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REFERENCE

1. Contraflow Bus Lanes Survey Results. Chicago Area Transportation Study, Chicago, Dec. 1982.

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Traffic Restraint on New York City's East River Bridges

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ABSTRACT

The analysis of traffic impacts associated with the New York City Department of Transportation's 1980 proposed morning peak-period driver-only ban on the four East River bridges is summarized. The ban would involve some 25,000 out of the 94,000 vehicles that enter Manhattan from 6:00 to 10:00 a.m. on the four free and three toll East River crossings. Its goal was to manage capacity consistent with transportation, economic, and air quality objectives. Driver-only cars occupy about half of all Manhattan-bound road space between 8:00 and 9:00 a.m., yet they carry less than 25 percent of the people. The traffic impact analysis considered likely changes in where, when, and how people travel. The changes were based on the equilibrium condition that would occur as traffic continually redistributes to where there is capacity. The analysis indicated that about 65 percent of the 25,000 driver-only cars on the free bridges would be diverted to toll crossings. The remaining 35 percent would be distributed in a variety of other ways. Under equilibrium conditions it is expected that queues would dissipate by 10:30 a.m. on both the Midtown Tunnel and Brooklyn-Battery Tunnel (currently, queues last until about 9:00 a.m. on the Brooklyn-Battery Tunnel and 10:00 a.m. on the Midtown Tunnel). These estimates assume that the reversible lanes

would be available on both of these facilities by 6:00 a.m. A contraflow bus lane on the approach to the Brooklyn-Battery Tunnel was implemented during 1980 as a traffic management complement. However, the ban was not allowed by the state court. The community and court response suggests that implementing such automobile-restraint measures will be a difficult task in U.S. cities.

The procedures used in analyzing the traffic impacts associated with the New York City Department of Transportation's (DOT) 1980 proposal to ban driver-only cars from the four free East River crossings during the weekday morning rush periods are described. Also, the associated planning and policy implications are summarized.

The proposal to ban driver-only cars was set forth by New York City DOT in June 1980. This demonstration project was suggested as a response to the New York City DOT's desire to reduce car trips in Manhattan. It was proposed for implementation by October 1980. Adding a toll to the free East River crossings—a much discussed proposal—was ruled out because of the time, costs, and impacts involved. The analyses herein reflect both the city's policy and the time constraints that were placed on the analysis.

CONCEPT

The number of vehicles entering Manhattan has nearly

doubled during the past 30 years. This trend is continuing at a rate of approximately 1.5 percent per year. This large increase has strained Manhattan's ability to handle automobile traffic, and it has necessitated a reevaluation of New York City's transportation philosophy. In the past, efforts were directed toward accommodating all vehicles that chose to enter Manhattan. With the continuing increase in traffic volumes, it has become apparent that the limited street space must be managed more effectively. To this end a hierarchy of vehicular trips was established, ranking driver-only cars [single-occupant vehicles (SOVs)] behind such uses as transit, taxis, commercial vehicles, and multi-occupant automobiles.

The proposed ban was designed to restrict the movement of single-occupant automobiles into Manhattan across the East River on the four city-owned free bridges. Drivers without passengers would not be allowed to enter Manhattan from 6:00 to 10:00 a.m., Monday through Friday, on the Queensboro, Williamsburg, Manhattan, and Brooklyn bridges (Figure 1). Under the plan cars with passengers, handicapped drivers, buses, taxis, trucks, and emergency vehicles would be exempt from the ban and would be allowed to use the bridges during these periods.

All types of vehicles would be permitted to use the three toll facilities operated by the Triborough Bridge and Tunnel Authority (TBTA)—Triborough Bridge, Queens-Midtown Tunnel, and Brooklyn-Battery Tunnel.

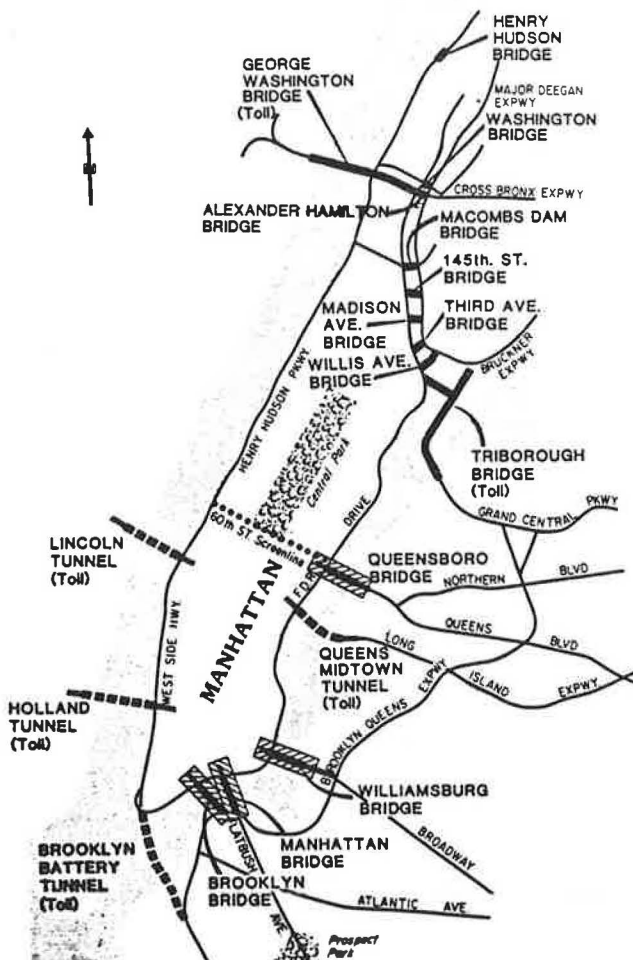


FIGURE 1 Proposed driver-only car ban, East River bridges, 6:00-10:00 a.m.

REASONS FOR THE PLAN

The goal of this plan is to manage the vehicular capacity of the East River crossings in a manner that is consistent with transportation, economic, and air quality objectives of New York City. The plan was structured to give preference to person capacity (the movement of people) rather than to vehicles. It was, perhaps, the boldest and most innovative traffic-restraint proposal for a major metropolitan area in the United States. In a sense, it adapted the Singapore automobile licensing and restraint concept to New York City (1).

In theory the driver-only car ban would apply road pricing (toll) and congestion pricing (travel time) to require peak-period driver-only cars to more equitably pay their share of transportation and nontransportation costs. The high cost of peak-hour automobile travel into congested city centers (such as Manhattan) has been recognized for several decades by transportation planners and economists.

The proposal attempts to redress the allocation of street space between driver-only cars and other vehicles. Driver-only cars occupy about half of all Manhattan-bound road space on the bridges from 8:00 to 9:00 a.m., but they carry less than 25 percent of the people. Finally, the high dependence on public transit for journeys to and from Manhattan (up to 90 percent of all person trips in peak periods) is recognized in the proposal.

The demonstration project was designed to provide a real-world assessment to the following questions.

1. Who will it help and who will it affect? Where will impacts take place?
2. How will toll revenues be affected?
3. How many people will change travel modes or paths?
4. What impacts will it have on air quality and congestion over the long run?
5. How will it influence Manhattan's economy?
6. How will it be enforced to keep violations to a minimum?
7. Is it worth continuing after a 3-month demonstration project? If it is continued, should it be modified?
8. Will the additional queues at toll plazas result in a long-run change in trip times or modes?
9. What are the legal implications?

