areas of downtown. During one 12-h weekday period, 97 000 pedestrians were counted at 31 locations. This volume is only 32 percent of that found on streets in the retail district.

### Safety Evaluation

In 1980 there were more pedestrian accidents in the downtown than in other parts of the city. Of total accidents, 17 percent or 231 occurred in the downtown. Two pedestrian deaths were also recorded. Pedestrian accidents occurred most frequently at midblock locations (52 percent) and, to a lesser degree, at street intersections in crosswalks (41 percent).

### Level-of-Service Analysis

A pedestrian level-of-service analysis was conducted based on work by Fruin (1) in which he defines six categories of pedestrian service. These range from unimpeded flow (level of service A) to jammed flow (level of service F). According to Fruin, the desirable pedestrian environment (level of service A) allows sufficient space to choose independently a relaxed walk speed, to bypass slower pedestrians, and to avoid conflicts with oncoming or crossing pedestrians. The following variables determine desirability: the area the pedestrian occupies, effective sidewalk width, queuing conditions, walk speed, pedestrian headways, and the number (or volume) of pedestrians within a given area.

By using the above variables, sidewalk level of service (s) was computed as

$$s = p/tw \quad (1)$$

where

p = number of pedestrians,
t = time interval, and
w = effective sidewalk width.

Crosswalk holding area capacity (h) was computed as follows:

$$h = (pt_1/t_2 1)q \quad (2)$$

where

$t_1$ = wait time,
$t_2$ = time interval,
l = traffic light cycle length, and
q = queuing space per pedestrian.

Last, crosswalk level of service (c) was computed by using the following values:

$$c = p(1 - t)/gw \quad (3)$$

where

t = reaction time,
g = pedestrian crossing time, and
w = crosswalk width.

As Table 2 indicates, the equations produced acceptable pedestrian service levels in 1981 and design year 2000 when successful public space and sidewalk management programs were assumed. Analysis indicated that service levels would decrease significantly to unacceptable levels if these programs were not implemented.

A separate analysis was conducted to determine pedestrian conditions at the Washington Convention Center. The facility, situated in the center of

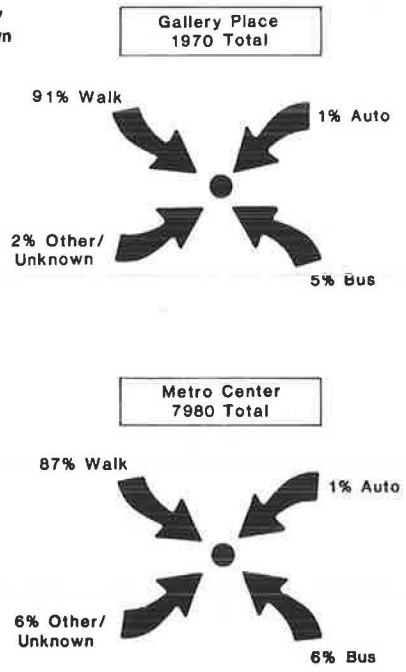



**Figure 2. Metrorail access by mode at two major downtown stations: afternoon peak, spring 1981.**

**Table 2. Results of level-of-service analysis for retail core: 1981 and 2000 pedestrian conditions.**

| | Sidewalk Level of Service | | | Crosswalk Hold Area Capacity | | | Crosswalk Level of Service | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2000 | | | 2000 | | | 2000 | |
| Location | 1981 | No Public Space Management | Public Space Management | 1981 | No Public Space Management | Public Space Management | 1981 | No Public Space Management | Public Space Management |
| 11th and G | A | C | A | + | - | + | A | D | A/B |
| 11th and F | A | C/D | A | + | - | * | A | D | A/B |
| 12th and G | A | C | A | + | * | + | A | D | A/B |
| 12th and F | A | D | A | + | - | - | A | F | C |
| 13th and G | A | F | A | + | - | + | A | D/E | B |
| 13th and F | A | D | A | + | - | + | A | D | A/B |

Note: + = adequate, - = not adequate, and * = moderately adequate.

