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Madison Avenue Dual-Width Bus Lane Project

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On May 26, 1981, New York City implemented an exclusive dual-width bus lane on Madison Avenue in midtown Manhattan, which was funded by a one-year federal demonstration grant. The facility operates from 2:00 to 7:00 p.m. on weekdays and carries 25 000 passengers daily. It shares a roadway with three lanes of mixed traffic and is defined by pavement markings and overhead signs, accompanied by intense enforcement. Initial results indicated that (a) peak-hour bus speed was increased by 83 percent, (b) peak-hour bus reliability was increased by 57 percent, (c) peak-hour bus density was reduced by 45 percent, (d) traffic speed on Madison Avenue was increased by 10 percent, (e) average speed on parallel avenues was unchanged, and (f) average speed on eastbound cross streets was unchanged and on westbound cross streets was reduced by 6 percent. This project represents one of the most ambitious transit-priority projects for an urban arterial short of a complete ban of other traffic. The evolution and results of the project are described, and the implementation process is emphasized.

The concept of exclusive bus lanes is well established. It has been tested on expressways and urban streets throughout the United States and is now an accepted method of moving more people faster. But the institution of a dual-width bus lane on the congested streets of midtown Manhattan must be one of the severest tests of this approach.

This paper presents the rationale for selecting Madison Avenue as the locale for such a project and describes the implementation of the project and its impacts.

DUAL-WIDTH BUS LANE PROJECT

Project Background

Planning for a major surface transit improvement in midtown Manhattan began in 1979. All major avenues in midtown Manhattan were examined as possible candidates. Madison Avenue was selected because it was characterized by the following:

1. The highest bus volumes on any midtown arterial--approximately 200 buses during the peak hour (approximately 24 000 people travel by bus between 2:00 and 7:00 p.m. on Madison Avenue),
2. The lowest bus travel speeds on any midtown avenue during midday and evening periods--approximately 4 mph, and
3. The lowest automobile travel speeds on any midtown avenue during the evening period--approximately 5 mph.

These characteristics of Madison Avenue stem from its location as the central corridor for office development in midtown. Five local bus routes (with a combined headway of 53 s during the peak hour) and 32 express bus routes traverse its length. [Express buses run nonstop between the Manhattan central business district (CBD) and residential areas in each of the city's boroughs.] Subway lines flank it two blocks away on both sides. A major commuter railroad terminal (Grand Central Station) is one block away on Park Avenue at 42nd Street (see Figure 1).

The site conditions of Madison Avenue are as follows:

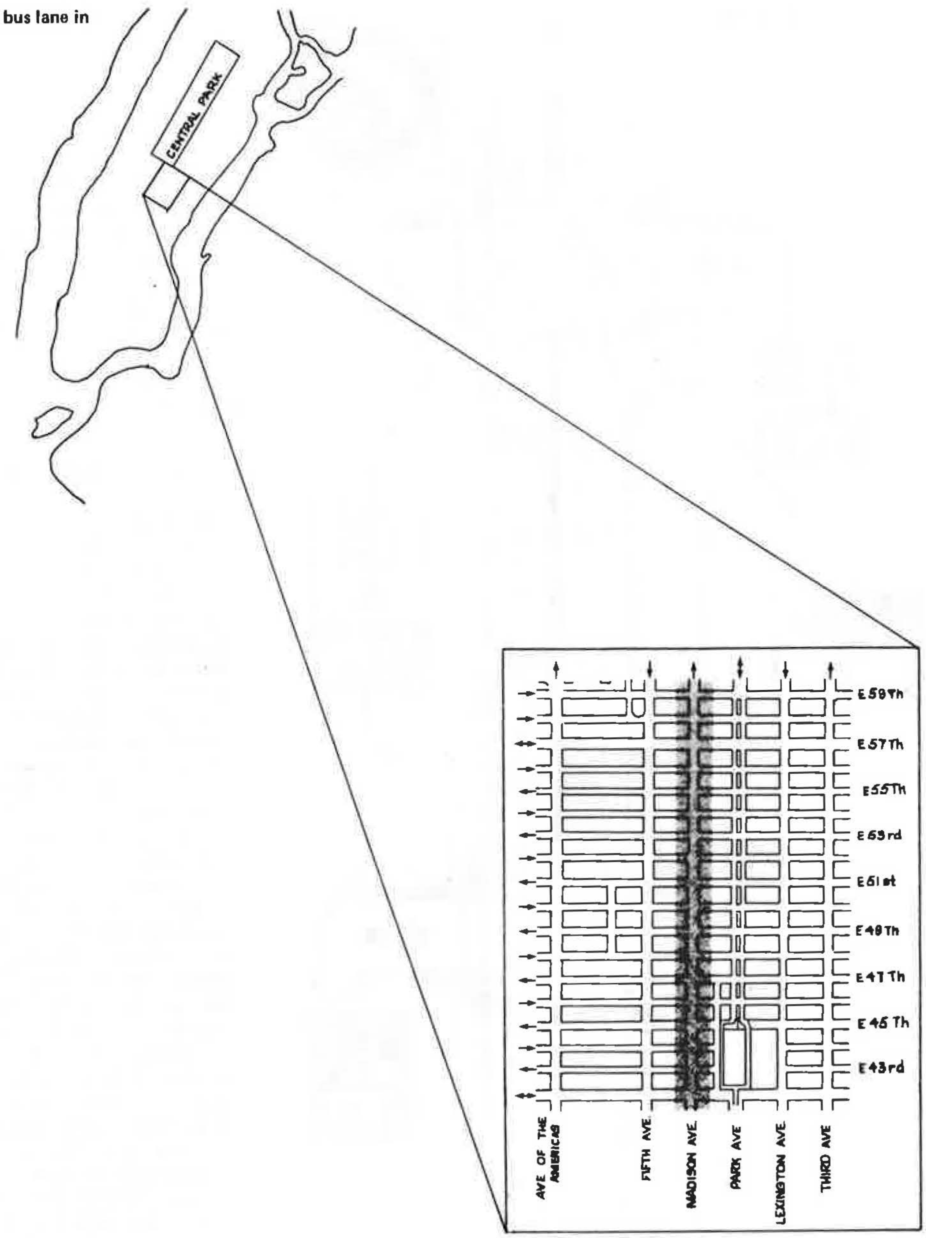
1. Roadway widths--Madison Avenue occupies an 80-ft right-of-way between 42nd and 60th Streets. The right-of-way consists of a 54-ft roadway and 13-ft sidewalks.
2. Traffic control devices--Madison Avenue is a one-way northbound arterial. Left turns are prohibited at the two-way cross streets in the project corridor. The remainder of the cross streets are one way. All intersections are signalized. There is a 27-mph northbound signal progression.
3. On-street parking regulations--Before implementation, the entire curb lane along the east (right) side of Madison Avenue was signed "No Standing, Bus Zone". Between 38th and 60th Streets, parking was prohibited along the west (left) curb, except for 54 spaces allocated for diplomats, 7 for the press, 11 for cars of handicapped drivers, and 5 for taxis.
4. Surface transit system--Between 42nd and 59th Streets Madison Avenue is directly served by 5 New York City Transit Authority (TA) local bus routes, 15 TA express bus routes, and 17 private express bus routes.
5. Land use--Both sides of Madison Avenue are characterized by office towers. At the time of project implementation, four major buildings were under construction.