EXISTING TRAFFIC CONDITIONS

Existing traffic conditions during the morning rush period were analyzed for each of the seven East River crossings. Traffic volume, speed and delay, and capacity data obtained from public agencies were supplemented by field studies of queuing. Traffic demands were derived by adding the number of vehicles queued to the recorded traffic volumes. The driver-only cars that use each river crossing were determined by field surveys.

Daily Traffic Volumes

Daily traffic volumes across the East River are given in Table 1. Some 600,000 vehicles crossed the East River in 43 lanes on a typical 1979 weekday. The Queensboro Bridge and the Brooklyn Bridge carried the highest flows—134,000 and 91,000, respectively. The Brooklyn-Battery Tunnel was the lightest used, carrying about 60,000 vehicles per day. Some 88 percent of all vehicles were passenger cars or taxis, 11 percent were trucks, and 1 percent were buses. The Manhattan Bridge, followed by the Queens-

TABLE 1 1979 Daily Traffic Volumes Across East River Into and Out of Manhattan

Crossing	Levels	Lanes	No. of Vehicles				Percent
			Cars	Buses	Trucks	Total	
Triborough Bridge (Manhattan) ^a	1	6	85,605 ^b	250 ^c	2,030 ^c	87,885 ^b	14.6
Queensboro Bridge	2	9	114,359	2,227	17,380	133,966	22.3
Queens-Midtown Tunnel ^a	1	4	61,669 ^c	1,189 ^c	6,969 ^c	69,827	11.6
Williamsburg Bridge	1	8	65,663	544	15,133	81,340	13.6
Manhattan Bridge	2	6	53,225	137	22,041	75,403	12.6
Brooklyn Bridge	1	6	90,272	64	983	91,319	15.2
Brooklyn-Battery Tunnel ^a	1	4	56,213	1,393 ^c	2,839 ^c	60,445	10.1
Total ^d		43	527,006	5,804	67,375	600,185	

Note: Data are from New York City DOT.

^a Toll facility with a \$0.75 charge.

^b Preliminary data.

^c Estimated by New York City DOT.

^d Total vehicle percentages are as follows: cars = 87.8 percent, buses = 1.0 percent, and trucks = 11.2 percent.

boro and Williamsburg bridges, carried the greatest number of trucks, with 22,000, 17,400, and 15,100 trucks, respectively. The Queensboro Bridge carried the largest number of buses on a daily basis, although the bus flows through the Queens-Midtown and Brooklyn-Battery tunnels are heavier in the peak hours.

Peak-Period Volumes

Westbound peak-period traffic flows on the seven river crossings are given in Table 2 (2). Some 94,000 vehicles entered Manhattan during the 4-hr

period, of which 27,400 entered between 7:00 and 8:00 a.m. and 29,000 between 8:00 and 9:00 a.m. The maximum volumes carried in a single hour were as follows:

1. Queensboro Bridge, 7:00 to 8:00 a.m.--5,690 vehicles (five lanes),
2. Triborough Bridge, 8:00 to 9:00 a.m.--3,860 vehicles (three lanes) (Manhattan Plaza),
3. Brooklyn Bridge, 8:00 to 9:00 a.m.--3,780 vehicles (three lanes),
4. Brooklyn-Battery Tunnel, 8:00 to 9:00 a.m.--3,750 vehicles (three lanes),

TABLE 2 Hourly Variations in Westbound Traffic on East River Crossings (2)

	Tri-borough Bridge	Queensboro Bridge	Queens-Midtown Tunnel	Williamsburg Bridge	Manhattan Bridge	Brooklyn Bridge	Brooklyn-Battery Tunnel	Total, All Crossings
6:00-7:00 a.m.								
Driver-only cars	1,025	1,958	783	1,372	1,100	1,307	1,091	8,636
Other cars	684	1,305	522	914	734	871	728	5,758
Taxis	70	350	60	30	50	100	40	700
Buses	10	29	60	18	0	0	40	157
Trucks	80	423	250	302	344	4	60	1,463
Total vehicles	1,869	4,065	1,675	2,636	2,228	2,282	1,959	16,714
Total passenger car units (PCUs)	1,914	4,291	1,830	2,796	2,400	2,284	2,009	17,524
7:00-8:00 a.m.								
Driver-only cars	2,140	2,328	1,538	1,511	1,496	1,931	1,841	12,785
Other cars	1,427	1,551	1,026	1,008	997	1,288	1,227	8,524
Taxis	120	734	83	40	62	145	80	1,264
Buses	20	46	80	41	8	0	75	270
Trucks	80	1,032	359	663	733	14	100	2,981
Total vehicles	3,787	5,691	3,086	3,263	3,296	3,378	3,323	25,824
Total PCUs	3,837	6,230	3,305	3,616	3,667	3,385	3,410	27,450
8:00-9:00 a.m.								
Driver-only cars	2,159	2,279	1,605	1,219	1,119	2,124	2,048	12,553
Other cars	1,440	1,519	1,070	812	747	1,416	1,365	8,369
Taxis	140	577	167	63	161	204	90	1,402
Buses	30	50	160	7	0	0	150	397
Trucks	90	1,085	351	1,100	1,537	32	100	4,245
Total vehicles	3,859	5,460	3,353	3,201	3,564	3,776	3,753	26,966
Total PCUs	3,919	6,003	3,609	3,754	4,332	3,792	3,878	29,287
9:00-10:00 a.m.								
Driver-only cars	1,952	2,025	1,627	1,075	1,045	1,584	1,856	11,164
Other cars	1,301	1,349	1,084	717	697	1,056	1,237	7,441
Taxis	220	442	249	40	80	114	100	1,253
Buses	20	62	114	10	1	2	40	249
Trucks	90	1,044	423	1,048	1,224	31	90	3,950
Total vehicles	3,583	4,922	3,497	2,890	3,055	2,787	3,323	24,057
Total PCUs	3,638	5,475	3,765	3,419	3,668	2,803	3,388	26,156
Total-6:00-10:00 a.m.								
Driver-only cars	7,276	8,590	5,553	5,177	4,760	6,946	6,836	45,138
Other cars	4,852	5,724	3,702	3,451	3,175	4,631	4,557	30,092
Taxis	550	2,103	559	173	361	563	310	4,619
Buses	80	187	414	76	9	2	305	1,073
Trucks	340	3,534	1,383	3,113	3,838	81	350	12,639
Total vehicles	13,098	20,138	11,611	11,990	12,143	12,223	12,538	93,561
Total PCUs	13,308	21,999	12,509	13,585	14,607	12,264	12,685	100,417

Note: Each bus and truck represents 1.5 PCUs. Driver-only cars = 60 percent of total cars. The number of westbound lanes is as follows: Triborough Bridge = 3, Queensboro Bridge = 5, Queens-Midtown Tunnel = 3, Williamsburg Bridge = 4, Manhattan Bridge = 3, Brooklyn Bridge = 3, and Brooklyn-Battery Tunnel = 3, for a total of 24 westbound lanes.

5. Manhattan Bridge, 8:00 to 9:00 a.m.--3,560 vehicles (three lanes),

6. Queens-Midtown Tunnel, 9:00 to 10:00 a.m.--3,500 vehicles (three lanes), and

7. Williamsburg Bridge, 7:00 to 8:00 a.m.--3,276 vehicles (three lanes).

In general, peak-hour use of each bridge reflects the available roadway capacity.

