Development and Application of Traffic-Management Models

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This paper summarizes the development of a freeway model and an arterial model and their application in assessing the impacts of traffic-management strategies. Previously developed models were modified to include energy and air-pollution impacts, and to include spatial and modal demand shifts due to freeway and arterial traffic-management strategies. The new freeway model was applied to a 20.2-km (12.6-mile) inbound section of the Santa Monica Freeway in Los Angeles during the morning peak period. Priority entry-control operations were found to be more effective than normal entry-control operations although an exclusive bus and car-pool lane was more effective than an exclusive bus lane. The new arterial model was applied to an 8-km (5-mile) section of Wilshire Boulevard in Los Angeles for two-way traffic operations during the afternoon peak period. Optimum signal-control strategies under existing street design conditions were found to be more effective than optimum signal-control strategies combined with either reversible lanes or exclusive bus-lane operations. Signal-control strategies under existing street design conditions were determined on a passenger basis and on a vehicle basis; these strategies resulted in a trade-off between passenger-time savings and reduction in air pollution and fuel consumption. Reversible-lane operations were found to be more effective than exclusive bus-lane operations. Future areas of research are identified.

Traffic-management research activities have been conducted at the Institute of Transportation Studies (ITS) at the University of California, Berkeley, for the past decade (1). Early research into macroscopic flow relationships and deterministic queuing analysis led to the development of the freeway simulation model FREQ (2). This model was extended to include mathematical search procedures capable of determining optimum redesign (3) and ramp-control strategies (4). Prior to undertaking the research described in this paper, ITS developed two decision models for freeway-corridor control (5) and priority-entry control (6). The freeway-corridor model combined the earlier developed freeway simulation model FREQ3 with the surface street model TRANSYT5 (7). The freeway priority-entry model FREQ3CP combined FREQ3 with a search procedure capable of determining optimal ramp control on a vehicle basis or a person basis.

During 1975 and 1976, the Traffic Management Group, one of five groups participating in a research project managing the future evaluation of the urban transportation system, modified FREQ3CP and TRANSYT6 to include energy and air-pollution impacts and to include modal and spatial demand shifts due to traffic-management strategies. The two modified models, FREQ4CP and TRANSYT6B, were applied to Santa Monica Freeway and Wilshire Boulevard to assess impacts and demand responses of various traffic-management strategies. Results of this research are documented in two reports that describe development and application of FREQ4CP (8) and TRANSYT6B (9).

FREEWAY MODEL DEVELOPMENT

FREQ3CP

The FREQ3CP (6) freeway model combines a simulation model with a search procedure capable of determining optimal ramp control on a vehicle basis or on a person basis. The input to the model consists of freeway-design parameters, origin-destination (O-D) traffic demand patterns, and linear programming objective and constraint specifications. The output is in three parts: simulation of existing traffic performance without control, optimal ramp-control strategy, and simulation of expected traffic performance with control strategy in effect.

The traffic performance for each subsection in each time segment is calculated and includes flow level, volume and capacity ratio, speed, density, travel time, total passenger-hours, total passenger-kilometers, and queuing characteristics. A directional freeway of 16 to 24 km (10 to 15 miles), including up to 20 on-ramps and 20 off-ramps, can be analyzed during every 10 to 15-min time segment during the peak traffic period. The model is macroscopic and deterministic, is written in ANS FORTRAN, is operated at CDC and IBM computer facilities, has been calibrated against field conditions, and has been applied to several different locations.

Energy and Air-Pollution Impact Extensions

FREQ3CP uses travel time as the primary impact measure. A study of other possible impact effects was undertaken, and energy and air pollution were selected for inclusion in the model. The results of previous energy (10) and air pollution (11) research were adopted, and energy and air-pollution algorithms were added to the existing model.

Three types of vehicles can be handled: passenger vehicle, gasoline-powered truck (or bus), and diesel-powered truck (or bus). For each vehicle type, fuel consumption rates are calculated based on average speed, volume and capacity ratio, and specified roadway design features. The user-specified roadway design features include gradient, curvature, and surface-condition features. Additional energy consumption due to stopping and starting, as well as idling, is included in the calculations. For the average vehicle, the three major pollutants (HC, CO, and NO_x) are calculated for both cruising and idling.