Project Design

After consideration of several approaches, including single- and double-width contraflow lanes, a transit mall, and rerouting of buses, the dual-width concurrent-flow approach was selected as optimal. The final design consisted of the following elements:

1. Reorganization of bus stops along the right curb. The frequency of bus stops for local buses was changed from every other block, on average about every 500 ft, to every third block, about every 750

Figure 1. Location of Madison Avenue duel-width bus lane in midtown Manhattan.



ft. The frequency of stops for express buses was changed from an average of every five blocks (1250 ft) to every seven blocks (1750 ft). In addition, bus stops were removed from critical block faces at points of anticipated high congestion.

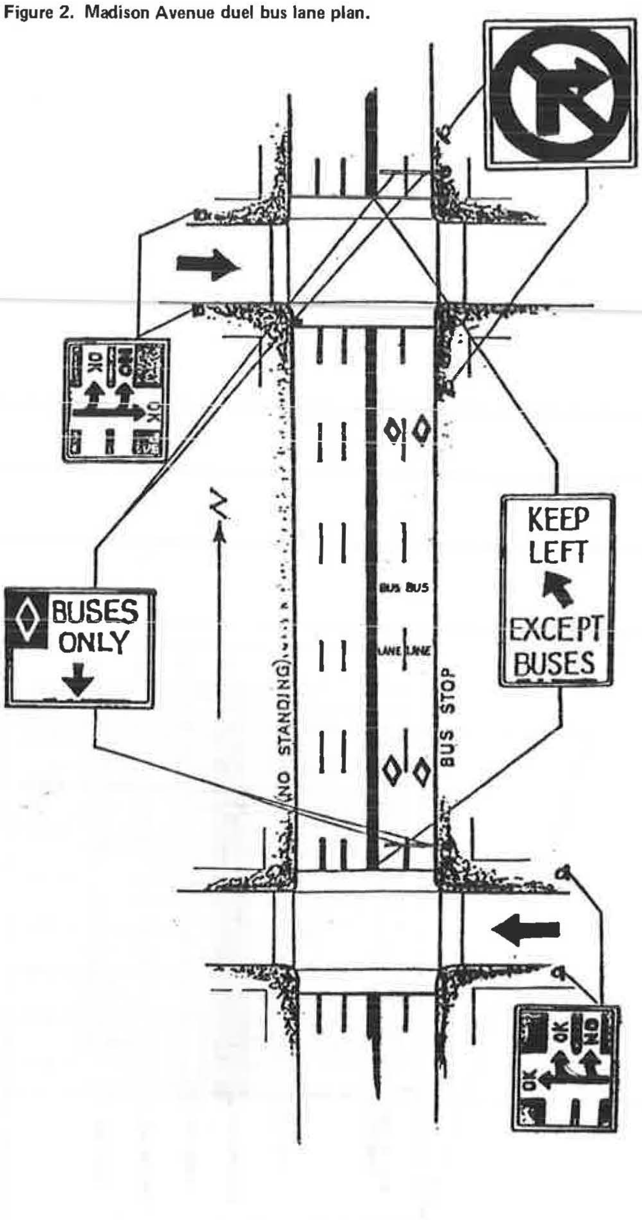
2. Removal of all parking from the left curb during hours of bus lane operations. Authorized parking was relocated to various cross streets, and taxi stands were eliminated. Replacing these were two regulations: "No Standing Except Trucks Loading and Unloading, 7 a.m.-1 p.m., Except Sunday", and "No Standing, 1 p.m.-7 p.m., Except Sunday." This was to allow vehicles to turn left from the left curb lane during hours of bus lane operations and to change the second-from-the-left lane from a turning lane to a through lane.