**Table 3. Afternoon peak level-of-service analysis for selected intersections.**

| Intersection | Level of Service | | | | |
|---|---|---|---|---|---|
| | | 1990 | | 2000 | |
| | 1981 | A | B | A | B |
| 4th Street and New York Avenue | A | D | C | E | D |
| 6th and E Streets | A | A | A | A | A |
| 6th Street and New York Avenue | C | F | E | F | F |
| 7th Street and Pennsylvania Avenue | B | F | E | F | D |
| 7th and H Streets | B | D | D | E | C |
| 9th Street and Pennsylvania Avenue | E | F | F | F | F |
| 9th and H Streets | C | D | C | E | D |
| 9th and L Streets | B | D | C | F | D |
| 11th and H Streets | A | C | B | D | C |
| 12th and G Streets | A | E | C | F | D |
| 13th Street and Massachusetts Avenue | B | F | E | F | F |
| 14th Street and Pennsylvania Avenue | D/E | F | F | F | F |
| 14th Street and New York Avenue | B/C | E | C | F | D |

Notes: A = transportation conditions including 40 percent automobile mode share, 1.5-person automobile occupancy, and 60 percent peak-hour factor; B = TSM actions resulting in conditions of 30 percent automobile mode share, 1.7-person automobile occupancy, and 50 percent peak-hour factor. Volumes are from manual "uncontrolled" assignment. Balancing of traffic among roadways could result in an improved level of service at particular intersections.

downtown, is expected to generate 10 000 pedestrian trips in either midday or evening peak periods, beginning in 1983. The analysis found that pedestrian conditions at the center will be close to if not intolerable during exiting times. System breakdown will be most apparent within at-grade crosswalk facilities. To safely accommodate peak pedestrian traffic, it will be necessary to "spread the peak," ensuring even distribution of traffic through designated egresses over a 20-min period, at minimum.

The pedestrian level-of-service analysis has clearly shown that pedestrian design standards are needed in the downtown to minimize the negative impacts of growth on the pedestrian network. These are discussed later in this paper.

## Metro System Capacity

An analysis was performed to determine whether the Metro system will be able to accommodate the ridership levels projected for the year 2000. Both train and station capacities were evaluated.

Trains were assumed to consist of eight cars, each capable of carrying 200 persons, for a total capacity of 1600 persons/train. Escalator capacity was set at 115 persons/min and fare gate capacity at 25 persons/min. The number of escalators and fare gates represents the full system design. Fare gates were assigned an entry or exit direction proportional to demand.

The computer model for determining station capacity calculates the number of seconds of wait experienced by the last passenger to leave the station following each train arrival during the morning peak hour. The model also computes the number of escalators required to clear the train platform within 2 min, regardless of train headway.

By 1986, transit use at the two Metro stations in the retail core will more than double. By the year 2000, volumes will have nearly tripled. Both Metro station capacity and train capacity were found to be sufficient to handle the projected number of commuters under the full-built scenario for the downtown, even when a 30 percent automobile mode split was assumed. However, this capacity is contingent on the ability of Metro to provide eight-car trains traveling on 2-min headways during the rush hour and stations being built to their design capacity. Near-perfect reliability will be required since little slack exists in the system. For example, a train that is 4 min late will increase passenger exiting time at one of the downtown stations by 3 min. Trains on certain lines would not be able to accommodate all passengers trying to board at stations near the periphery of the downtown during the afternoon peak period if headways are longer than 3 min. This commitment to the Metro system becomes all the more imperative when it is realized that a very high transit mode share is necessary to avoid intolerable congestion on the street network.

## Road System Level of Service

Level-of-service analyses were performed for 13 intersections in and around the downtown. The methodology followed was the critical-lane-volume technique taken from Transportation Research Circular 212 (2).

Most of the intersections were found to be operating without considerable delay during the peak periods (see Table 3). However, committed development will cause traffic volumes to increase from 50 to 100 percent by 1986, which will use up most of the existing capacity in the heart of the downtown. By the year 2000, 11 of the 13 intersections will be operating at unsatisfactory levels of service (E or F) under the "do-nothing" scenario. If this is permitted to happen, it could have severe implications for the attractiveness of the downtown as a work and shopping location. A successful TSM program would result in only 4 of these intersections operating at level of service E or F.

## Parking Supply and Demand

A parking analysis was conducted to determine the amount of parking that is consistent with the modal split and automobile occupancy goals that have been established. An inventory of the existing on-street and off-street parking supply in the downtown yielded a supply of 25 000 spaces. The number of parking spaces that will be lost due to new development was subtracted from the supply. By the year 2000, only 16 000 of the current spaces will remain. From this figure it was then possible to calculate the appropriate amount of new parking.

The parking demand ratio (PDR) was calculated for each land use category. Mode split and automobile occupancy figures are based on goals set for the year 2000. Parameters such as average density of employees and shoppers are based on current figures.

