USER AND COMMUNITY BENEFITS IN INTERCITY FREEWAY CORRIDOR EVALUATION

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Quantitative measures are proposed for evaluating the impact of new freeways on desired state development patterns and on opportunities for employment and other socioeconomic interactions. Implications of different relative weights for combining these measures with user benefits were investigated and appropriate relations proposed. Combining all benefits into a dollar-equivalent effectiveness allowed computation of an effectiveness-cost ratio useful for establishing corridor priorities. This evaluation methodology is applied to 17 potential freeway corridors in New York State.

•THIS paper presents a methodology of highway corridor evaluation that was found useful in a recent study of potential additions to the New York State freeway system. The study was conducted as part of a coordinated program to develop a statewide highway plan that will include freeways, other expressways, arterials, and perhaps also collectors in both urban and rural areas. The approach taken in the evaluation is generally applicable and may be of interest to analysts faced with similar tasks in other states and to those interested in consistency of evaluation among states.

THE PROBLEM

The problem addressed in a study of rural highway needs is different from that of many other transportation studies. The problem faced is not one of solving a crisis situation, as it often is in urban transportation studies. Primarily because of the far-reaching Interstate program, the present system of expressways and major arterials serving long-distance travel is extensive, direct, and at most times free of congestion. In New York State average operating speeds in rural corridors are typically only slightly lower than the legal speed limit. Planned and committed extensions of the intercity expressway system in the state will increase rural expressway mileage (not including parkways) from 960 miles in 1971 to more than 1,400 miles by 1975. Although it is true that in many rural sections greater highway capacity is required to accommodate increasing travel demand, few rural roads need to be upgraded to expressway standards. Adequate capacity can usually be provided at much lower cost by widening existing roads where needed, constructing grade-separated interchanges at strategic locations, and improving traffic control.

Additions to the freeway system may, however, be justified for other reasons. For example, they may be needed to stimulate economic activity in some areas. Or they may be needed to improve access to recreational areas or cultural activities. In other words, the evaluation of potential freeways cannot depend solely on an analysis of user benefits such as reduction of vehicle operating costs or highway safety. Community benefits should be considered in the evaluation as well.

PURPOSE AND SCOPE OF STUDY

The purpose of the highway corridor evaluation was to identify routes or major sections of routes in the nonurban highway system that could justifiably be upgraded to

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freeway standards. No attempt was made to determine whether improvement of any of these routes or sections to less than freeway standards would be a better economic investment. A marginal investment analysis of lesser levels of improvement would be necessary before any route could be finally designated as a possible freeway.

A total of 920 miles of potential additions to the existing and committed intercity freeway system was considered. The 17 corridors evaluated, identified as corridors A through Q, included most routes that the Department of Transportation had seriously considered as potential locations for some type of rural expressway. The locations were selected on the basis of earlier suggestions from several sources: department staff, staff of the former New York State Office of Planning Coordination, regional planning boards, county and local planners, and other responsible agencies and individuals. Because of the broad range of sources, it can be assumed that statewide interests were well represented in the selection of possible expressway locations. Most corridors were analyzed in more than one segment, the length of each segment varying from 4.4 to 76.7 miles.

APPROACH

The corridor evaluation relied heavily on previous analysis and available data. Although the large number of expressway proposals considered in past years by the department had received varying degrees of study (generally on a project-by-project basis), the extent of these proposals was sufficiently large to form, with minor additions, a comprehensive network from which recommended freeway corridors could be drawn.

It was recognized that a highway plan should reflect the broadest range of transportation goals (6). The goals considered in the evaluation of potential freeway corridors were of 2 types: user benefits, which involve the maximum return on public investment in terms of reduced accidents, operating costs, and travel time; and community benefits, which are achieved primarily by promoting desirable development patterns (7) and increasing interaction opportunities, the opportunities of residents of one area to satisfy employment, medical, and similar needs in other areas. Because techniques for considering user benefits and community benefits together are still rudimentary, the evaluation stressed consistency and realistic assumptions rather than rigorous analysis and development of new data.