3. Dedication of the right two lanes exclusively for buses between 42nd and 59th Streets (0.85 mile), 2:00-7:00 p.m., weekdays. The selected cross section of the bus lane (from right to left) consists of two 11-ft lanes for buses, a 3-ft solid white thermoplastic mall to separate the bus lanes from the mixed-traffic lanes, two 10-ft mixed-traffic lanes, and a 9-ft mixed-traffic curb lane. The bus lanes are identified by overhead signs, pavement markings of thermoplastic diamonds with the word message "Bus Lane", and roll-out signs at the head of each block (see Figure 2). Vehicles from the cross streets are allowed to turn into Madison Avenue but not into the bus lane. Taxis and trucks as well as cars are prohibited from the bus lane, except as described in 5 below.

4. Prohibition of right turns. For capacity and safety reasons, and to prevent confusion in enforcement, right turns were banned from north of 42nd Street to south of 62nd Street, a distance of a little under 1 mile. Within these limits, traffic destined for areas east of Madison Avenue either had to avoid Madison Avenue or execute three left turns instead of a right turn.

5. Allowance of taxis to 46th Street. As part of the public transportation system, taxis are allowed certain privileges not accorded other vehicles. In the case of the Madison Avenue bus lane,

Figure 2. Madison Avenue duel bus lane plan.



taxis with passengers are allowed to enter the bus lane at 42nd Street and proceed without stopping to 44th or 46th Street, where they must turn right. This eliminates considerable circuity for taxis from Grand Central Station.

6. Design of termination points. The project starts at 42nd Street, where the avenue widens from 45 to 54 ft, curb to curb. Advance warning signs were placed upstream at several locations. The project ends at 59th Street, the northern boundary of the CBD where traffic generally becomes lighter, but the first eastbound street where a right turn is possible is 62nd Street. Heavy turning volumes were anticipated at this location. To accommodate these vehicles, the block face on Madison Avenue between 61st and 62nd Streets was cleared of bus stops, the parking regulations on 62nd Street were changed to eliminate standing along one curb during the hours of bus lane operation, and additional traffic signal green time was provided.

7. Hours of operation. The Madison Avenue bus lane was originally envisioned as a 24-h installation. However, as planning progressed, it became apparent that there were constituencies with strong feelings against disrupting traffic during hours when bus volumes were light. Because Madison Avenue serves primarily as an outbound artery, the strategy that was finally adopted was to establish the bus lane for the period of highest congestion (2:00-7:00 p.m.) with intense enforcement.

8. Enforcement. The decision to adopt a part-time operation implied a reliance on enforcement rather than on a physical barrier to limit violations. A staff of 24 civilian enforcement agents plus supervision was funded for one year by a federal grant.

9. Restriction on construction and street openings. Rules were established forbidding the use of Madison Avenue, including the curb lane, for storage of construction equipment or supplies between 1:00 and 7:00 p.m. All street openings except for verified emergencies were prohibited except at night.

PROJECT IMPLEMENTATION

Preliminary planning for the project was performed by the consulting firm of Edwards and Kelcey, which produced a report on the project in April 1980. As the project developed, interested community and professional groups were brought into the planning process. By the time it was implemented, 64 separate organizations had been exposed to, or participated in, its design. The planning culminated in a one-year Section 6 (Urban Mass Transportation Act of 1964, as amended) demonstration grant request for \$788 000, which was awarded on September 30, 1980.

The Madison Avenue dual-width bus lane project was organized into three phases for implementation. Phase 1 was the reorganization of bus stops along Madison Avenue between 38th and 63rd Streets. This was completed by March 30, 1981. Phase 2 was the relocation of authorized parking and the change in parking regulations on the left (west) curb of Madison Avenue between 38th and 62nd Streets. This was completed by May 15, 1981. Phase 3 was the implementation of the Madison Avenue dual-width bus lane itself on May 26, 1981.

Prior to the implementation of each phase, a public-information campaign was conducted, primarily through the distribution of fliers and direct contacts with affected individuals and groups (see Figure 3). In addition, during the first week immediately following bus stop reorganization, professional staff was assigned to aid travelers looking for their new bus stop locations.