In the case of office development, the following formula was used to compute the number of parking spaces required to meet the demand of employees in each 1000 ft² of development:

$$PDR(\text{office}) = (A_1/A_2)E_1E_2 + V \quad (4)$$

where

$A_1$ = automobile mode share,
$A_2$ = automobile occupancy,
$E_1$ = persons/1000 ft² of office space,
$E_2$ = adjustment factor for employee absenteeism, and
$V$ = visitor parking.

The equation was solved for a 30 percent mode split, 1.7 persons/car, 4 persons/1000 ft² of office space, a 15 percent absenteeism rate, and 10 percent visitor parking. The result was one parking space for each 1400 ft² of office development, which is close to the one space for each 1250 ft² currently being provided.

A similar formula was developed for retail trips:

$$PDR(\text{retail}) = T_1T_2(A_1/A_2)F \quad (5)$$

where

$T_1$ = trips generated/1000 ft² of retail space,
$T_2$ = percent of shopper trips, and
F = shopper peaking factor.

The equation was solved for a 7 percent automobile mode share, 1.8 persons/car, 35 trips/1000 ft² of retail space, 90 percent shopping trips, and a peaking factor of 0.25. This resulted in one parking space for each 3250 ft² of retail space. No figures for the amount of retail parking being supplied for new developments were available for comparison. However, 2900 on-street spaces are designated for short-term parking, and most parking garages have been found to have at least a 10 percent vacancy rate.

The PDR for hotel rooms was calculated by using the following formula:

$$PDR(\text{hotel}) = (A_1/A_2)R \quad (6)$$

where R is room occupancy.

Assuming an automobile mode share of 20 percent (not including taxi trips), an automobile occupancy of 1.6 persons/vehicle, and an average room occupancy of 2.2 persons results in a PDR of one space for each 3.6 rooms. This figure is very close to current zoning requirements.

The residential parking requirement was set to reflect the current zoning requirement in the downtown: one space for every two condominiums and one space for every three apartments.

Based on the land use projected for the year 2000 (Table 1), 28 000 parking spaces will be required in the downtown. Current development practices imply that 15 000 new spaces will be constructed in the downtown, which is about 4000 more than the number required for the mode split and automobile occupancy goals that have been set.

## DOWNTOWN TSM PROGRAM

The District of Columbia DOT has taken several actions and is developing additional programs to respond to the goals of the downtown plan and the findings of the analysis cited in the previous section of this paper. A "Downtown TSM Notebook" has been prepared that brings together these policies and programs in one document. The notebook will be distributed widely to developers, building owners, and employers. It will represent an important component in the District of Columbia DOT's outreach effort to the private sector. The following topics are included: goals, objectives, and policies; pedestrian program; street classification system; streetscape guidelines; sidewalk cafe legislation; public transit; ridesharing; parking management; and goods movement.

The pedestrian program has been developed to meet goals in the areas of physical improvements, design improvements, and public and private management. The downtown street classification plan identifies streets with a pedestrian emphasis and their operational requirements. The streetscape design review process sets the standards for the design and allocation of elements in the public space to improve the pedestrian environment. The sidewalk cafe legislation has been written to preserve pedestrian clear space and provide an attractive and comfortable pedestrian environment. The transit program attempts to reduce conflicts between transit patrons and pedestrians through improvements in the location of bus stops and the use of space around Metro stations. The parking management and ridesharing programs have as one of their goals a reduction in the number of vehicles entering the downtown. Finally, one of the goals of the goods movement program is to reduce conflicts between pedestrians and delivery vehicles.

The remainder of this paper discusses these topics.

### Pedestrian Program

A comprehensive pedestrian program has been developed that will meet the following objectives:

1. Physical improvements--(a) Provide a pedestrian network accessing the entire downtown, (b) provide sufficient space for pedestrian circulation by regulating the location, type, and design of all sidewalk "furniture" (e.g., trees, benches, vending machines, signs, and vaults), (c) install curb ramps at all pedestrian crossing locations (ramp slopes should not be greater than 1 in/ft or exceed a 5 percent grade), (d) provide shelder, sun protection, and security at major pedestrian locations, (e) provide traffic signals timed for pedestrian rather than vehicle traffic, where appropriate, and (f) encourage consolidated freight deliveries at times least disruptive to pedestrian movement;
2. Design improvements--(a) Develop streetscape guidelines that provide clear technical standards for use of public space, (b) beautify public space by landscaping and providing trees, and (c) ensure attractive, well-designed pedestrian amenities, seating, and standing areas; and
3. Public and private management--(a) Promote well-designed, safe, and well-maintained public space amenities and activities within special pedestrian areas, (b) ensure security, and (c) coordinate street activities such as festivals, sales, art programs, and commercial street fairs.