The basis for evaluation was effectiveness-cost analysis, which emphasizes quantitative measurment of benefit and cost, even where these measures are in units that are incommensurate. Measurement of benefits was carried beyond the traditional measurement of savings in travel time, accidents, and operating cost, in that an attempt was made to establish measures for the impact of potential freeways on area development and interaction opportunities. Other benefits, such as highway-system continuity and facilities for national defense, were assigned a subjective but consistent weighting in the evaluation.

A network analysis for the computation of diversion from one freeway to another would require input data and techniques that are yet to be developed. It is anticipated, however, that system impacts would be relatively minor. The amount of freeway construction funds expected for the next decade limits the extent of the future freeway system. But, even if more funds were available, it is unlikely that many freeways would be added to the system; most of the major corridors among major cities have either existing or committed freeways, and there will be a decreasing return for each additional dollar invested. Thus, with the relatively large spacing anticipated (compared with the average length of trips on such roads), only limited diversion of travel from one freeway to another can be expected.

If it is assumed that the diversion to and from routes in alternative freeway plans is negligible for most alternate plans, route analysis can be used for the evaluation. Previous volume estimates, made independently on a project-by-project basis, were therefore used to derive the volume-related benefits. In cases where system impacts from existing or committed freeways had not been considered in previous volume estimates and were felt to be significant, an adjustment was made.

User benefits (time, accident, and operating-cost savings) were determined in a relatively straightforward manner, with assumed characteristics of the potential freeway and assumed accident rates, operating costs, and travel speeds. Community benefits were determined less directly. Fostering the physical development of the state and increasing interaction opportunities are often the major purposes of freeway and expressway proposals. There are areas in which the state wishes to encourage growth; increasing the access to those areas, it is hoped, will make them more desirable locations for new activity. Measures of these community benefits were therefore related to the increase in accessibility. Community benefits unrelated to accessibility were determined by means of a subjective index.

Construction costs from existing studies were used in the analysis after adjustment of some figures to bring the costs to a common year. It was anticipated that many routes would not require development to full freeway standards at first; therefore, the desirability of staging was considered for each route.

USER BENEFITS

The benefits of reduced travel time, reduced vehicle operating costs, and increased safety must be evaluated in the justification of any freeway. The benefits traditionally considered include savings to the automobile travelers and truckers who would use the new expressway and to the traveler who would continue to use existing highways that would become less congested as a result of the new expressway. The procedure used to calculate savings in time, operating costs, and accidents is similar to that used in urban transportation studies and to the procedure recommended in the AASHO guidelines (1), and will therefore not be repeated here. Only some of the inputs to the analysis of user savings will be discussed.

To estimate savings in travel time, we calculated both free-flow and average daily operating speed for each section of each existing highway and each proposed freeway. Free-flow speed was assumed to equal a route section's average speed limit, which was obtained from statewide highway records. Average operating speed for each section was determined by adjusting free-flow speed to reflect speed reductions during the daily peak travel hours; speed-volume curves in the Highway Capacity Manual (5) were used to make the adjustment.

When possible, estimates of average daily traffic were taken from past studies conducted by the department. If volume estimates had to be developed, they were calculated by using the traffic forecasting procedure followed for the 1970 Interstate cost estimate (2), the same procedure used to prepare many of the previously published estimates of average daily traffic. Predicted volumes were found to be low when compared to urban expressway forecasts, and generally much lower than freeway capacity. Average daily traffic ranged from about 4,000 to 14,000 for 1975 and from about 5,000 to 22,000 for 1990.

The unit cost figures used to convert travel-time benefits into dollar values are consistent with those used in the department's urban transportation studies. Travel time was valued at $2.50 per vehicle hour. This figure was obtained by adjusting the value suggested by the Federal Highway Administration for cost-of-living increases and an assumed average truck proportion of 10 percent (3).

To quantify the second type of user benefit, reduction in vehicle operating costs, we used operating costs of 4 and 10 cents per mile for automobiles and trucks respectively.