The revised model output includes energy and air-pollution rates for each subsection during each time segment and summary tables that indicate energy and air-pollution impacts (as well as travel time) of various traffic-management strategies.

Spatial and Modal Demand-Response Extensions

FREQ3CP did not include demand-shift responses caused by various traffic-management strategies. A study of possible demand responses was undertaken, and spatial and modal demand shifts were selected for inclusion in the model. The results of previous research on spatial and modal demand shifts (12, 13) were adapted, and demand-response algorithms were developed for the existing model. Although the algorithms were not computerized and added internally to FREQ4CP, the developed algorithms were used off-line. The resulting spatial and modal demand shifts were determined, and the O-D patterns were manually modified for FREQ4CP long-term computer runs. The basic equation used to estimate demand shifts is

$$\text{Demand shift} = \text{sensitivity} \times \text{stimuli} \qquad (1)$$

where

demand shift = percentage of passengers shifted from one route (or mode) to the other,
sensitivity = attractiveness consideration in changing routes or modes (i.e., availability of parallel routes and available unused capacity for route shift, and availability and quality of bus service for mode shift), and
stimuli = difference in travel time (i.e., freeway and ramp times are compared with alternate route travel times for route shift, and changes in bus travel time and nonpriority vehicle travel time are compared for mode shift).

Demand shifts are calculated in sequence; spatial shifts are calculated first and then modal shifts are calculated. At present no iteration procedure is used.

Two sets of analyses are undertaken for each freeway traffic-management strategy: short-term analyses that do not include the consequences of potential demand shifts and long-term analyses that include the consequences of spatial and modal demand shifts.

FREQ4CP

A flow chart of FREQ4CP is shown in Figure 1. FREQ4CP consists of the previously developed FREQ3CP, which was extended to include energy and air-pollution impacts as well as spatial and modal demand responses.

The user specifies the freeway design features, the selected freeway traffic-management strategy, and the freeway demand pattern. FREQ4CP predicts the travel time, energy consumption, and air pollution for existing conditions without the selected freeway strategy in effect and for both short- and long-term consequences with the selected freeway strategy in effect. In addition, FREQ4CP automatically constructs various contour maps (speed, volume and capacity ratio, density, energy, and air pollution). The new model also produces summary tables of traffic performance, impacts, and demand responses.

FREEWAY MODEL APPLICATIONS

The FREQ4CP model was applied to a 20.2-km (12.6-mile) section of the inbound Santa Monica Freeway during the morning peak period from 6:30 to 10:30 a.m. The freeway section was divided into 38 subsections, and the morning peak period was divided into sixteen 15-min segments. There were 20 demand input locations and 18 output locations. Prior to initiating production runs, existing conditions were simulated to ensure that model predictions realistically represented actual field conditions.

The experiment design for studying the various traffic-management strategies is shown in Figure 2. Four groups of traffic-management strategies were studied: priority-entry control operations, normal vehicle-entry control operations, exclusive bus-lane operations, and exclusive bus and car-pool lane operations. Both the short- and long-term consequences of these strategies were analyzed. Selected strategies were further modified considering user equity and additional practical aspects.

Tables 1, 2, and 3 give results for all selected freeway traffic-management strategies. The impacts and demand effects of priority-entry control were just slightly better than those of normal vehicle-entry control. Both strategies had favorable short-term consequences and led to even more favorable long-term consequences. The incremental benefits of priority-entry control over normal vehicle-entry control would be greater if the buses had used ramps that were controlled and if future traffic demand levels increased.

The preferential bus and car-pool lane had more favorable short-term and long-term impacts and demand effects than the preferential bus lane. The selected preferential bus and car-pool lane strategy was to reserve one lane for vehicles that carried three or more persons.