### Downtown Street Classification Plan

Underlying many of the transportation objectives is the concept of a street classification plan. The downtown street network provides mobility and access for automobiles, trucks, surface transit, and pedestrians. Its proper functioning is also a key determinant of the quality of life experienced by persons in the downtown. Since the downtown is slated to experience major growth and since it is only possible to make minor physical modifications to the downtown streets, the existing system must be carefully managed so that it can best respond to these needs. The downtown street classification policy identifies how each street should function and how conflicts between the different uses of the street space can be resolved.

The street classification policy defines the role each downtown street plays in the provision of access and circulation. To this end, city streets are grouped in three basic hierarchical classifications: traffic streets, bus streets, and streets with a pedestrian emphasis. Each classification is further divided based on its role in the overall street system. Figures 3-5 show maps displaying the classification system and explain the functional purpose, traffic operations, transit operations, access, and pedestrian treatment of the streets shown. In several instances, because streets serve two purposes they have been given a dual classification.

### Streetscape Design Review Process

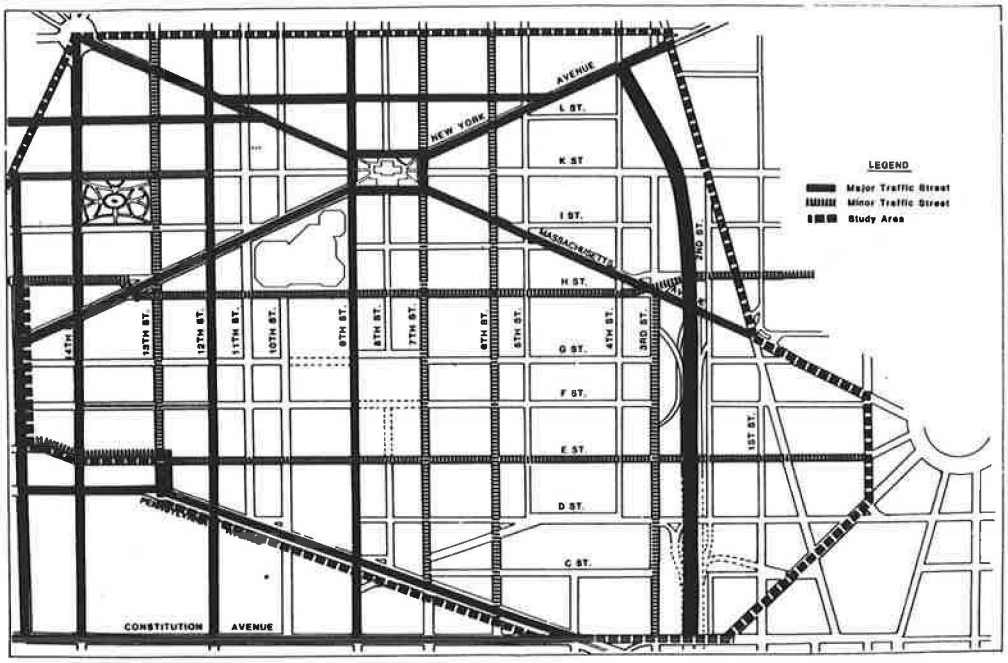
As part of the building and remodeling process, developers are responsible for restoring sidewalk areas. Increasingly, they have begun to install

their own sidewalk improvements. The City realized that guidance and coordination were needed if these improvements were, in fact, to represent an upgrading of the quality of public space design. Although the City has construction, design, and materials specifications, its role in approving elements proposed for use in public space as part of the building permit process was limited, focusing primarily on safety concerns and the needs of utilities.

Recognizing the opportunity that the redevelopment of the downtown presented, the DOT and the Office of Planning and Development (OPD) produced a draft downtown streetscape notebook in the fall of 1981. It included standards for the design and location of building and utility vaults, paving materials, trees and landscaping, curb cuts and driveways, and street lights. One of the most significant elements was the requirement that developers pay for the installation and maintenance of the landscaping and sidewalk paving elements.