Construction of four major buildings on Madison Avenue and street openings by utilities had to be controlled for smooth implementation of the project on schedule. Special meetings were held with groups involved in these functions, and rules were laid down forbidding activity that would impact the avenue during hours of bus lane operation, except for verified emergencies. Experience has shown that this prohibition has to be constantly monitored to ensure compliance.

The implementation of the bus lane on May 26 went smoothly, owing principally to the following special procedures:

1. An early morning tour of inspection by all responsible agencies to eliminate any last minute problems.

2. The establishment of an on-site communications command post. This was a trailer supplied by the Police Department equipped with radios and telephone lines. A list of emergency telephone numbers was developed. The command post was constantly manned by the commanding officer for the traffic control agents, by the planning staff, and by the police.

Figure 3. Public information fliers.

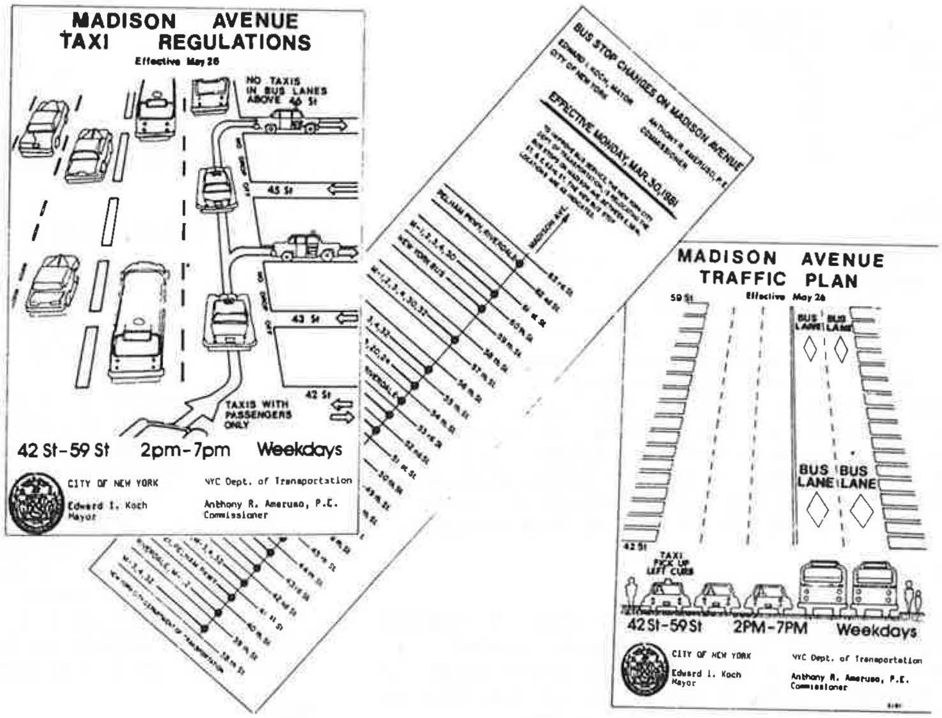
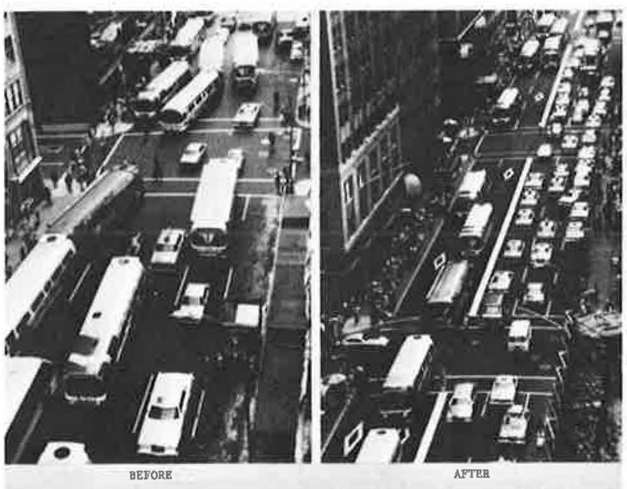


Figure 4. Before and after photographs of bus lane.



3. Constant surveillance during the first weeks at critical locations by radio-equipped members of the planning staff.
4. Establishment of a radio-equipped observation post on a high building.
5. Intensified enforcement during the first two weeks.

The normal complement of traffic and parking agents was nearly tripled and a police car was assigned to the bus lane. Six tow trucks were posted throughout the corridor to quickly respond to disabled or illegally parked vehicles, and the bus companies were required to provide trucks capable of towing buses.

IMPACT ANALYSIS

The Madison Avenue dual-width bus lane project was implemented by the New York City Department of Transportation on May 26, 1981 (Figure 4). The results show great benefits and limited adverse impacts on displaced traffic.

Bus Speeds and Reliability

Average peak-hour (5:00-6:00 p.m.) bus travel time through the project corridor decreased from approximately 18 min to less than 10 min (-45 percent). Speeds increased from 2.9 to 5.3 mph (+83 percent). During the entire 2:00-7:00 p.m. period, average bus travel time declined from 14.5 min to less than 9 min (-40 percent). Speeds increased from 3.5 to 6.0 mph (+71 percent).