The accident rates used to calculate accident savings were taken from the Traffic Engineering Handbook (4) and were developed for several levels of average daily traffic and roadway type. The unit cost of an accident was set at $2,920, which reflects wage losses, insurance costs, property-damage costs, and medical expenses. This average cost was estimated as a function of the mix of accidents (personal injuries, fatalities, and property damage) and the probability of occurrence of each accident type.

To perform an economic analysis of each proposed expressway required that an interest rate be specified for discounting future user savings to a present dollar value; a 10 percent interest rate was used in the study. All dollar equivalents of user benefits are assumed to be constant "real" values; they were adjusted to reflect anticipated future inflation. The Consumer Price Index, which was used to inflate user savings, was assumed to decrease from approximately 5 percent annually in 1970 to 2½ percent annually from 1975 through 1990.

COMMUNITY BENEFITS

Unlike urban freeways, which are often built because user benefits have been found to equal or exceed the total construction and maintenance cost, freeways in rural areas usually cannot be justified solely on the basis of user savings; user savings are likely to be large yet insufficient to cover costs. Identification and quantification of other benefits are essential in determining whether a rural freeway is justified. The part of the New York freeway corridor evaluation that is really different from past transportation studies is the explicit account of the goals of promoting desired development patterns and increasing interaction opportunities. These goals may be broadly classified as community benefits of the transportation system.

Although it is clear that improvements to transportation affect community goals, the extent of this effect in relation to other development prerequisites is not clear. Therefore, the approach taken in the study was not to attempt measuring actual benefits but to develop measures indicating the relative impact of alternative expressway proposals on community goals without assuming any specific magnitude of these impacts. It was believed that, if community benefits can be determined or assumed for one corridor, these measures permit the computation of corresponding community benefits for all other corridors.

The basic concept to which these goals were related is that of accessibility. Defined as "ease of communication," accessibility rises as the number of potential destinations or attractions increases, and it decreases as various impedances, such as distance or travel time, increase; when a new road is added, travel time shortens, increasing the accessibility of the zones directly affected by the road. Accessibility is also an important factor in defining an effective market for commercial, industrial, cultural, and other activities, and thus it is important in industrial and other economic activity location. Represented by population or other attractions, markets are weighted according to their distance or travel time from the zone in which the activity is, or may be, located.

The accessibility measure used in the corridor evaluation is expressed as

$$A_i = \sum_j P_j / T_{ij}^k$$

where

A_i = accessibility of zone i,
P_j = population (or other attraction) of zone j,
T_{ij} = travel time between zones i and j, and
k = distance exponent.

The accessiblity measure was calculated by the use of 633 zones within the state (zone boundaries coincide with one or more minor civil divisions) and 67 larger zones representing adjacent state areas. Accessibility was summed over all zones within the state to determine total, or statewide, accessibility.

To demonstrate the change in accessibility that results from the addition of an express highway and to provide a guide for selecting an appropriate distance exponent, k, we analyzed the existing highway system with and without the addition of I-88 between Binghamton and Albany. As shown in Figure 1, the increase in accessibility is generally greatest for zones adjacent to the new facility. k = 1 was selected after a comparison was made of the extent and distribution of accessibility changes resulting from different k-values with what was intuitively felt to be the influence area of the expressway.

Specific measures related to accessibility were developed for the 2 goals; the measures are called index A and index B. Index A was used to measure the degree to which desired development patterns would be fostered. Index B was used to measure the degree to which interaction opportunities would be increased.

Desired Development Patterns

The change in relative accessibility was considered the best measure of the effect that a freeway might have on the degree to which economic development is directed from one zone to another. Relative accessibility is defined as

$$RA_i = A_i/A$$

where A is the sum of the accessibility of all zones in the state.

The change in relative accessibility identifies zones affected negatively as well as those affected positively. For example, the addition of I-88 to the existing system changed the relative accessibility of Oneonta (located on the freeway) and Buffalo (approximately 200 miles from Oneonta), as shown below:

Zone	RA_i	Change (percent)
Oneonta	+0.00004455	+3.00
Buffalo	-0.00000268	-0.03

The relative accessibility of Oneonta increased by 3 percent, while that of Buffalo dropped slightly. These changes are small, but to Oneonta's economy they may be significant.