Within the downtown, developers of new or rehabilitation projects are now required to submit a streetscape plan for review and approval by the Streetscape Review Committee. The process is a two-

**Figure 3. Proposed street functional classification plan showing major, minor, and local traffic streets.**




Major Traffic Street

- prime carrier of traffic
- special effort to maintain efficient flow
- transit vehicles permitted
- curb cuts permitted
- special effort to ensure safe pedestrian crossings

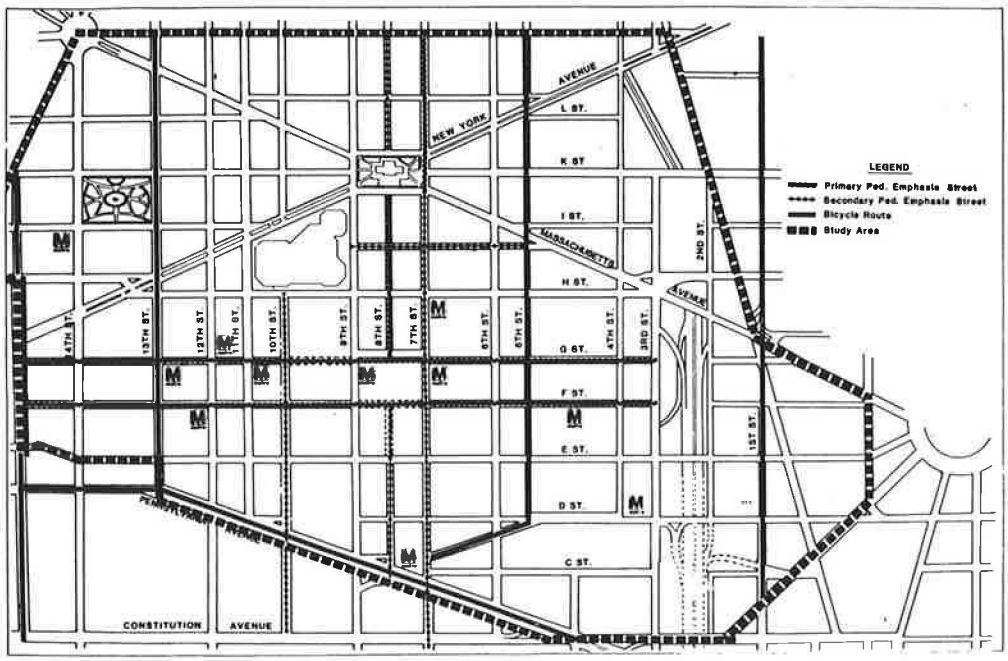
Minor Traffic Street

- distribution function
- efforts made to maintain efficient flow
- transit vehicles permitted
- preferred location for curb cuts
- ensure safe pedestrian crossings

Local Traffic Street

- serve abutting street
- ensure street operates safely
- transit vehicles permitted
- preferred location for curb cuts
- enhance pedestrian environment

**Figure 4. Proposed street functional classification plan showing streets with major or minor pedestrian emphasis and bicycle streets.**




Major Pedestrian Emphasis Street

- prime street for pedestrian activity
- minimize auto traffic
- transit vehicles permitted
- curb cuts prohibited unless no reasonable alternative
- pedestrian movement and amenity is prime concern