The comparison between priority-entry control and preferential bus and car-pool lane presents a trade-off among different impacts and demand responses. The following table highlights the predicted long-term differences between these two strategies for the morning peak period. The difference (priority-entry control minus preferential bus and car-pool lane) between these two strategies is as follows (where 1 L = 0.3 gal, 1 kg = 2.2 lb, and 1 km = 0.6 mile):

Item	Difference
Travel time, passenger·h	−6058
Fuel consumption, L	+647
Pollution, kg	−2703
Travel, vehicle·km	+3393

Priority-entry control strategy results in less travel time and air pollution but higher fuel consumption and vehicle-kilometers of travel. These trade-offs, plus the approximate manual procedures used in calculating demand shifts between modes and alternate routes, preclude specific conclusions.

ARTERIAL MODEL DEVELOPMENT

TRANSYT6

The TRANSYT6 (7) arterial model combines a simulation model with a search procedure capable of selecting near-optimum signal settings on a vehicle basis or a person basis. The input to the model consists of arterial design parameters, traffic-flow patterns, traffic-signal settings, and selected traffic-management strategies. The output is in three parts: simulation of traffic performance under existing conditions, near-optimum signal settings, and simulation of expected traffic performance with new signal settings.

The traffic performance for each directional link is calculated and includes flow level, degree saturation, distance traveled, travel time, delay time, stops, and maximum queue lengths. TRANSYT6 can be used as a network model, as well as an arterial model, and can include a maximum of 50 signalized intersections and 300 directional links. The model is macroscopic and deterministic, is written in FORTRAN, is operational on several different computer facilities, has been calibrated against field conditions, and has been applied at numerous locations throughout the world.

Energy and Air-Pollution Impact Extensions

TRANSYT6 uses delay time and number of stops as the primary impact measures. A study of other possible impact effects was undertaken, and energy and air pollu-

Figure 1. Flow chart of the FREQ4CP.

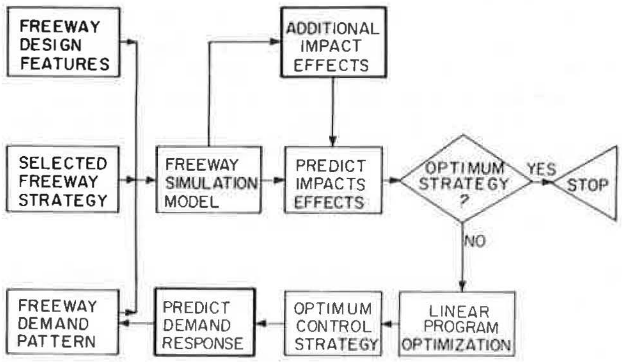

Figure 2. Design of experiment for freeway strategies.

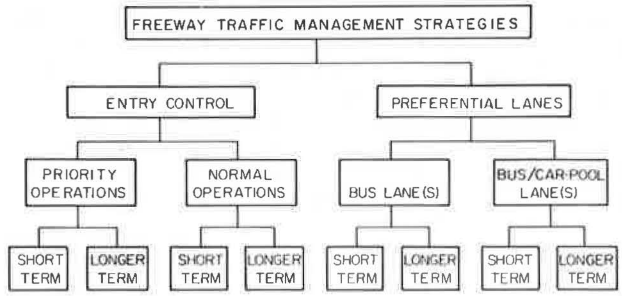

Table 1. Effects of freeway traffic-management strategies on travel time, fuel consumption, and air quality.

Strategy	Travel Time (passenger · h)		Fuel Consumption (L)		Air Pollutants (kg): HC		CO		NO_x		Total	
	Amount	Percent	Amount	Percent	Amount	Percent	Amount	Percent	Amount	Percent	Amount	Percent
Entry control												
With priority operation												
Short term	-1 934	-20	+773	+1	-65	-7	-511	-5	+261	19	-315	-3
Long term	-2 410	-25	-2719	-3	-125	-12	-1 129	-12	+209	15	-1 045	-9
Without priority operation												
Short term	-1 829	-18	+758	+1	-61	-6	-463	-5	+257	18	-267	-2
Long term	-2 380	-24	-2592	-3	-124	-12	-1 094	-11	+213	15	-1 005	-8
Preferential lanes												
Bus lane												
Short term	+14 639	+148	+2250	+3	+927	+93	+10 925	+113	-567	-40	+11 285	+94
Long term	+8 451	+85	-2885	-3	+507	+51	+6 452	+67	-550	-39	+6 409	+53
Bus and car-pool lane												
Short term	+11 110	+112	+2385	+3	+714	+72	+8 627	+89	-499	-35	+8 842	+73
Long term	+3 648	+37	-5208	-6	+156	+16	+1 989	+21	-447	-32	+1 698	+14

Note: 1 L = 0.26 gal; 1 kg = 2.2 lb.