Driver-Only Cars

The New York City DOT estimated that driver-only cars accounted for 60 percent of all westbound passenger vehicles during the 4-hr morning peak period. The 94,000 westbound vehicles on the seven crossings between 6:00 and 10:00 a.m. included

- 25,600 driver-only cars on the free bridges,
- 31,100 other vehicles on the free bridges, and
- 37,300 vehicles on the toll crossings (driver-only cars, cars with passengers, and trucks).

Driver-only vehicles accounted for 48 percent of all entering vehicles but transported only 25 percent of the people entering across the East River. In contrast, buses represented 1 percent of the vehicles but carried 24 percent of the people. Thus SOVs carried a disproportionately small share of the total passenger load relative to the street space they occupied.

Initial Capacity Estimates

Passenger car units (PCUs) were computed for the peak hours on each facility by assuming that each bus or truck (including light trucks) was equivalent to 1.5 passenger cars (results are given in Table 2). The resulting PCUs for the 8:00 to 9:00 a.m. period are compared with estimated capacities (service level E) in Table 3. Independent capacity estimates from an earlier source are given for comparative purposes. The capacities coordinate closely with actual peak-hour volumes, which indicate that the river crossings essentially operate at capacity during this hour.

Queuing Analysis

Field checks of existing congestion on approaches to the East River crossings are shown in Figure 2. Congestion develops on approaches to all river cross-

ings, which indicates that there is little if any capacity reserve in the system. The congestion that builds up in advance of the Queens-Midtown Tunnel and the Brooklyn-Battery Tunnel are especially significant because these queues may be extended when the driver-only ban is enacted.

Figure 3 shows the queues on approaches to the tunnel crossings by time of day and length of queue as observed during mid-1980. This diagram quantifies the vehicle hours of delay associated with the existing facilities.

Refined Volume-Capacity Analysis

Existing queues were related to flows on the Queens-Midtown and Brooklyn-Battery tunnels to identify actual demands and to refine capacity estimates. It was assumed that the recorded traffic flow represents the actual capacity wherever queues exist. The demand is the sum of the capacity and the observed queue during the same time period. During the 4-hr period demand equaled the westbound volume, exceeded it during the height of the peak, and fell short at other times.

The data in Tables 4 and 5 give the details of the volume-capacity queuing analysis. Salient results are as follows.

1. Maximum queues on approaches for the Midtown Tunnel approximate 625 vehicles. Queues dissipate by or before 10:00 a.m.

2. Maximum queues on approaches to the Brooklyn-Battery Tunnel approximate 170 vehicles. Queues dissipate by 9:00 a.m.

The data in Tables 6 and 7 indicate how these queues would be reduced by opening toll booths earlier and by initiating lane reversals by 6:00 a.m. on the Brooklyn-Battery Tunnel and by 6:30 a.m. on the Queens-Midtown Tunnel. With earlier lane reversals, the maximum queues on the Midtown Tunnel would dissipate by 9:15 a.m. The lane reversals on the Brooklyn-Battery Tunnel would virtually eliminate all queuing on the approaches.

The demands, capacities, and queues given in these tables were used in deriving actual traffic impacts of the driver-only ban on the four free bridges.

AFFECTED MOTORISTS

The proposed driver-only ban would affect some 25,000 motorists on the four free East River bridges

TABLE 3 Volume-Capacity Comparisons Across the East River, 8:00 to 9:00 a.m. Westbound

Crossing	Lanes, 1980	Driver-Only Cars	Other Vehicles	Total PCUs	Capacity (PCUs)	
					Creighton ^a	Preliminary Capacity Estimate
Triborough Bridge	3	2,159	1,760	3,919	4,080	4,080
Queensboro Bridge	5	2,279	3,723	6,002	7,450 ^b	6,000 ^c
Queens-Midtown Tunnel	3	1,605	2,004	3,609	4,170	4,000
Williamsburg Bridge	4	1,219	2,535	3,754	3,800	3,800
Manhattan Bridge	3 ^d	1,119	3,214	4,333	4,810	4,500
Brooklyn Bridge	3	2,124	1,668	3,792	4,700	4,500
Brooklyn-Battery Tunnel	3	2,048	1,830	3,878	4,170	4,000
Total ^e	24	12,553	16,734	29,287	33,180	30,880

Note: Data are from the New York City DOT. It is assumed in the data that driver-only cars are 60 percent of all passenger cars.

^a Data are from estimates done by Rodger Creighton and Associates.

^b Six lanes.

^c Five lanes.

^d Three lanes designated, but four lanes used.

^e Total vehicle percentages are as follows: driver-only cars = 42.9 percent, and other vehicles = 57.1 percent.

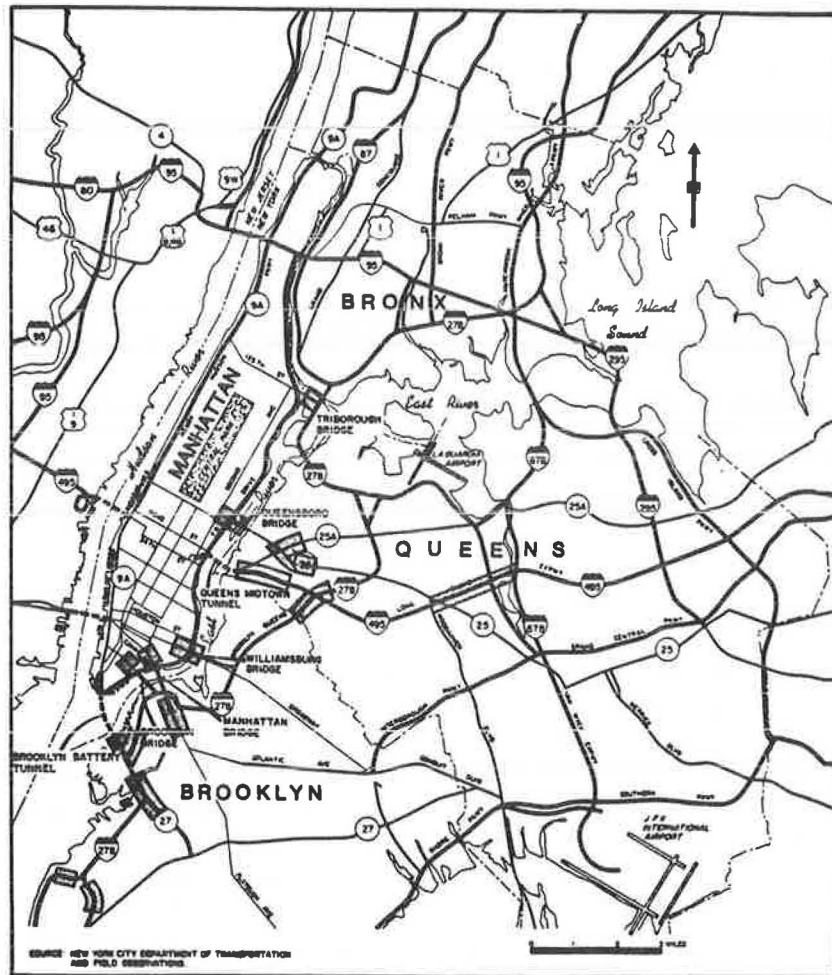


FIGURE 2 Existing queues, East River crossings, 7:30-8:30 a.m.