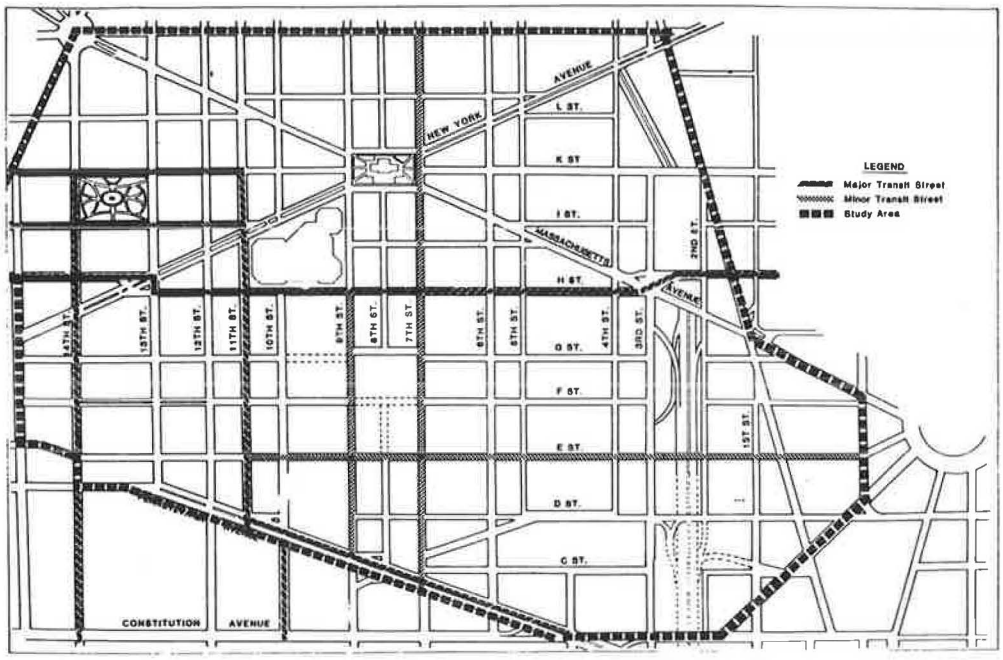
Minor Pedestrian Emphasis Street

- emphasis on pedestrian movement
- discourage auto traffic
- transit vehicles permitted
- curb cuts prohibited unless no reasonable alternative
- pedestrian movement and amenity is prime concern

Bicycle Street

- provide safe route for bicycles
- special effort made to increase safety
- transit vehicles permitted
- limited curb cuts
- enhance pedestrian environment

**Figure 5. Proposed street functional classification plan showing major and minor transit streets.**




Major Transit Street

- facilitate movement of transit vehicles
- special effort to improve bus speed and reliability
- buses given preferential treatment
- curb cuts limited near bus stops
- convenient and comfortable transfer points

Minor Transit Street

- provide local transit service
- provide for frequent bus stops
- provide local bus service
- curb cuts limited near bus stops
- convenient and comfortable bus stops

step one, requiring the submission of a streetscape plan at the beginning of the building process, before underground permit approval is given, and at the end, before paving and other public space permits are issued. Although the review process does not replace any public space permit requirements, it provides a coordinated, one-step review by the city DOT of elements in the public space.

Plans for more than 28 projects have formally been submitted and at least a dozen more developers have met with staff for guidance. Although there have been minor problems of coordination in establishing the process, developers have, for the most part, been supportive and have voluntarily followed the guidelines. However, all developers are unlikely to meet the standards unless required to do so. Passage of authorizing legislation is needed to ensure the success of the program.

## Sidewalk Cafe Legislation

The District of Columbia DOT has worked closely with the City Council and citizen groups to develop sidewalk cafe legislation. The purpose of this legislation is to preserve the pedestrian clear space and provide an attractive and comfortable pedestrian environment. Many of the existing sidewalk cafes have been constructed so that they make pedestrian circulation difficult. Others have erected "permanent" walls that create a de facto advance in the building line and have negative effects on the pedestrian environment.

The legislation specifies that the cafes may not be enclosed between May 15 and October 15 and may not project more than 20 ft from the building line or occupy more than 60 percent of available surface space. All existing enclosed sidewalk cafes must comply with these standards within 18 months of the effective date of the act.

## Public Transit

The analysis has shown that many of the arterial roadways leading to the downtown are congested today, and downtown development committed for 1985-1986 will use up much of the existing capacity on the downtown streets. As a result, a policy that gives priority to the use and development of public transit service to the downtown has been adopted.

To ensure the city's return on its Metrorail investment, increased emphasis on both the use and revenue-generating potential of the system is necessary. As stated earlier, the system must be operating at its design capacity of 2-min headways and eight-car trains if it is to accommodate year-2000 demand. The city DOT encourages developers to construct mixed-use projects in order to balance transit demand over the day and evening hours. In this way, the system will be used during peak and nonpeak travel periods.

Proposed changes to the zoning regulations permit parking requirements for nonresidential structures within a radius of 800 ft of a Metrorail station to be reduced by 25 percent. In addition, the Board of Zoning Adjustment will be able to reduce or eliminate the amount of required parking spaces for nonresidential buildings if the building is provided with a direct connection to a Metrorail station or there is a high level of public transportation service in the area.

The current road network in the downtown offers little in the way of preferential treatment for buses. The street classification policy defines a system of bus streets with the goal of improving bus level of service, travel times, and schedule adherence. But stops in the downtown are not well designed, signed, or located. The widening of the bus-passenger waiting islands along K Street from 6 to 13 ft and the installation of shelters is one step being taken to improve the situation. The city DOT will begin designing and installing attractive and functional bus shelters for the entire central business area in the fall of 1983.

The District of Columbia DOT intends to work closely with the private sector to develop transit incentive and transit promotion programs. A downtown transportation coordinator will be hired for this purpose. The coordinator will make available

to employees WMATA's bus-rail combination flash pass and encourage employers to provide passes to employees at a discount, free, or in lieu of subsidized parking. The coordinator will have at his or her disposal a terminal so that transit information can be provided to employees by using WMATA's AIDS computerized schedule and routing information system. The coordinator will also provide printed transit information. The transit promotion program will work in concert with the parking management program to encourage a mode shift to transit.