Table 2. Effect of freeway traffic-management strategies on demand.

Strategy	Satisfied (%): No Delay	Satisfied (%): Little Delay	Transferred to Next Time Slice (%)	Diverted to Arterial Route (%)	Unsatisfied Queue at End (%)	Kilometers of Travel: Vehicle Amount	Vehicle Percent	Passenger Amount	Passenger Percent	Passengers in Vehicles (%): Priority	Non-priority
Entry control											
With priority operation											
Short term	95	2	2	1	0	0	0	–	–	–	–
Long term	96	2	1	1	0	-21 022	-4	–	–	–	–
Without priority operation											
Short term	94	2	2	2	0	0	0	–	–	–	–
Long term	96	2	1	1	0	-21 022	-4	–	–	–	–
Preferential lanes											
Bus lane											
Short term					12	0	0	0	0	1.5	98.5
Long term					8	-21 022	-4	0	0	4	96
Bus and car-pool lane											
Short term					10	0	0	0	0	10.0	90
Long term					3	-26 460	-6	0	0	14.0	86

Note: 1 km = 0.6 mile.

Figure 3. Flow chart of TRANSYT6B.

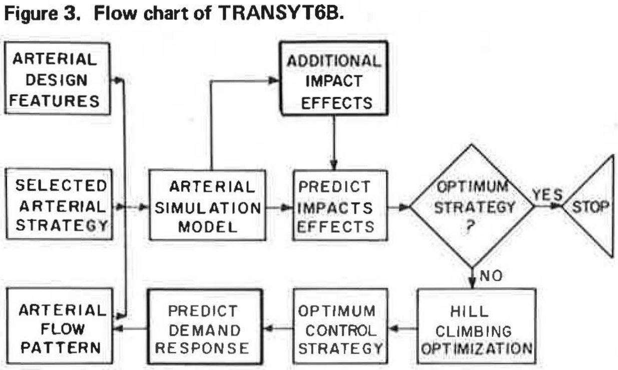

Table 3. Duration and extent of controls of freeway traffic-management strategies.

Strategy	Duration (a.m.)	No. of Ramps
Entry control		
With priority operation		
Short term	7:00 to 8:30	6
Long term	7:00 to 8:00	6
Without priority operation		
Short term	7:00 to 8:30	6
Long term	7:00 to 8:15	6
Preferential lanes		
Bus lane		
Short term	6:30 to 10:30	–
Long term	6:30 to 10:30	–
Bus and car-pool lane		
Short term	6:30 to 10:30	–
Long term	6:30 to 10:30	–

tion were selected for inclusion in the model. The results of previous energy (10) and air-pollution (11) research were adopted, and energy and air-pollution algorithms were added to the existing model. The procedures used in the arterial model are similar to those used in the freeway model previously described.

The revised model output includes energy and air-pollution rates for each directional link plus summary tables that indicate energy and air-pollution impacts, delay time, and number of stops of various traffic-management strategies.

Spatial and Modal Demand-Response Extensions

TRANSYT6 does not include demand-shift responses caused by various traffic-management strategies. A study of possible demand responses was undertaken, and spatial and modal demand shifts were selected for inclusion in the model. The results of previous spatial and modal demand-shift research (12, 13) were adapted, and demand-response algorithms were added to the existing model. The algorithms have been computerized and added internally to the TRANSYT6B arterial model and can automatically be employed by model users. The basic equation used for estimating demand shifts is

$$\text{Demand shift} = \text{sensitivity} \times \text{stimuli} \qquad (2)$$

where

- demand shift = percentage of passengers shifted from one route (or mode) to the other,
- sensitivity = attractiveness consideration in changing routes or modes (i.e., availability of parallel routes and available unused capacity for route shift and availability and quality of bus service for mode shift), and
- stimuli = difference in travel time (i.e., travel time on the studied arterial is compared with user-specified alternative route travel time for route shift, and changes in bus travel time and nonpriority vehicle travel time are compared for mode shift).