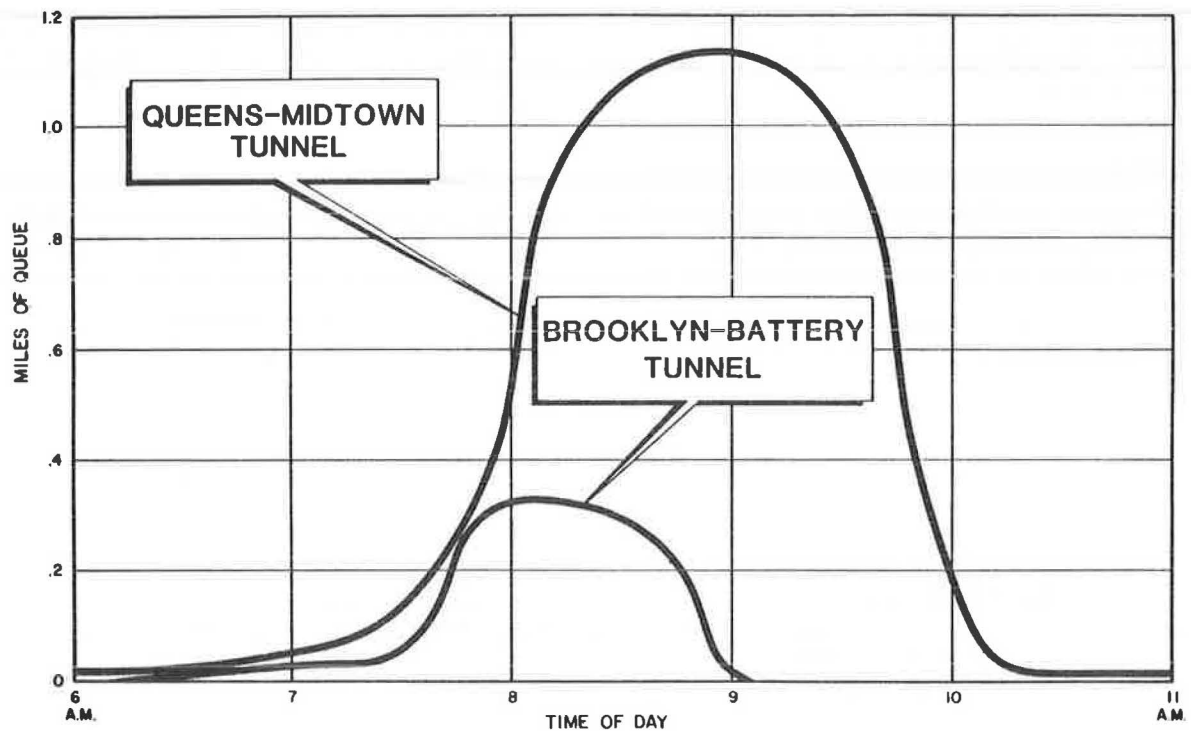


FIGURE 3 Variations in queues.

between 6:00 and 10:00 a.m. These motorists account for less than 1 percent of the 2.87 million people who enter Manhattan each day and 1.7 percent of the people who enter Manhattan from 6:00 to 10:00 a.m. These motorists account for 4.0 percent of the total daily vehicles that enter Manhattan and 27 percent of the peak-period vehicles that cross the East River from 6:00 to 10:00 a.m. The following list gives some statistics on the affected motorists [note that some data are from the Tri-State Regional Planning Commission (3,4), and the data for the driver-only cars are estimated from 1979 bridge data furnished by the New York City DOT]:

1. Total people entering Manhattan (1978): all day = 2,870,000, and between 6:00 and 10:00 a.m. = 1,504,000;

2. Total people entering Manhattan each day from Brooklyn-Queens sector (1978) = 1,364,000;

3. Number of people entering in driver-only cars on four East River bridges (1979) = 25,000; percentage of total people entering Manhattan all day = 0.87, percentage of total people entering Manhattan between 6:00 and 10:00 a.m. = 1.67, and percentage of total people entering Manhattan from Brooklyn-Queens sector all day = 1.83;

TABLE 4 Existing Demand-Capacity Queues, Queens-Midtown Tunnel

Time Beginning	1979 Westbound Volume ^a	Demand	Estimated Capacity ^b	Difference	Cumulative Queue ^c (end of period)
5:00 a.m.	793	793	2,600	1,807 ^d	
6:00 a.m.	1,830	1,830	2,600	770 ^d	
7:00 a.m.	1,585	1,660	1,600	60	60
7:30 a.m.	1,720	1,950	1,750	200	260
8:00 a.m.	1,800	2,085	1,750	335	595
8:30 a.m.	1,859	1,930	1,900	30	625
9:00 a.m.	1,883	1,800	1,900	100 ^d	525
9:30 a.m.	1,882	1,354	1,779 ^e	425 ^d	100
10:00 a.m.	2,805	2,705	3,200	495 ^d	
11:00 a.m.	2,540	2,540	2,900	360 ^d	
12:00 noon	2,276	2,276	2,600	324 ^d	
Total	20,923	20,923			

^aData are from New York City DOT.

^bReflects volumes passing through tunnel where queue exists.

^cField observations, 1980.

^dSurplus.

^eCapacity adjusted from 1,780 to 1,779 to balance volumes.

TABLE 5 Existing Demand-Capacity Queues, Brooklyn-Battery Tunnel

Time Beginning	1979 Westbound Volume ^a	Demand	Estimated Capacity ^b	Difference	Cumulative Queue ^c (end of period)
5:00 a.m.	517	517	3,400	2,883 ^d	
6:00 a.m.	2,009	2,009	3,400	1,391 ^d	
7:00 a.m.	1,700	1,705	1,700	5	5
7:30 a.m.	1,710	1,863	1,700	163	168
8:00 a.m.	1,950	1,940	1,950	10 ^d	158
8:30 a.m.	1,928	1,780	1,950	170 ^d	
9:00 a.m.	1,710	1,710	1,950		
9:30 a.m.	1,678	1,678	1,950		
10:00 a.m.	2,022	2,022	3,400		
11:00 a.m.	1,810	1,810	3,400		
12:00 noon	1,353	1,353	3,400		
Total	18,387	18,387			

^aData are from New York City DOT.

^bReflects volumes passing through tunnel where queue exists.

^cField observations, 1980.

^dSurplus.

TABLE 6 Anticipated Demand-Capacity Queues, Queens-Midtown Tunnel

Time Beginning	1979 Westbound Volume ^a	Demand	Estimated Capacity ^b	Difference	Cumulative Queue ^c (end of period)
5:00 a.m.	793	793	2,600	1,807 ^d	
6:00 a.m.	1,830	1,830	3,600	1,770 ^d	
7:00 a.m.	1,585	1,660	1,900	240 ^d	
7:30 a.m.	1,720	1,950	1,900	50	50
8:00 a.m.	1,750	2,085	1,900	185	235
8:30 a.m.	1,859	1,930	1,900	30	265
9:00 a.m.	1,883	1,800	1,900	100 ^d	165
9:30 a.m.	1,882	1,354	1,900	456 ^d	
10:00 a.m.	2,805	2,705	3,800		
11:00 a.m.	2,540	2,540	3,800		
12:00 noon	2,276	2,276	3,200		
Total	20,923	20,923			

^aData are from New York City DOT.