New York State's development plan suggests that, for the social, economic, and physical benefit of the state, growth in some zones should be emphasized. The plan identifies other zones in which development should be retarded because an increase in activity would create environmental pressures in conflict with the plan. In corridor evaluation, therefore, the change in relative accessibility should be weighted by a factor reflecting the extent to which the change in projected growth varied from the change in growth judged desirable in the state development plan. The summation for all zones within the influence area of a proposed facility of this weight multiplied by the change in relative accessibility (index A) was used as the measure of achievement of the goal of promoting the state development plan:

$$\text{Index A} = \sum_i w_i \times RA_i$$

where

w_i = weight given to zone i, and
RA_i = change in relative accessibility of zone i.

Development weights ranging from -3.5 to 7.5 were developed in cooperation with the Office of Planning Coordination. Positive values indicate zones where growth is favored. When relative accessibility significantly increased in zones with negative weights, these zones were identified and appropriately considered in the further evaluation of route impacts.

The relation between the Department of Transportation and the Office of Planning Coordination is analogous to the relation between transportation planning and comprehensive regional planning agencies in metropolitan areas. Unlike most other corridor planning, however, the New York freeway evaluation attempted to quantify goal achievement rather than to rely on the traditional intuitive approach.

Interaction Opportunities

The addition of a freeway may provide benefits other than user benefits and the promotion of desired development. A new freeway may also improve the access of residents in one area to job opportunities, emergency medical facilities, cultural activities, and other attractions available in other areas. The ability of residents of one area to interact with other areas to take advantage of such opportunities is a true benefit, even if infrequently used.

Although specific interaction opportunities can be located, projected, and used in the analysis, it was assumed for this study that attractions such as retail, medical, and cultural facilities are distributed in the same way as population. It was assumed, therefore, that a zone's change in accessibility, as defined above, is an appropriate measure of the zone's change in interaction opportunities.

Inasmuch as this benefit accrues to every resident of the zone, the zone population times the change in accessibility summed over all zones affected (index B) was used as a measure of how much a new freeway would increase interaction opportunities.

$$\text{Index B} = \sum_i P_i \times \Delta A_i$$

where

P_i = population of zone i, and
ΔA_i = change in accessibility of zone i.

Other Benefits

Certain attractions, such as recreation areas and colleges, are not distributed in the same way as population. Improvement in access to such facilities and provision for other needs such as national defense and system continuity cannot be measured by index B. These benefits were identified where possible and evaluated on a subjective but consistent basis. Unavoidable adverse impacts on the environment that were identified were included as negative benefits. An index based on a 0 to 10 scale was assigned to each corridor.

COSTS

Most of the potential freeways analyzed had been the subject of previous department studies, and their costs had been estimated in project information reports, route-location studies, or the 1970 Interstate cost estimate. All construction costs were updated to 1970 dollars by means of the Highway Bid Price Index. It was assumed that inflation would increase 1970 costs by a factor of 2 by 1990; this increase reflects a 7 percent annual price increase through 1972 with a leveling off to 3 percent annually after 1974. Most of the cost increase would be due to growing labor costs, although rising material and equipment costs would also contribute. All costs were inflated to year of construction—1975 for stage 1 of the plan and 1985 for stage 2—before present worths were calculated. Maintenance costs were assumed to be $5,000 per mile for routine snow removal, painting, grass mowing, and rubbish removal. Reconstruction of the pavement was assumed to be required every 20 years, at a cost of $100,000 per lane-mile.

Staged construction, 2 lanes at a time, was considered because low volumes were forecast in some corridors. However, including staged construction in the analysis had a negligible effect on results because roads with very low volumes were not chosen as desirable investments.

User Benefit-Cost

As a first step in evaluating each proposed route, the ratio of user savings to costs, the benefit-cost ratio, was calculated with construction assumed during the 1975-80 period. This ratio served as the bench mark for evaluating the dollar value of development and other benefits of freeway construction. The results of the calculation are given in Table 1 under the column heading "Standard Variables."