Demand shifts are calculated in sequence; spatial shifts are calculated first and then modal shifts are calculated. An iteration procedure is used in the spatial shift but not in the modal shift.

Two sets of analyses are undertaken for each arterial traffic-management strategy: short-term analyses that do not include the consequences of potential demand shifts and long-term analyses that include the consequences of spatial and modal demand shifts.

TRANSYT6B

A flow chart of TRANSYT6B is shown in Figure 3. TRANSYT6B consists of the previously developed TRANSYT6, which was extended to include energy and air-pollution impacts as well as spatial and modal demand responses.

The user may investigate traffic-management strategies that are concerned only with improving signal settings or may investigate strategies in which the arterial design features (preferential lanes or contraflow lanes) with or without improved signal settings are considered. TRANSYT6B predicts the travel time, energy, and air pollution for existing conditions without the selected arterial strategy in effect and for both short- and long-term consequences with the selected arterial strategy in effect.

In addition, the objective function was broadened so that minimizing delay time, number of stops, fuel consumed, air pollution, or any combination of these is possible. However, this feature has not been used, and a user input has not been developed. The new model also produces summary tables of traffic performance, impacts, and demand responses.

ARTERIAL MODEL APPLICATIONS

TRANSYT6B was applied to an 8-km (5-mile) section of Wilshire Boulevard (both directions) during the afternoon peak period studied. The arterial was divided into 276 directional links with 47 signalized intersections. Prior to initiating production runs, existing conditions were simulated to ensure that model predictions realistically represented actual field conditions.

The experiment design for studying the various traffic-management strategies is shown in Figure 4. Four groups of traffic management strategies were studied: optimizing signal control on a vehicle basis, optimizing signal control on a passenger basis, reversible-lane operations with optimizing signal control on a vehicle basis, and exclusive bus-lane operations with optimizing signal control on a passenger basis. Both the short- and long-term consequences of these strategies were analyzed. Sensitivity values selected for this operating environment were high for spatial shifts and average for modal shifts. Tables 4 and 5 give the results for all selected traffic-management strategies. Three of the four traffic-management strategies resulted in favorable short-term consequences, i.e., 3 to 10 percent reduction in travel time, fuel consumption, and air pollution. The exclusive bus-lane operation with optimizing signal control on a passenger basis was predicted to significantly increase travel time, fuel consumption, and air pollution in the short term. Optimizing signal control on a passenger basis and on a vehicle basis had the greatest short-term benefits.

The results of the long-term consequences are more difficult to interpret because of the spatial and modal demand shifts. The predicted long-term results of the exclusive bus-lane operations indicate little change in total travel: Passenger-hours of travel are reduced by 5.8 percent, fuel consumption is increased by 3.4 percent, and air pollution is increased by 2.0 percent. Unless the impacts are weighted in some fashion, the findings are inconclusive.

The predicted results of the other three traffic-management strategies were quite similar. The improvement in traffic operations on Wilshire Boulevard caused a significant demand shift to Wilshire Boulevard. In the long term, the impacts return approximately to their initial values. The significant change was the increased productivity on Wilshire Boulevard: It will handle 14 to 16 percent more traffic at the same level of travel time, fuel consumption, and air pollution as encountered before the study. Another interpretation is that traffic flows on parallel routes will be less and the traffic impacts will be improved. On a set of parallel arterials, therefore, seven improved arterials could handle the traffic of eight existing arterials without adverse impacts.

FUTURE RESEARCH DIRECTIONS

Research efforts will continue, and special attention will be given to the linear freeway and arterial traffic-flow models and to initial work linking these two linear models into a single corridor and network model.

Table 4. Effects of arterial traffic-management strategies.