An even more important effect than improvement in average bus speeds was an improvement in bus reliability. For peak hours the standard deviation of travel was cut by 59 percent (2.7 min) for local buses and by 56 percent (3.5 min) for express buses. The standard deviation as a fraction of the average travel time dropped from 26 to 18 percent for local buses and from 35 to 31 percent for express buses. In terms of the 85th percentile, travel times went from 22 to 13 min for local buses and from 25 to 11 min for express buses.

Figure 5 shows this information graphically. In comparing before and after trip times, note that the graphs are shifted to the left and are more compact. This illustrates how both trip times and dispersion in trip times were dramatically reduced.

Bus Volumes

Bus volumes for the bus lane operating period remained essentially unchanged. The total number of buses that use the bus lane for the entire 5 h is approximately 680 buses; there is a peak-hour (5:00-6:00 p.m.) average of 218 buses/h, as shown in the table below:

	Bus Volume	
Time (p.m.)	Before	After
2:00-3:00	80	78

Time (p.m.)	Bus Volume Before	After
3:00-4:00	82	83
4:00-5:00	160	174
5:00-6:00	221	218
6:00-7:00	140	125
Total	683	678

Bus Ridership

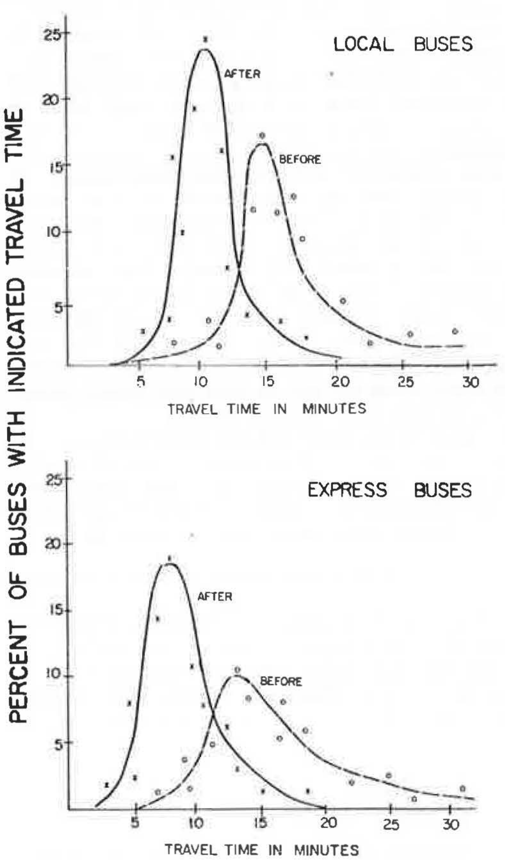
Before implementation, Madison Avenue buses carried approximately 24 000 passengers between 2:00 and 7:00 p.m. Surveys conducted after the implementation showed that the number of buses remained unchanged, yet passengers carried increased 7 percent on the local service and 4 percent on the express service. Comparable figures for Sixth Avenue, a nearby parallel avenue, showed essentially no change. It is assumed that this volume increase was due to the improvement in transit speeds produced by the bus lanes. A passenger attitudinal survey is scheduled for spring 1982 to confirm this result.

Bus Density

Density is a measurement of the number of vehicles that occupy a unit length at a given instant. In this instance, it is related to the visual impact of buses on pedestrians, a key source of dissatisfaction among local residents and merchants.

The relation used in calculating density is as follows: density = flow ÷ speed. Density calculation of buses for the peak hour (5:00-6:00 p.m.) indicated a reduction from 76 buses/mile to 42 buses/mile (-45 percent), with an associated reduction in visual impact and air pollution.

Figure 5. Madison Avenue improvement of travel time and reliability (5:00-6:00 p.m.).



Madison Avenue Automobile Traffic

The effect of the bus lanes on the remaining traffic was manifested primarily in the redistribution of traffic across the remaining lanes. A discussion of this subject is followed by an assessment of this effect on overall speeds, volumes, and other traffic measures.

Distribution of Volume by Lane

In spite of the dedication of two lanes exclusively for buses, the project did not reduce the capacity of Madison Avenue to handle the remaining traffic. This was accomplished by four actions:

1. Removal of buses from mixed traffic,
2. Removal of all parking from the west curb,
3. Elimination of right turns, and
4. Increased enforcement.

To assess these effects, lane-distribution data were collected on Madison Avenue at 47th Street, approximately at the midpoint of the project area. The data show a dramatic increase in the proportion of volume carried in lane 2 and a slight increase in lane 3. The proportion of volume carried in lane 4 dropped because it carried only buses (see Figure 6).