At first glance, these benefit-cost ratios appear to be extremely low. They range from somewhat more than 0.5 for corridors A, L, M, and O to as low as 0.17 for corridor Q. (A wider range of benefit-cost ratios was observed on individual route segments.) These results must, however, be considered in light of the historical development of the state's intercity freeways and of recent trends in the construction industry.

New York's existing freeway system, which was constructed during the past 2 decades, has preempted the corridors with the highest volumes and the highest congestion levels. The corridors considered in this study, on the other hand, are generally characterized by relatively low traffic volumes and fairly high traffic speed. Unlike earlier facilities, many of the recent proposals would provide small unit benefits to a small traffic volume. Consequently, the aggregate of benefits is low. Another important consideration affecting the benefit-cost ratios is the rapidly increasing cost of construction. The estimated costs used here are considerably higher than estimates used in earlier studies. The value of benefits has also been inflated, but at a lower rate.

It was considered necessary to isolate the impact of changes in input data and thus verify the reasonableness of the results. A sensitivity analysis was performed by varying 1 variable at a time while all others remained constant. Variable changes were as follows:

Variable	Standard	Changed
Interest rate, percent	10	6
Time value, $/vehicle-hour	2.50	1.75
Accident value, $/accident	2,920	5,840
Expressway threshold volume, vehicles/day	6,000	9,000
Expressway volume increase, percent	—	30
1990 Nonexpressway speed reduction, percent	—	30
Inflation rate		
Costs, percent	3.0	6
Benefits, percent	2.5	5

The results of this analysis are given in the remaining columns of Table 1.

The sensitivity analysis indicated that changes in several factors may materially affect the benefit-cost ratio. The most sensitive variable was the assumed average operating speed on the existing road. Changing the interest rate also had a significant effect; using a rate of 6 percent rather than 10 percent increased the benefit-cost for all routes by approximately 65 percent. The unit value of time was important, and the rate of inflation was also found to be of consequence. In contrast, changing the estimated expressway volume, the unit value of accidents, and the expressway threshold volume (i. e., the volume at which 4 lanes are required) resulted in only minor changes in the benefit-cost ratios. The most important input variables were carefully reexamined to ensure that the best available information was used in establishing their values.

Community Benefit-Cost

The community benefit-cost ratio was not used alone as a measure but was combined with the user benefit-cost ratio into an effectiveness-cost ratio, as described in the next section. The community benefit-cost ratios for each route are shown as part of the effectiveness-cost ratios in Figure 2.

CORRIDOR EVALUATION

The measures of user and community goal achievement were integrated into a total benefits, or effectiveness, measure for each corridor, and the resulting effectiveness-cost ratio of each potential freeway was used in arriving at a final corridor recommendation.

Community benefits cannot be assigned dollar values and, thus, cannot be added directly to user benefits. Furthermore, there is no objective way of establishing a unit value for community benefits. Consequently, because their weighting must necessarily be based on subjective judgment, the total value of these benefits is open to discussion.

What were believed to be reasonable unit values for the selected community-benefit measures (index A, index B, and the index for other benefits) were established by

Figure 1. Accessibility change with addition of I-88.