Strategy	Vehicle[a]	Travel Time (h): Vehicle Amount	Per-cent	Travel Time (h): Passenger Amount	Per-cent	Fuel Consumption (L) Amount	Per-cent	Air Pollutants (kg): HC Amount	Per-cent	CO Amount	Per-cent	NO_x Amount	Per-cent	Total Amount	Per-cent
Signal control															
Short term															
Vehicle basis	Nonpriority	-81.8	-9.4	-97.6	-9.3	-234.0	-5.9	-9.0	-9.3	-109.6	-10.6	-4.5	-9.7	-123.1	-10.5
	Priority	-1.1	-5.0	-49.3	-4.9	-7.3	-6.7	-0.1	-4.8	-1.6	-7.5	0.0	0.0	-1.7	-7.0
	Both	-82.9	-9.3	-146.9	-7.2	-241.3	-5.9	-9.1	-9.3	-111.2	-10.6	-4.5	-9.8	-124.8	-10.4
Passenger basis	Nonpriority	-78.5	-9.0	-93.6	-8.9	-215.8	-5.4	-8.2	-8.6	-98.2	-9.5	-3.7	-8.0	-110.1	-9.4
	Priority	-1.4	-0.9	-65.4	-1.2	-10.0	-9.2	-0.1	-4.8	-2.0	-9.4	-0.1	-11.1	-2.2	-9.0
	Both	-79.9	-8.9	-159.0	-7.9	-225.8	-5.5	-8.3	-8.5	-100.2	-9.5	-3.8	-8.1	-112.3	-9.4
Long term															
Vehicle basis	Nonpriority	8.0	0.8	12.7	0.8	157	3.5	–	–	–	–	–	–	–	–
	Priority	0.1	0.0	6.3	0.3	-2	0.0	–	–	–	–	–	–	–	–
	Both	8.1	0.8	19.0	0.9	155	3.4	–	–	–	–	–	–	–	–
Passenger basis	Nonpriority	7.0	0.7	11.3	0.9	119	2.6	–	–	–	–	–	–	–	–
	Priority	-0.2	-0.7	-11.8	-1.2	-4	-3.9	–	–	–	–	–	–	–	–
	Both	6.8	0.7	-0.5	0.0	115	2.5	–	–	–	–	–	–	–	–
Signal control and design															
Short term															
Bus lanes	Nonpriority	508.1	58.2	607.5	57.6	1338.0	33.6	46.8	49.0	532.9	51.7	4.1	8.9	583.8	49.8
	Priority	-2.9	-13.1	-103.7	-13.4	-24.6	-22.6	-0.3	-14.3	-4.0	-18.8	-0.2	-22.2	-4.5	-18.5
	Both	505.2	56.4	503.8	23.1	1313.4	32.1	46.5	47.7	528.9	50.3	3.9	8.3	579.3	48.4
Reversible lanes	Nonpriority	-66.4	-7.6	-78.6	-7.5	-131.9	-3.3	-6.3	-6.6	-76.0	-7.4	-2.5	-5.4	-84.8	-7.2
	Priority	-0.2	-0.9	-12.8	0.2	-0.8	-0.7	0.0	0.0	-0.4	-5.6	-0.4	0.0	-0.4	-1.1
	Both	-66.6	-7.4	-91.4	-4.5	-132.7	-3.3	-6.3	-6.5	-76.4	-7.3	-2.5	-5.5	-85.2	-7.1
Long term															
Bus lanes	Nonpriority	18.6	2.1	19.8	1.8	168	4.1	–	–	–	–	–	–	–	–
	Priority	-2.9	-13.2	-139.7	-14.0	-25	-23.0	–	–	–	–	–	–	–	–
	Both	15.7	1.7	-119.9	-5.8	143	3.4	–	–	–	–	–	–	–	–
Reversible lanes	Nonpriority	6.4	0.6	9.4	0.8	196.2	4.2	–	–	–	–	–	–	–	–
	Priority	0.1	0.5	2.4	0.2	-2.0	-1.4	–	–	–	–	–	–	–	–
	Both	6.5	0.6	11.8	0.5	194.2	4.1								

Note: 1 L = 0.26 gal; 1 km = 0.6 mile; 1 kg = 2.2 lb.

[a]Total distance traveled: nonpriority vehicles, 18 554.8 km; priority vehicles, 340.2 km.