Speeds

Speeds on Madison Avenue improved from 5.7 to 6.0 mph during the 2:00-7:00 p.m. period. During the peak hour (5:00-6:00 p.m.) the automobile speed changes were even greater. Speeds during this period went from 4.8 to 5.3 mph, a 10 percent improvement. There were also corresponding improvements in automobile travel times, as shown in the tables below:

Time (p.m.)	Speed (min) Before	After	Difference	Difference (%)
5:00-6:00	18.2	16.3	-1.9	-10.4
2:00-7:00	15.3	14.5	-0.8	-5.2

Time (p.m.)	Speed (mph) Before	After	Difference	Difference (%)
5:00-6:00	4.8	5.3	+0.5	+10.4
2:00-7:00	5.7	6.0	+0.3	+5.3

Volumes

Volume counts, including buses, show an increase of about 10 percent for the 5:00-6:00 p.m. rush hour, the period with the heaviest congestion, and also the 2:00-7:00 p.m. period (see Table 1).

Classification

A comparison of after data taken in week 2 with before data shows essentially no change in the distribution of vehicle types, as shown in the table below (note that data for 2:00-4:00 p.m. were unavailable):

Time (p.m.)	Period	Classification (%) Car	Taxi	Truck	Bus
5:00-6:00	Before	44	32	8	16
	After	48	32	6	14
4:00-7:00	Before	41	39	9	11
	After	47	35	7	11

Taxi Use of Bus Lane

As mentioned previously, taxis with passengers are

Figure 6. Madison Avenue volume distribution by lane at 47th Street.

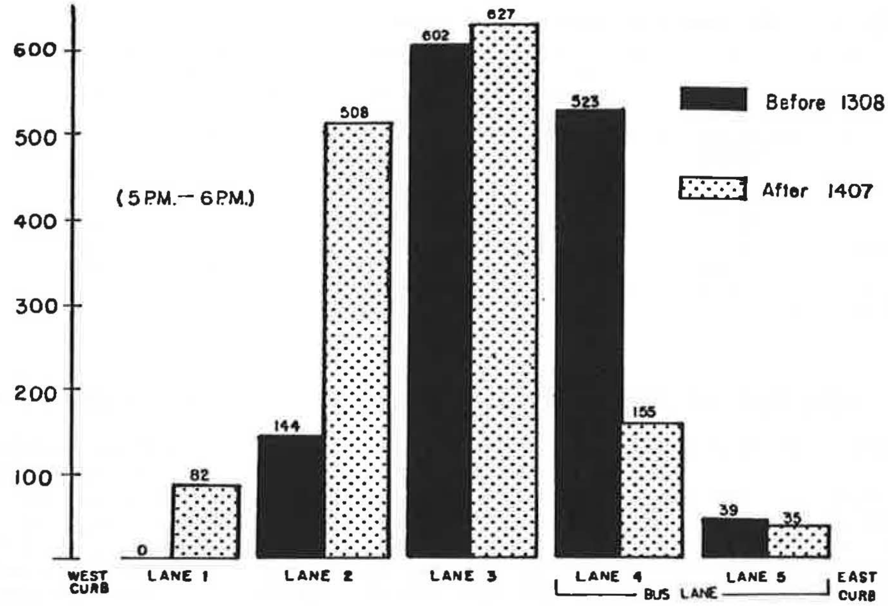


Table 1. Madison Avenue volumes.

Time (p.m.)	Location	Volume (no. of vehicles) Before	After	Change (%)
5:00-6:00	46th-47th Streets	1308	1420	+8
	52nd-53rd Streets	1233	1386	+12
2:00-7:00	46th-47th Streets	6423	6797	+6
	52nd-53rd Streets	6269	6998	+12

permitted to use the bus lane between 42nd and 46th Streets, where they must turn. An analysis was conducted to determine what proportion of taxis on Madison Avenue below 46th Street took advantage of this arrangement. The figures show that about 10 percent of the total taxi volume used the bus lane during both the 5:00-6:00 p.m. rush-hour period and the whole 2:00-7:00 p.m. bus lane operating period.

Impacts on Avenues Parallel to Madison Avenue

To determine the effect of the Madison Avenue bus lane on nearby parallel avenues, the avenues were separated into two groups: northbound (which is the same direction as Madison Avenue) and southbound.

Northbound Avenues

Any effects on other avenues would be expected to manifest themselves primarily on those avenues going in the same direction as Madison Avenue because these would be the routes likely to be selected by diverted traffic. But, as shown in the previous sections, traffic engineering changes on Madison Avenue resulted in no loss of capacity. This minimized the effect on other northbound avenues.

Field data showed that average northbound speed was essentially unchanged. Between 2:00 and 7:00 p.m. the average change is only +1 percent, and between 5:00 and 6:00 p.m. the average change is -2.7 percent (see Table 2). The respective changes in volumes were also small: Average increases were 4 percent between 2:00 and 7:00 p.m. and 2 percent between 5:00 and 6:00 p.m.

Southbound Avenues

Because Madison Avenue is northbound, one would not expect southbound avenues to be very much affected. The one exception if Fifth Avenue. Because vehicles on Madison Avenue that have destinations farther east can no longer turn right, they must either divert to other avenues or make three left turns. A portion of the path of the three left turns involves Fifth Avenue, which might be adversely affected. But, as shown in Table 3, this effect is small.