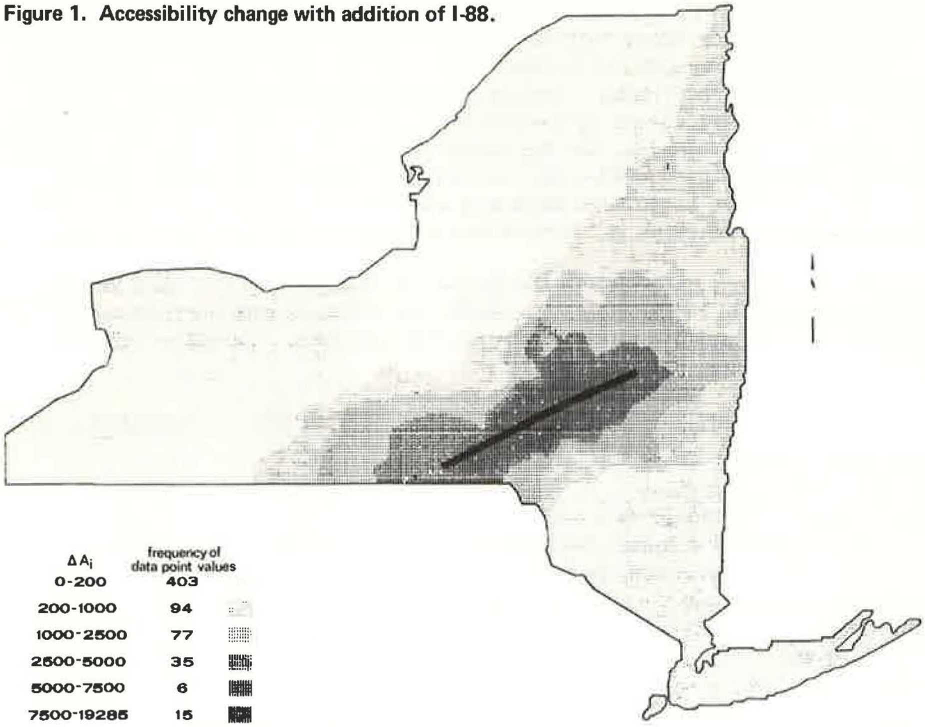

Figure 2. Corridor ratings.

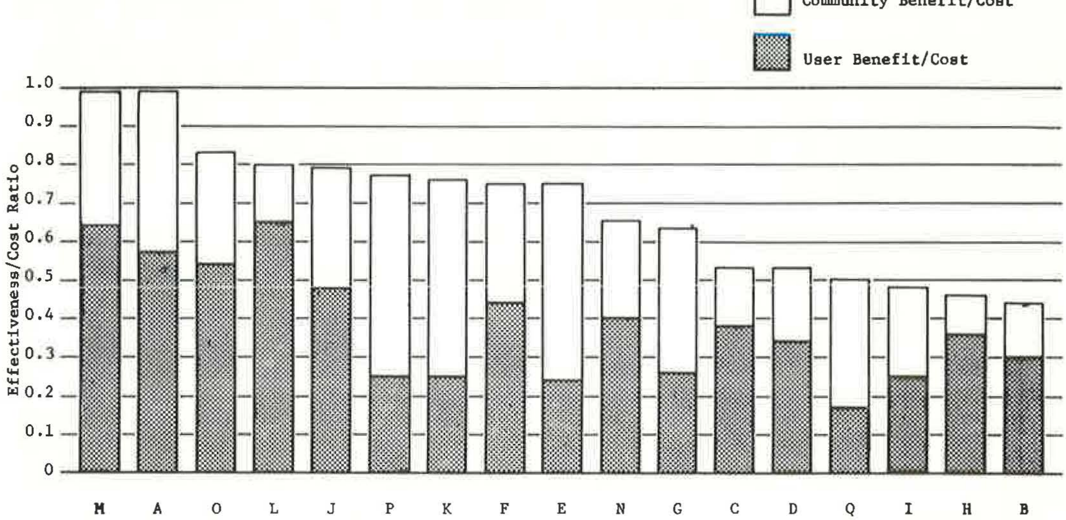

Table 1. User benefit-cost ratios with standard and changed variables.