^bAssumes maximum observed flow rate through toll station.

^cField observations, 1980.

^dSurplus.

TABLE 7 Anticipated Demand-Capacity Queues, Brooklyn-Battery Tunnel (existing traffic and improved operation)

Time Beginning	1979 Westbound Volume ^a	Demand	Estimated Capacity ^b	Difference
5:00 a.m.	517	517	3,400	2,883 ^c
6:00 a.m.	2,009	2,009	3,900	1,391 ^c
7:00 a.m.	1,700	1,705	1,950	245 ^c
7:30 a.m.	1,710	1,863	1,950	87 ^c
8:00 a.m.	1,950	1,940	1,950	10 ^c
8:30 a.m.	1,928	1,780	1,950	170 ^c
9:00 a.m.	1,710	1,710	1,950	
9:30 a.m.	1,678	1,678	1,950	
10:00 a.m.	2,022	2,022	3,900	
11:00 a.m.	1,810	1,810	3,900	
12:00 noon	1,353	1,353	3,400	
Total	18,387	18,387		

^aData are from New York City DOT.

^bAssumes maximum observed flow rate through toll station.

^cSurplus.

4. Total vehicles entering Manhattan each day (1978) = 649,000; and

5. Number of driver-only cars entering Manhattan on four East River bridges between 6:00 and 10:00 a.m. (1979) = 25,000; percentage of total vehicles entering all day = 3.85.

TRAVEL IMPACTS

Estimating impacts was a challenging procedure because there were few, if any, real precedents. Moreover, a complex series of choices are associated with the proposed ban. There would be changes in where, when, and how people travel. There would be changes in mode and route. Like any transport change, a chain reaction of impacts would occur when the project is implemented.

1. The first-day impacts would involve major shifts to toll crossings (where driver-only cars would pay the \$1.00 toll). This would substantially increase the existing congestion at toll plazas.

2. Over time a new equilibrium condition would be reached as traffic continuously redistributes to

where roadway capacity is available. This is a reasonable assumption in a large metropolitan area where motorists have many ways to travel from where they live to where they work.

The general impact sequence is shown in Figure 4. Driver-only cars initially would be required to shift to toll crossings, thus causing an increase in congestion levels. The increased congestion on toll crossings would cause multi-occupant vehicles to shift to free crossings and some driver-only cars to shift to alternative modes, thereby causing some people to become carpool passengers or transit riders. This would serve to reduce congestion on the toll crossings and in the long run return some traffic to the free facilities.

Over time the cyclical effect will stabilize and a net diversion will occur (Figure 5). It was assumed that this stabilization would be achieved within a 90-day test period. Thus congestion that results from implementation of the ban will be less after a period of stabilization has been reached. If such a redistribution did not take place, serious congestion would remain on the toll crossings. This would then lead to revising or discarding the demonstration.

Diversion Estimates

Estimates of equilibrium impacts were derived from various studies of traveler responses to price increases in the New York City area. Results of Hudson crossing driver surveys and Midtown automobile driver surveys provided a basis for making modal diversion estimates. These findings and the resulting diversion estimates for the East River crossings are given in Table 8.

One-third of the drivers of driver-only cars were estimated to change their travel behavior: about half of these motorists would no longer drive because they would become carpool passengers, take transit, or not make the trip across the East River. Another one-third of these drivers would remain on the free bridges but would change their time (before

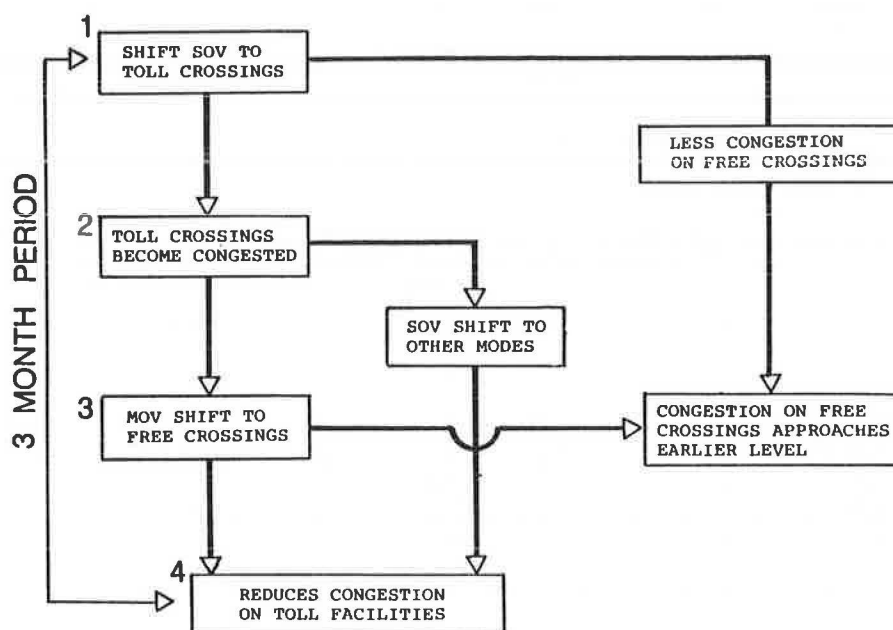


FIGURE 4 General impact sequence.

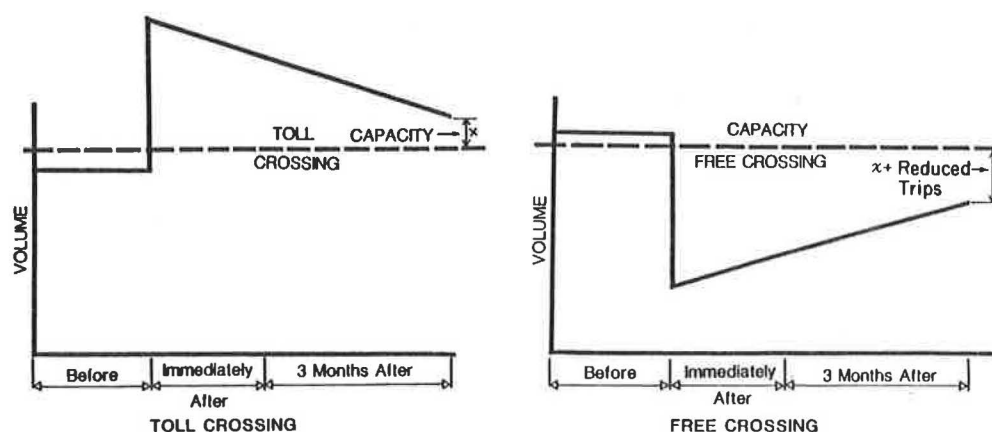


FIGURE 5 Anticipated impacts over time.