The average changes in speeds on southbound avenues were slight: a -3 percent change in speed between 2:00 and 7:00 p.m., and a +5 percent increase in speed between 5:00 and 6:00 p.m. The average volume changes were -2 percent between 2:00 and 7:00 p.m. and -2 percent between 5:00 and 6:00 p.m.

Table 2. Changes in speeds and volumes on northbound avenues.

Avenue	Time (p.m.)	Speed Before (mph)	After (mph)	Change (%)	Volume Before (no.)	After (no.)	Change (%)
Third	2:00-7:00	8.1	9.5	+17	8 829	10 076	+14
	5:00-6:00	6.5	6.9	+6	1 746	1 967	+13
Park[a]	2:00-7:00	7.6	7.6	0	7 530	7 441	-1
	5:00-6:00	6.3	6.2	-2	1 704	1 591	-7
Sixth	2:00-7:00	8.5	7.5	-12	11 252	11 227	0
	5:00-6:00	7.3	6.6	-10	2 301	2 268	-1

[a]Northbound.

Table 3. Changes in speeds and volumes on southbound avenues.

Avenue	Time (p.m.)	Speed			Volume		
		Before (mph)	After (mph)	Change (%)	Before (no.)	After (no.)	Change (%)
Lexington	2:00-7:00	10.6	11.3	+7	6436	5838	9
	5:00-6:00	10.0	11.6	+16	1151	1081	-6
Park[a]	2:00-7:00	9.6	9.1	-5	6216	6221	0
	5:00-6:00	10.1	10.9	+8	1174	1178	0
Fifth	2:00-7:00	7.9	7.3	-8	8259	8421	+2
	5:00-6:00	8.1	7.8	-4	1583	1590	0

[a]Southbound.

Impacts on Streets that Cross Madison Avenue

Westbound Streets

Because of the right-turn ban, vehicles on Madison Avenue with destinations farther east are required to make three left turns. This affects primarily the block segments between Madison and Fifth Avenues. For the surveyed streets, average speeds declined from 5.0 to 4.4 mph (-12 percent) for the 2:00-7:00 p.m. period and from 5.2 to 4.9 mph (-6 percent) during the 5:00-6:00 p.m. rush hour.

Less volume data were collected than speed data, but these indicate a change in the expected direction. For the streets surveyed, the average volume between Madison and Fifth Avenues increased by 6 percent from 2:00 to 7:00 p.m. and also during the 5:00-6:00 p.m. rush-hour period.

Eastbound Streets

The effects of the right-turn ban should influence only the block segments between Fifth and Madison Avenues, with two exceptions. The first is 62nd Street. This is the first eastbound street accessible from Madison Avenue north of 42nd Street. Consequently, increased volume on this street was expected, and techniques were developed to increase its capacity, as previously described.

The second exception is the group of streets that includes 40th and 41st Streets and 42nd Street eastbound. These are the last eastbound corridors south of the bus lane and its associated right-turn ban. It was expected that these streets might absorb some of the eastbound traffic that previously turned right between 44th and 59th Streets.

The average speed on the surveyed eastbound crosstown streets declined slightly from 5.3 to 5.1 mph (-2 percent) for the 2:00-7:00 p.m. period and was unchanged for the 5:00-6:00 p.m. period (before and after speeds were 4.8 mph). The speed on 62nd Street increased 39 percent (from 4.4 to 6.1 mph) for the 2:00-7:00 p.m. period and 19 percent (from 4.2 to 5.0 mph) from 5:00 to 6:00 p.m. Excluding 62nd Street, the average volume change between 2:00 and 7:00 p.m. was -6 percent and between 5:00 and 6:00 p.m. it was -3 percent. For 62nd Street the corresponding volume figures were +22 percent for 2:00-7:00 p.m. and +15 percent for 5:00-6:00 p.m.

The speeds on 40th and 41st Streets did not decline. In fact, they increased. This implies that they were not used as shunts to the east for traffic previously turning right between 42nd and 59th Streets. This is confirmed by examination of the turning volume from Madison Avenue onto these two streets, which did not increase. It is assumed that some of this traffic made three left turns to go right farther north. The remainder presumably avoided the corridor entirely, as designed for in the original plans.

CONCLUSIONS AND RECOMMENDATIONS

The Madison Avenue dual-width bus lane imposed major changes on traffic and access patterns in one of the most intensely used corridors in the nation. In spite of this, the implementation went remarkably smoothly. Some of the important considerations that surfaced in developing and implementing the project are the following:

1. Involvement of relevant groups throughout project definition, design, and installation. About half of this contact was made at public meetings that included invited participants in favor of the project, as well as some who might be opposed. The remainder of the contacts was made at meetings to address specific issues within the context of a project that had already gained considerable momentum.
2. Support by an activist administration willing to take risks. The project involved little in the way of permanent installation and was always billed as an experiment that would be withdrawn if it failed. This stance had credibility, since the same administration had shortly before removed a bicycle lane that had proved unpopular.
3. Modest beginning. Originally conceived as a 24-h, 7-day/week facility with physical barriers to prevent violations, the project was reduced in scope to 5 h/day on weekdays without a physical barrier. This minimized the disruption and ensured that there would always be a high frequency of buses visibly benefiting from the lane. The hope is that the success of the bus lane will build support for making the project permanent and for expansion in terms of hours or to other areas.
4. Consistent enforcement. Without physical barriers, the project is completely dependent on consistent enforcement for success. For the first year this is ensured by the federal grant. Thereafter, New York City will have to fund the project. This has its drawbacks, because the city will have to resist the temptation to shift its limited number of enforcement agents from area to area in response to changing needs.
5. Initial enforcement saturation. To ensure a smooth operation during the critical initial period, normal enforcement levels were tripled and professional staff equipped with radios closely monitored every block. A radio control center and elevated observation post were set up, and arrangements were made to respond instantly to disruptions of any sort.
6. Anticipation of problems. One of the subjects we knew would be most difficult was the reduction in access to garages directly east of Madison Avenue. Because of automobile arrival patterns, we felt that the impact of the bus lane on business would be minimal, but we also knew that the garage owners might dispute this. Consequently, special before surveys were conducted to have a measure

against which the effect of the bus lane could be judged.

7. Continuing involvement of planning staff. Although the project became routine after the first two weeks, unusual conditions continued to arise, e.g., plates over street openings shifted to create hazards, construction equipment that obstructed a lane was used without authorization, enforcement personnel were shifted to other locations, etc. Continuous monitoring and interest in the project by the planning staff enabled these problems to be addressed before they seriously degraded bus lane operation.

Data-gathering efforts and analysis are continuing. In the coming period, the following topics will receive particular attention:

1. Experimentation with differing enforcement strategies, including various mixes of signing, personnel, and traffic cone placement, to determine the most cost-effective method of keeping violation rates at an acceptable level;
2. Development of benefit/cost ratios, including the real operating cost savings to the bus companies; and
3. Assessment of impact on access to cross streets where right turns are banned.

ACKNOWLEDGMENT

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Public Transit Planning by Using Interactive Computer Graphics in Bellevue, Washington

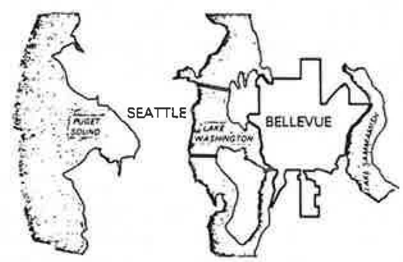
ROBERT A. WHITE, JAMES W. CLARK, AND TOMOKI NOGUCHI

The interactive graphic transit design system (IGTDS) demonstration study was conducted in the City of Bellevue, Washington. IGTDS is a set of computer programs that enable the planner to design and evaluate alternative transit systems through the use of computer graphic techniques. The IGTDS model estimates travelers' choices between automobile and transit modes for systems that serve trips from many origins to a single destination. IGTDS is easy to use; it was especially designed for transportation planners who do not have computer programming backgrounds. Facility requirements are accessed to a time-shared computer system and a computer graphics display terminal. The IGTDS demonstration study successfully accomplished its three primary objectives. IGTDS was used to evaluate different transit service concepts that ranged from the do-nothing alternative (reference case for other alternatives) to the 1990 regional transit plan with park-and-ride service to the Bellevue central business district and transit service to the Crossroads shopping center area. Comparison with the Bellevue manual sketch-planning subarea study revealed that approximately one-half as much effort was required for the IGTDS method as for manual sketch planning. The IGTDS demonstration study evaluated approximately 300 transit service designs, an increase in design productivity over the manual method by a factor of 60 to 1. The different transit system design results produced by IGTDS were presented in graphical form at a high level of detail. The graphic presentation allowed rapid comprehension of the results, and rapid feedback of information also increased understanding of the sensitivity of transportation performance to policy changes. The demonstration study showed that IGTDS is a very useful transportation sketch-planning tool.

Bellevue, Washington, is one of the principal suburbs of Seattle and has a population of approximately 80 000. Bellevue was selected for the interactive graphic transit design system (IGTDS) demonstration study because IGTDS is well-suited to planning new transportation services for small or medium-sized urban areas. Bellevue has a well-defined central business district (CBD), and the current public transportation services that serve Bellevue are provided specifically for the Seattle CBD (Figure 1).

The objectives of the IGTDS demonstration study (1) were as follows:

Figure 1. Location of Bellevue.



1. Apply IGTDS to the solution of actual transit planning problems in a real-world planning effort;
2. Develop comparisons between IGTDS and more conventional transit planning techniques in terms of design results, resource requirements, and other factors; and
3. Test the usefulness of this technology as a communication medium for facilitating decisionmaker understanding of transit patronage and cost variables in an actual transit plan development environment.

An important constraint on the first objective was to perform the study without collecting new data. That is, the input data needed for IGTDS were obtained from previous transportation studies and from readily available local sources.

BACKGROUND

Currently, passenger transportation to and within the Bellevue CBD is provided primarily by private automobiles. In 1979 only about 2 percent of all trips to the CBD were made by public transportation. Island-like building developments surrounded by large parking lots, lack of pedestrian amenities, and wide arterial streets with many curb cuts for