Corridor	Section	Benefit-Cost Ratio With Standard Variables	Benefit-Cost Ratio With Variables Changed for Sensitivity Analysis: Interest Rate of 6 Percent	Time Value	Accident Value	Expressway Threshold Volume	Expressway Volume Increased	1990 Nonexpressway Speed Reduced	Inflation Rate
A	1	0.27	0.47	0.21	0.34	0.32	0.31	0.60	0.36
	2	1.30	2.24	0.97	1.44	1.30	1.51	2.82	1.71
	3	0.85	1.43	0.64	0.96	0.85	0.96	1.82	1.11
	Total	0.57	0.97	0.43	0.66	0.63	0.65	1.23	0.75
B	1	0.10	0.17	0.08	0.10	0.10	0.12	0.22	0.13
	2	0.36	0.55	0.29	0.44	0.43	0.39	0.89	0.43
	3	0.36	0.58	0.29	0.45	0.39	0.42	0.83	0.46
	Total	0.30	0.47	0.23	0.36	0.32	0.33	0.70	0.37
C	1	0.56	0.92	0.46	0.74	0.56	0.64	1.22	0.71
	2	0.18	0.31	0.14	0.23	0.20	0.21	0.60	0.24
	3	0.39	0.60	0.30	0.44	0.47	0.42	0.88	0.47
	4	0.32	0.46	0.26	0.35	0.37	0.32	0.66	0.37
	Total	0.38	0.59	0.30	0.46	0.42	0.41	0.87	0.46
D	1	0.12	0.17	0.08	0.11	0.13	0.12	0.37	0.14
	2	0.32	0.51	0.26	0.38	0.39	0.35	0.75	0.39
	3	0.85	1.40	0.66	1.04	0.85	0.97	1.83	1.09
	Total	0.34	0.51	0.26	0.39	0.37	0.36	0.80	0.40
E	Total	0.24	0.39	0.20	0.36	0.26	0.29	0.61	0.31
F	1	0.31	0.52	0.23	0.33	0.40	0.35	0.81	0.41
	2	0.59	0.99	0.46	0.66	0.59	0.68	1.19	0.77
	Total	0.44	0.74	0.34	0.49	0.50	0.50	0.99	0.57
G	Total	0.26	0.40	0.21	0.33	0.31	0.30	0.63	0.32
H	1	0.49	0.81	0.39	0.61	0.49	0.56	1.13	0.63
	2	0.26	0.43	0.21	0.36	0.26	0.30	0.76	0.33
	3	0.25	0.41	0.20	0.28	0.29	0.29	0.63	0.32
	Total	0.36	0.61	0.29	0.45	0.38	0.42	0.89	0.47
I	Total	0.25	0.44	0.21	0.33	0.26	0.30	0.58	0.33
J	1	0.55	0.84	0.40	0.57	0.61	0.63	1.69	0.68
	2	0.37	0.55	0.29	0.45	0.44	0.42	1.12	0.45
	3	0.51	0.75	0.39	0.59	0.59	0.58	1.53	0.61
	Total	0.48	0.72	0.36	0.54	0.55	0.54	1.46	0.58
K	1	0.30	0.52	0.23	0.36	0.34	0.35	0.67	0.40
	2	0.19	0.30	0.15	0.23	0.23	0.21	0.45	0.23
	Total	0.25	0.42	0.20	0.31	0.29	0.29	0.57	0.32
L	Total	0.65	1.07	0.50	0.71	0.70	0.74	1.31	0.84
M	1	0.77	1.24	0.58	0.92	0.77	0.91	1.83	0.98
	2	0.57	0.92	0.42	0.58	0.57	0.68	1.49	0.73
	Total	0.64	1.04	0.48	0.70	0.64	0.76	1.62	0.82
N	Total	0.40	0.64	0.32	0.52	0.40	0.47	1.04	0.51
O	1	0.71	1.14	0.55	0.84	0.71	0.82	1.58	0.90
	2	0.41	0.66	0.33	0.49	0.49	0.48	0.86	0.52
	Total	0.54	0.87	0.43	0.64	0.60	0.63	1.18	0.69
P	1	0.32	0.55	0.24	0.35	0.38	0.37	0.88	0.42
	2	0.15	0.21	0.11	0.17	0.16	0.15	0.50	0.17
	Total	0.25	0.39	0.19	0.27	0.28	0.26	0.71	0.31
Q	1	0.30	0.51	0.25	0.37	0.32	0.36	0.62	0.39
	2	0.15	0.27	0.12	0.19	0.20	0.18	0.34	0.20
	Total	0.17	0.31	0.13	0.21	0.22	0.20	0.39	0.23

Table 2. Effectiveness-cost ratios with varying weights of community benefits.