TABLE 8 Estimated Effects of a \$1.00 Increase in Tolls or Parking Charges

Item	Hudson River Crossings, All Vehicles, 1978 Survey, Toll Changes ^a (%)				Midtown Automobile Driver Survey, Parking Changes ^b (%)			
	All Trips		Work Trips		All Trips		East River Free Crossings (%): Anticipated Traffic Reduction in Driver Only Cars (peak period)	
	Driver Response	Traffic Reduction (peak hour)	Driver Response	Traffic ^c Reduction (peak hour)	Driver Response	Traffic Reduction (peak hour)		
No change	73	87	77	88	70	84	67	
Change	27	13	23	12	30	16	33	
Join start-up carpool	4	2	4	2	-	-	11 ^c	
Begin taking public transit	4	4	4	4	11	11	8	
Change time of day when trip began	16	5	11	3	-	-	10	
Would not make trip as often (fewer trips)	2	1	2	1	11	5	2	
Would not make trip at all	1	1	2	2	-	-	2	
Change parking place	-	-	-	-	8	-	-	

^a Data are from Levinson et al. (5).^b Data are from Crossley Surveys (6).^c Assumes 5 percent carpool passengers and 6 percent new multiple-occupancy vehicles.

or after the ban), and the remainder would become carpool drivers.

Figure 6 shows details of the anticipated travel impacts of the driver-only ban. About 65 percent of the 25,000 driver-only cars on free bridges would be diverted to toll crossings, and the remaining 35 percent would be distributed as follows:

Impact	Percent	Vehicles
Stay on free bridges in peak	8	2,038
New carpools	6	
Miscellaneous vehicles	2	
Stay on free bridges off peak	10	2,547
Divert to toll crossings	65	16,557
Reduced traffic	17	4,331
Total		25,473

Quantifying Traffic Impacts

Detailed traffic assignments were made for the 25,000 diverted vehicles to the various toll crossings. The steps were as follows.

Step 1. The net traffic remaining on each of the free bridges was computed on an hour-by-hour basis by deducting the driver-only cars that would (a) represent reduced traffic (17 percent) and (b) divert to toll crossings (65 percent). In addition, the traffic that would travel outside of the peak period was reassigned: 6 percent to 10:00-11:00

a.m. and 4 percent to 5:00-6:00 a.m. These vehicles were deducted from traffic in the 4 peak hours as follows: 65 percent of the additional traffic in the 5:00 to 6:00 a.m. period was deducted from the 7:00 to 8:00 a.m. period, and 35 percent was deducted from the 8:00 to 9:00 a.m. period; similarly, 65 percent of the additional traffic in the 10:00 to 11:00 a.m. period was deducted from the 9:00 to 10:00 a.m. period, and 35 percent was deducted from the 8:00 to 9:00 a.m. period. Minor adjustments were made to reflect these time shifts in the traffic diverted to toll crossings. Some 8 percent of the driver-only cars would remain on each free crossing.

Step 2. The traffic diverted to toll facilities was reassigned to each toll crossing in accordance with traffic flow patterns based on reviews of existing travel patterns.

Step 3. Traffic impacts on toll crossings were derived as follows.

1. The diverted traffic was superimposed on the existing toll crossing demands on an hour-by-hour basis, taking into account the anticipated capacities of each toll crossing (i.e., earlier start-up and later ending of the reversible lane operations on the Brooklyn-Battery and Queens-Midtown tunnels).

2. The expected demands were compared with available capacities and queues were identified. Multiple-occupant cars on the toll crossings were

then back diverted to free bridges, based on the following two criteria: (a) 20 percent of the additional queue would remain or (b) not more than 75 percent of the eligible vehicles would shift from the toll crossings. For the Triborough and Queens-Midtown toll facilities it was assumed the 80 percent of the maximum additional queue would divert (20 percent remain). On the Brooklyn-Battery Tunnel a diversion level of 75 percent from toll to free was assumed for eligible vehicles.

3. The resulting 3-month after capacity deficiencies and queues were quantified, and adjustments were made for some shift to the 7:00 to 8:00 a.m. hour, thereby reflecting the motorists' attempt to reduce queues.

4. The resulting demands, volumes, capacity deficiencies, and queues on each toll crossing were estimated.

5. Because at 10:00 a.m. all vehicles would be eligible to use the free bridges, it was assumed that 50 percent of the vehicles queued by (or just before) 10:00 a.m. would shift to the free crossings. Based on this shift, adjusted volumes on each toll crossing were computed.

Step 4. The vehicles shifting from toll crossings to free bridges were assigned to the free bridges according to previously developed traffic distributions. This traffic was then added to the existing traffic remaining on the free bridges.

The hour-by-hour traffic volumes on the seven crossings as of October 1979 and 3 months after the proposed experiment are given in Table 9. A review of the data in this table indicates the following:

1. Total traffic from 5:00 to 11:00 a.m. would decrease from 160,800 to 156,500--about 4,300 vehicles;
2. Total traffic from 6:00 to 10:00 a.m. would decrease from about 100,400 to 90,800--about 9,600 vehicles;
3. Total traffic from 10:00 to 11:00 a.m. would increase from 19,800 to 24,100--about 4,300 vehicles;
4. There would be virtually no increase in the peak flows through the three toll plazas because of capacity restraints; and
5. The peak flows through the free bridges would decrease as follows:

Bridge	Before	After
Queensboro	6,200	5,130
Williamsburg	3,750	3,580
Manhattan	4,330	3,880
Brooklyn	3,790	3,290

FLOW AND CONGESTION IMPACTS

The traffic impacts are far broader than merely redistributing road space by type of user: (a) there would be less overall traffic during the morning peak period with net reductions in Manhattan and across the East River; (b) traffic would be reduced on city street approaches to the free bridges at Queens Plaza, Williamsburg, and downtown Brooklyn; and (c) queues would be limited to express highways that are removed from the business centers.

Current and anticipated queues on the Midtown Tunnel and Brooklyn-Battery Tunnel are given in Table 10. It is expected that queues would dissipate by 10:30 a.m. on both facilities. Maximum delays to individual vehicles could range from about 20 to 30 min (currently, queues last until about 9:00 a.m. on the Brooklyn-Battery Tunnel and 10:00 a.m. on the Midtown Tunnel). These estimates assume that the re-

versible lanes would be available on both of these facilities by 6:00 a.m.

The anticipated congestion impacts are shown in Figure 7. Queues would be reduced on local streets and limited to express highway approaches, where increases in their length and duration are anticipated.

The number of vehicles entering Manhattan on each toll crossing is limited by toll plaza capacity. Therefore, during most of the peak period relatively little additional traffic is expected on Manhattan streets at the exits of the three TBTA facilities.

EXPECTED BENEFITS

Estimates were also made of the impacts of the ban on vehicle miles of travel (VMT), toll revenues, transit ridership, parking revenues, and implementation costs.

VMT

The automobile driver ban is expected to result in 4,300 fewer vehicle trips each day. This corresponds to a reduction of almost 70,000 VMT daily, assuming the 8-mile vehicle trip length derived by the Tri-State Regional Planning Commission. It amounts to about 17,500,000 fewer VMT annually. The travel distances to lower Manhattan from points in Brooklyn and Queens are about the same over toll and free crossings. This is also true for trips to midtown Manhattan from the two boroughs. Therefore, it is unlikely that changes in driver trips between toll and free crossings would increase the VMT.

Toll Revenues

Almost 8,000 additional vehicles would likely use TBTA facilities to enter Manhattan each day. This corresponds to some \$2,000,000 in annual revenues.