The coordinator will also work with employees to develop flexitime programs to alleviate the peak load on the Metrorail and bus system, which will decrease operating costs. For example, for a 30 percent mode split, if 60 percent of travel occurs during the peak hour there will be 32 700 transit trips. However, if the peak hour generates only 50 percent of the transit trips, there will be 27 250 transit trips, or a reduction of 17 percent in required transit capacity.

### Ridesharing

Policy actions to encourage ridesharing are recommended elements of the downtown plan. Office buildings, in particular, provide an excellent focus for ridesharing and other TSM programs. Developers, building owners, and employees will be asked to organize activities such as carpool matching, preferential parking for carpools and vanpools, distribution of transit passes, and staggered work hours. The proposed changes to the zoning regulations permit the amount of required parking to be reduced or eliminated if the building has a ridesharing program approved by the director of the city DOT.

The Washington Area Council of Governments (COG) is operating an areawide ridesharing program. Currently, COG has ridesharing coordinators representing the federal government, Virginia, and Maryland. However, no such person or activity exists for Washington (except the federal sector). The downtown transportation coordinator will work closely with COG, making use of their forms, data bases, and matching capabilities. The coordinator will work with employees to publicize the program, distribute ridesharing forms, obtain the matches on a terminal in his or her office, and, once a sufficient data base has been established, provide real-time matches at the employment site by using a portable terminal.

### Parking Management

A balanced parking supply is necessary to support the objectives of the downtown plan. If an oversupply of inexpensive long-term parking is made available, there will be a strong incentive for the commuter to drive alone to work. A successful parking management program will reinforce transit, vanpool, and carpool travel and the walk- or bicycle-to-work trip and thus alleviate the problems associated with the enormous growth predicted for the downtown. The city DOT has been working closely with the Zoning Commission and the Board of Trade to develop new parking regulations for the downtown. The following are some of the modifications that have been proposed:

1. Reduction or elimination of parking requirements for buildings with a direct Metrorail connection or an approved ridesharing program or for buildings located in an area with a high level of public transit,
2. Reduction in the amount of required parking by up to 50 percent if it is located in a collective or shared parking facility,
3. Provision by hotels of off-street parking spaces for tour buses within a 4-mile radius of the hotel, and
4. Provision of bicycle parking spaces equal to or greater than 5 percent of the required number of automobile parking spaces.

The District of Columbia DOT has developed and is maintaining an up-to-date on- and off-street parking inventory within the downtown that shows the location, type, description, and characteristics of use. A microcomputer model has been developed for comparing the parking supply for each sector of the downtown with the demand for parking, given the mode split and automobile occupancy goals. The model can test the effect of various policy alternatives for five-year increments up to the year 2000. The city DOT is able to inform developers of the amount of parking to be provided consistent with its goals. Current trends indicate a parking supply that will be adequate for office-oriented needs and that will work toward lower automobile use. Relatively high prices and strong demand for spaces can be expected.

Complementary to these activities is the highly successful parking enforcement and adjudication program. Before the implementation of this program, a study found 4 illegally parked vehicles per block in close-in residential neighborhoods and 10 illegally parked vehicles per block in the downtown. The Bureau of Parking and Enforcement was established to perform parking studies, manage the parking meter operation, and enforce parking regulations. More than 50 civilian parking patrol aides issue tickets, and more than 450 illegally parked vehicles are towed each day. Cars belonging to scofflaws are immobilized by placing a Denver boot on the front tire. The owner must pay all outstanding fines plus a $25 booting fine before the vehicle will be released. The Bureau of Traffic Adjudication was established to process all parking offenses and remove this burden from the court system.

The residential parking permit program has also been very successful in helping the city achieve its transportation goals. Commuters had been parking in neighborhoods near the city center, major traffic generators, or major transit routes. Following a petition signed by a majority of the residents on a block, an investigation is conducted to determine whether at least 70 percent of the available spaces are occupied and at least 10 percent of the vehicles parked are from outside the District. If the street qualifies, signs are installed and permits are sold for $5/year.

### Goods Movement

Although it is realized that goods movement activities are essential for the vitality of the city, unregulated truck access and loading will disrupt traffic operations and pedestrian activity. To minimize potential conflicts, an effective goods movement policy must deal with both the design of facilities (number, size, and location of curb cuts, alleys, and loading docks) and the time of day during which goods movement activities are permitted. Proposed amendments to the zoning regulations include the following topics related to goods movement:

1. Requirements on the size and number of loading berths have been modified to reflect better the actual need.
2. All loading berths are to be accessible directly from an improved alley or from private driveways that are 12-25 ft in width and lead to an improved alley. Access from a street is allowed only if approved by the director of the city DOT.