Figure 4. Design of experiment for arterial strategies.

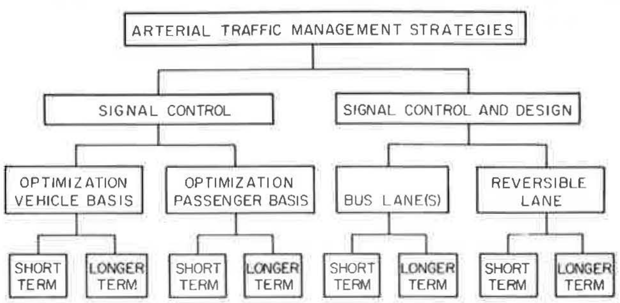

Table 5. Results of arterial traffic-management strategies.

Strategy	Base Conditions (km)	Strategy Results (km)	Change in Productivity (%)
Signal control			
Vehicle basis	18 773.9	21 479.5	14.4
Passenger basis	18 773.9	21 483.6	14.4
Signal control and design			
Bus lanes	18 773.9	18 481.6	-2.0
Reversible lanes	18 773.9	21 783.7	16.0

Note: 1 km = 0.6 mile.

FREQ4CP and TRANSYT6B will be extended to further evaluate demand responses, impacts, and control strategies in specified environments given alternative objective functions. Areas for possible research include the following:

1. Field validation and further refinement of spatial and modal demand shifts;
2. Extension of demand responses to include shifting demand over time and modifying total demand level;
3. Field validation and further refinement of energy and air-pollution impacts;
4. Extension of impact responses to include noise, safety, and operating costs;
5. Improvement of search procedures to obtain optimum control strategies that consider equity and additional practical aspects;
6. Extension of control strategies to include exclusive use of arterials for priority vehicles, bus and carpool lanes on arterials, and contraflow lanes on freeways;
7. Application of linear freeway and arterial models to additional operating environments and sensitivity analysis of operating environmental parameters; and
8. Provision for alternative objective functions and constraints and sensitivity analysis of the effect of these alternatives on evaluating the impacts of management strategies.

Management strategies affect traffic on a corridor and network basis; consequently, future research should also be directed to corridor and network models. Two approaches are contemplated: combining FREQ4CP and TRANSYT6B models or structuring a new modeling approach that is more macroscopic. The first approach will be initiated and will serve as a standard of comparison with the new modeling approaches. We anticipate that only feasibility studies of new modeling approaches will be undertaken in the coming year. Areas for possible research in combining FREQ4CP and TRANSYT6B models include the following:

1. Application of existing freeway corridor model, CORQ1C;
2. Provision of demand responses that include spatial, modal, time, and total demand responses;
3. Provision of impact responses that include energy, air pollution, noise, safety, and operating costs;
4. Improvement of search procedures to obtain optimum control strategies that consider equity and additional practical aspects;
5. Extension of control strategies to include integrated freeway and arterial traffic-management strategies;
6. Application of existing freeway corridor to additional operating environments and sensitivity analysis of operating environmental parameters; and
7. Provision for alternative objective functions and constraints and sensitivity analysis of the effect of these alternatives on evaluating the impacts of management strategies.

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Abridgment

County Evaluation of Traffic Engineering Activities

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The National Highway Safety Act of 1966 was the result of national concern over traffic accidents and fatalities. Its enactment by the 89th Congress was based on the realization that uniform standards had to be established to effectively reduce safety deficiencies. In 1969, the National Highway Safety Bureau revised and published Highway Safety Program Standards, a manual prescribing standards for traffic engineering and operations. These standards attempt to accomplish the following:

1. Provide recommendations for the identification, surveillance, and correction of accident locations;
2. Establish uniformity in traffic-engineering operations, analysis control, and design of highway facilities; and
3. Ensure pedestrian safety.

To aid the various communities in Oakland County, Michigan, to achieve the standards of the highway safety act, the Traffic Improvement Association (TIA) of Oakland County, a private nonprofit organization, undertook a project to compare traffic-engineering operations in the county with appropriate safety standards and to develop corrective actions. This paper describes the data-collection procedure and summarizes the results