Transit Revenues

An estimated 8 percent of the 25,000 driver-only vehicles would divert to public transport services, whereas the equivalent of 1 percent would shift from transit into newly formed carpools. Some 1,750 net additional daily transit riders would generate an annual revenue of \$656,000. The subway system has potential track capacity to carry some 100,000 additional riders in a single hour as compared with the 25,000 driver-only cars in a 4-hr period.

Parking

Some 150,000 vehicles park each day in the Manhattan central business district (CBD). If all 25,000 driver-only cars were removed--an unlikely condition--it would represent a 16 percent reduction. Even then some of the spaces would become available for high turnover parking, thereby reducing revenue loss to the parking industry.

A more realistic impact is the effects of the 4,300 vehicles that would no longer drive to or through Manhattan. This represents less than a 3 percent reduction in the number of parked vehicles in Manhattan at the time of the maximum parking accumulation. Assuming an average parking charge of \$3.60 per day and a parking tax of 14 percent, this corresponds to a daily loss in tax revenue to the city of about \$1,500, or about \$375,000 per year. [These estimates assume that about 70 percent of the

TABLE 9 Current and Anticipated Westbound Traffic Volumes, Equilibrium Conditions (PCUs)

Hour Beginning	Tri-borough ^a (toll)		Queensboro ^b		Queens Midtown Tunnel ^c (toll)		Williamsburg ^d		Manhattan ^e		Brooklyn ^f		Brooklyn-Battery Tunnel ^g (toll)		All Free Crossings		All Toll Crossings		Grand Total, All Crossings	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
5:00 a.m.	415	415	1,684	2,028	793	793	1,430	1,637	1,025	1,215	930	1,208	517	517	5,069	6,088	1,725	1,725	6,794	7,813
6:00 a.m.	1,914	2,373	4,291	2,490	1,830	3,393	2,796	1,534	2,400	1,388	2,284	1,082	2,009	3,896	11,771	6,494	5,753	9,642	17,524	16,136
7:00 a.m.	3,837	4,080	6,230	5,126	3,305	3,800	3,616	2,739	3,667	2,703	3,385	2,196	3,410	3,900	16,898	12,764	10,552	11,780	27,450	24,544
8:00 a.m.	3,919	4,080	6,003	5,031	3,609	3,800	3,754	3,316	4,332	3,883	3,792	2,625	3,878	3,900	17,881	14,855	11,406	11,780	29,287	26,635
9:00 a.m.	3,638	4,055	5,475	4,136	3,765	3,800	3,419	2,808	3,668	3,009	2,803	1,821	3,388	3,900	15,365	11,774	10,791	11,755	26,156	23,529
Subtotal (6:00-10:00 a.m.)	13,308	14,588	21,999	16,783	12,509	14,793	13,585	10,397	14,067	10,983	12,264	7,724	12,485	15,576	61,915	45,887	38,502	44,957	100,417	90,844
10:00 a.m.	2,588	2,588	4,317	5,105	2,805	3,127	2,973	3,578	2,743	3,372	2,385	3,292	2,022	2,997	12,418	15,347	7,415	8,712	19,833	24,059
11:00 a.m.	2,357	2,357	3,764	3,764	2,540	2,540	2,601	2,601	2,707	2,707	2,182	2,182	1,810	1,810	11,254	11,254	6,707	6,707	17,961	17,961
12:00 noon	2,029	2,029	3,271	3,271	2,276	2,276	2,345	2,345	2,412	2,412	2,085	2,085	1,353	1,353	10,113	10,113	5,658	5,658	15,771	15,771
Total (5:00 a.m.-1:00 p.m.)	20,697	21,977	35,035	30,951	20,923	23,529	22,934	20,558	23,154	20,689	19,846	16,491	18,387	22,253	100,769	88,689	60,007	67,759	160,776	156,448

^aCapacity = 4,080.
^bCapacity = 6,000-6,300.
^cCapacity = 3,800.
^dCapacity = 3,800.
^eCapacity = 4,300-4,500.
^fCapacity = 4,700.
^gCapacity = 3,900.

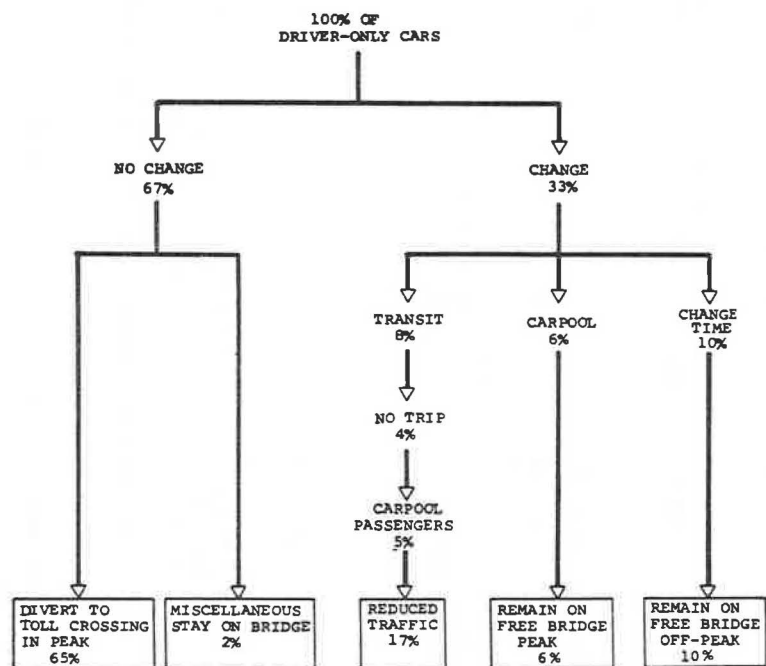


FIGURE 6 Anticipated impacts of driver-only ban on driver-only cars.

TABLE 10 Queue Characteristics

	Current Traffic		Anticipated Traffic with Improved Operations ^a		
	Existing Conditions	With Improved Operations ^a	First Day (no back-diversion)	Before Redistribution After 10:00 a.m.	After Redistribution After 10:00 a.m.
Queens-Midtown Tunnel					
Maximum queue	625	265	3,900	1,200	1,200
Lasts until	10:00 a.m.	9:15 a.m.	1:00 p.m.	10:50-11:00 a.m.	10:15-10:30 a.m.
Brooklyn-Battery Tunnel					
Maximum queue	168	-	5,700	1,950	1,950
Lasts until	9:00 a.m.	-	12:45 p.m.	11:00-11:10 a.m.	10:30 a.m.

^aEarly opening of toll booths' reversible lane.