3. Curb cuts must be no closer than 40 ft to a street intersection for berths serving 30-ft vehicles and no closer than 55 ft for larger vehicles.
4. Joint loading berths serving two or more buildings are permitted.
5. The Board of Zoning Adjustment is authorized to reduce or eliminate the number of loading berths required and to approve the use of off-site loading facilities, including joint loading berths for buildings that front on a major pedestrian-emphasis street.

To ensure that goods delivery does not impede pedestrian and traffic movement within the downtown public right-of-way, the city DOT is considering putting time restrictions on certain activities and on certain streets where this is deemed appropriate. Goods movement and delivery criteria will be established for each street classification.

## CONCLUSIONS AND SUMMARY

The District of Columbia DOT has developed a TSM program designed to maximize the use of public space in the downtown for the mutual benefit of all travel modes. This management plan is part of a new Master Plan for Downtown Washington, which includes a street classification system, a parking management program, public transit enhancements, carpool and vanpool incentives, improved pavement markings and signs, regulations governing the movement of goods, and improved safety and security for bicycle users.

This coordinated TSM planning effort is a result of the city DOT's analysis of the potential effects on the transportation system that could result from anticipated land development by the year 2000. Travel demand, mode choice, intersection and arterial capacity, transit needs, parking supply and demand, and goods movement were all examined. The findings of the analysis concluded that a balanced approach to transportation service delivery in the downtown was necessary if the livability and diversity goals set for the downtown were to be realized.

As the level of activity in the downtown increases, the TSM plan should provide for fewer conflicts among travel modes while affording a high level of service for all movements. A pedestrian network, for example, will be designed to provide safe and enjoyable pedestrian access to all portions of the downtown. Sidewalk clutter will be removed and vehicle intrusion minimized, which will result in improved pedestrian mobility. Streetscape guidelines will provide a high level of sidewalk treatment complemented by uniform signing and lighting. Automobile level of service will be maintained through the encouragement of the transit and ridesharing modes, restrictions on goods delivery, and a limitation on curb cuts on major through-traffic routes. The existing downtown signal system is being replaced, which will greatly improve reliability. Metro buses will be given priority and will run more efficiently on bus-oriented streets.

The development community will be a major participant in the TSM program. Revised parking standards for new buildings will require carpool and vanpool spaces and encourage, through incentives, the establishment of transit incentive programs for tenants of new buildings. Thus, central-city employees will be encouraged, at the workplace, to rideshare or take transit.

These initiatives should improve the overall use of public space in the downtown and, over time, provide transportation services that will complement the objectives of the Master Plan for Downtown Washington.

## REFERENCES

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2. Interim Materials on Highway Capacity. TRB, Transportation Research Circular 212, 1980.

*Publication of this paper sponsored by Committee on Transportation System Management.*

# Making Progress with Traffic Restraint: The Role of Research

**A.D. MAY**

**The range of measures proposed for restraining peak-period car traffic in urban areas is reviewed, and it is demonstrated that very few of them have been successfully implemented. Based on reported decisions and discussions with decisionmakers, the reasons for rejection of these proposals are identified and the strength of the criticisms made is assessed. Although the need for restraint is still not clearly demonstrated, it is concluded that traffic restraints can probably be justified as a means of improving efficiency and the environment and that fiscal measures are the most appropriate for further development. A number of issues are identified on which further research could usefully concentrate to ensure that future proposals can be more adequately formulated, and several new research developments in the United Kingdom that will contribute to this are mentioned.**

The year 1983 marks the 20th anniversary of the publication in the United Kingdom of Traffic in Towns (1), a report whose influences are still felt in much of current policy on urban road provision, traffic control, and environmental management. Although many of its recommendations have found their way into practice, not just in the United Kingdom but around the world, one is particularly noticeable for its absence. Lord Crowther, in his preface to the report, said, "Distasteful though we find the whole idea, we think that some deliberate limitation of the volume of motor traffic in our cities in quite unavoidable." In practice, however, with one or two notable exceptions, politicians in the United Kingdom and elsewhere have avoided such limitations for the past two decades and show no signs of implementing a policy of traffic restraint in the near future. Why is this? Were Crowther and Buchanan and his team wrong in their analysis? Have the