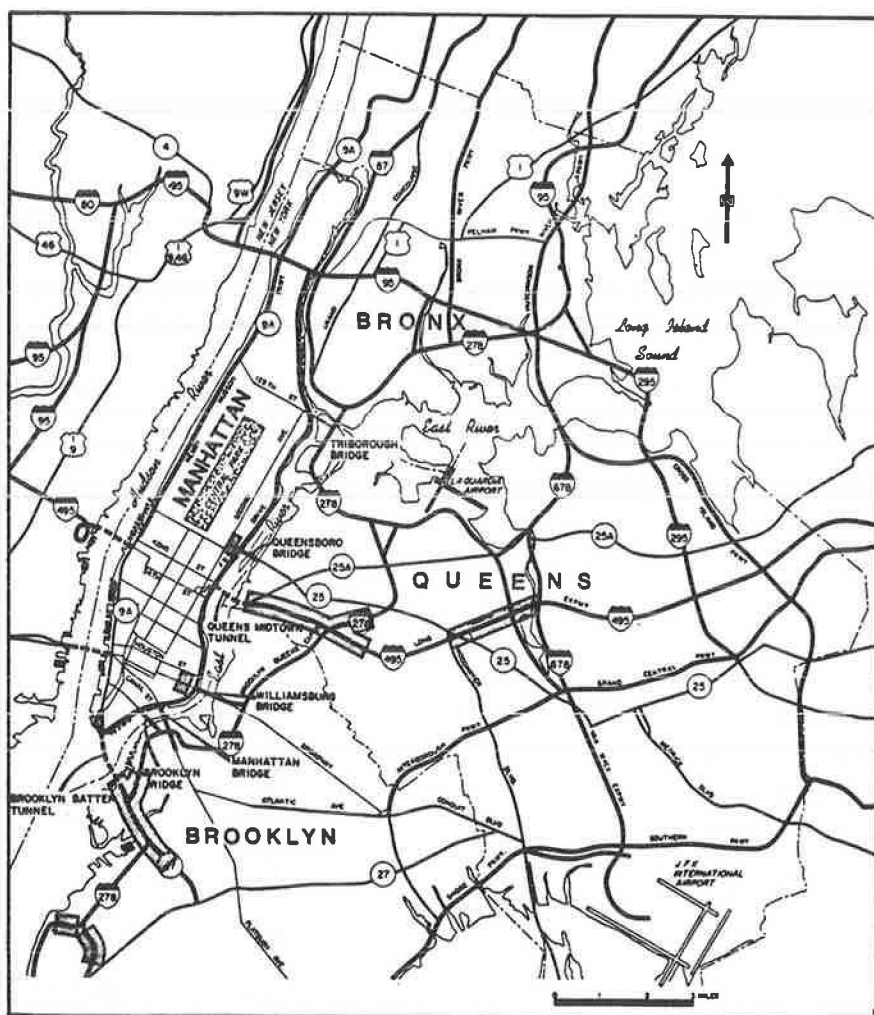


FIGURE 7 Anticipated queues with demonstration project (3 months later).

reduced trips parked in Manhattan (off street), 10 percent parked on street, and 20 percent were passing through.]

Implementation Costs

The automobile driver ban would require some 18 patrolmen to enforce it over the first 3 months, after which the number of patrolmen would be reduced to 12. The New York City DOT estimated that some 12 police officers would be required to enforce the project at an annual cost of \$450,000. It was estimated by the city that minimum installation costs would be needed.

Total Costs and Benefits

In summary, the city would spend or lose \$825,000 annually while the New York City Transit Authority and the TBTA would gain \$2,656,000. Collectively, the public agencies would gain \$1,831,000 in annual revenues.

TRAFFIC MANAGEMENT PROPOSALS

Traffic management proposals were recommended to complement the driver-only ban and to alleviate im-

pacts of added traffic on the Queens-Midtown Tunnel (Figure 8). It was essential to initiate the reversible lane operation on the two tunnels at 6:00 a.m. to minimize queue build up. It was also necessary to provide a southbound contraflow bus lane on the Gowanus Expressway approach to the Brooklyn-Battery Tunnel to enable some 120 to 150 buses each peak hour to bypass queues.

Additional measures included the following: (a) brochures describing features of the plan and alternate routes for Queens, Brooklyn, Richmond, and Long Island motorists; (b) give advance warning notices for 2 weeks before the experiment begins; (c) extensive media publicity; (d) advance signing and trail-blazers on key approach streets and highways; (e) a TBTA campaign to encourage and increase token use (this will help speed up transactions at toll plazas); (f) emphasize park-and-ride facilities at such key locations as Shea Stadium and South Beach, and better park-and-ride use of available space at city-owned garages in Long Island City and downtown Brooklyn; and (g) adjustments in traffic signal sequences and timing on key streets and junctions (i.e., Queens Boulevard, Greenpoint Avenue, Atlantic Avenue).

STATUS AND IMPLICATIONS

The Gowanus Expressway contraflow bus lane was im-

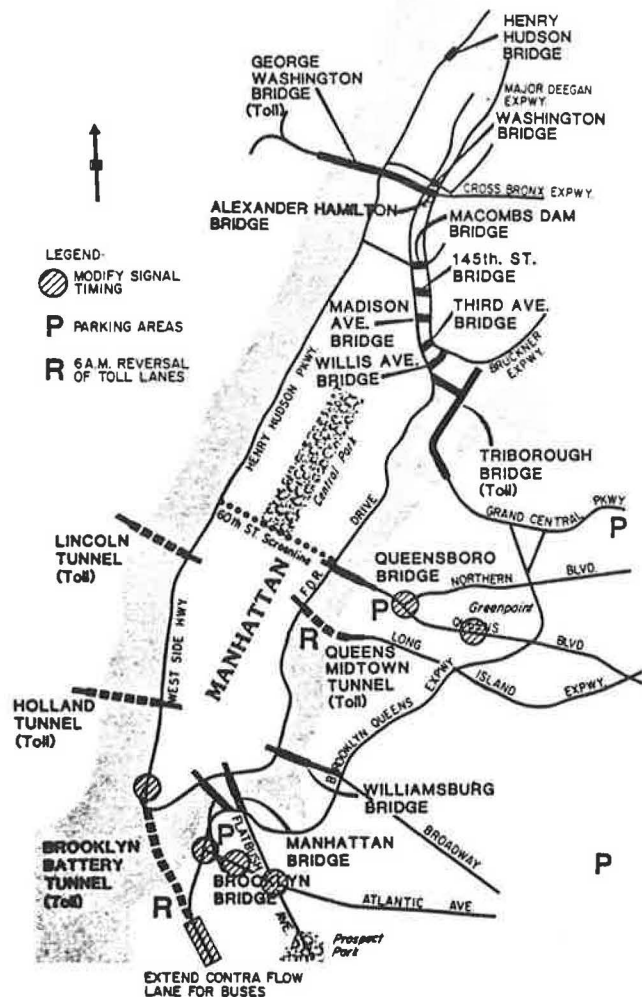


FIGURE 8 Traffic management concept.

plemented during September 1980. It saves some 5 min, on average, for more than 15,000 bus passengers each weekday during the morning peak period.

The driver-only ban was to have been implemented during September 1980 as a 3-month demonstration project. The Automobile Club of New York and the Manhattan Parking Association contested its legality in court. The court held that the city did not have

the legal authority to establish such a regulation--that such legal authority rested with the state.

Restraining car use by means of an automobile driver ban has, therefore, proved difficult in New York City, the most transit-oriented central area in the United States. This implies that other U.S. cities must look carefully before they enact traffic-restraint measures.

If it were possible to place tolls on all crossings, and if there were adequate storage capacity in all toll booth plazas, it would be possible to obtain a system of equilibrium by offering positive pricing incentives at all facilities for carpools. Such a plan might resolve the legal and political difficulties, but it is not possible, at least in the short run.

The analytical approaches, however, have direct transferrability to other situations. These include use of observed queues to estimate demands, attitude surveys to estimate impacts of traffic-restraint actions, and sequential manual traffic assignments to estimate long-term impacts on various river crossings.

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