Corridor	60-20-20 Weight[a] 50[b]	75[b]	100[b]	40-40-20 Weight[a] 50[b]	75[b]	100[b]	User Benefit-Cost Ratio
M	0.88	0.99	1.11	0.88	1.00	1.12	0.64
A	0.86	0.99	1.14	0.85	0.99	1.14	0.57
O	0.73	0.83	0.92	0.73	0.83	0.92	0.54
L	0.75	0.80	0.85	0.75	0.80	0.85	0.65
J	0.69	0.79	0.90	0.68	0.79	0.89	0.48
P	0.60	0.77	0.95	0.57	0.73	0.89	0.25
K	0.59	0.76	0.92	0.63	0.82	1.01	0.25
F	0.65	0.75	0.86	0.64	0.74	0.83	0.44
E	0.58	0.75	0.92	0.55	0.70	0.85	0.24
N	0.57	0.65	0.73	0.57	0.65	0.73	0.40
G	0.51	0.63	0.75	0.50	0.62	0.74	0.26
C	0.48	0.53	0.59	0.48	0.53	0.57	0.38
D	0.47	0.53	0.60	0.46	0.52	0.58	0.34
Q	0.40	0.50	0.61	0.37	0.47	0.57	0.17
I	0.41	0.48	0.56	0.41	0.49	0.56	0.25
H	0.42	0.46	0.49	0.42	0.45	0.48	0.36
B	0.39	0.44	0.48	0.39	0.44	0.49	0.30

[a]Weights given to (a) promoting the state development plan, (b) increasing interaction opportunities, and (c) other benefits, such as national defense and system continuity.

[b]Community benefits as a percentage of user benefits, with corridor A as the base.

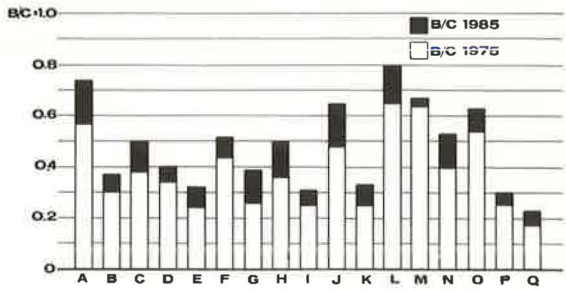

Figure 3. User benefit-cost ratios for different construction years.

Table 3. Corridor evaluation summary.

		User Benefits			Community Benefits				Cost (millions)			
Corridor	Factor[a]	Reduced Travel Time	Reduced Operating Costs	Increased Safety	Promotion of State Development Plan	Increased Interaction Opportunities	Other Benefits	Total Benefits or Effectiveness	Construction	Maintenance	Effectiveness and Cost Ratio	User Benefit and Cost Ratio
A	1	36	3	6	70	41	6					
	2	90	3	18	50	17	17	194	180	15	0.99	0.57
	3	0.46	0.02	0.09	0.26	0.09	0.09					
B	1	16	6	4	19	14	3					
	2	41	6	12	13	6	8	85	176	20	0.44	0.30
	3	0.21	0.03	0.06	0.07	0.03	0.04					
C	1	40	16	11	59	26	3					
	2	99	16	31	42	11	8	207	350	38	0.53	0.38
	3	0.26	0.04	0.08	0.11	0.03	0.02					
D	1	26	6	5	44	18	4					
	2	64	6	14	31	8	11	134	226	26	0.53	0.34
	3	0.26	0.02	0.06	0.13	0.03	0.04					
E	1	5	-1	3	43	15	2					
	2	12	-1	9	30	6	6	63	74	9	0.75	0.24
	3	0.14	-0.01	0.11	0.36	0.08	0.07					
F	1	23	10	3	55	23	2					
	2	57	10	3	39	10	6	129	156	14	0.75	0.44
	3	0.33	0.06	0.05	0.23	0.06	0.03					
G	1	8	0	2	34	17	3					
	2	21	0	7	24	7	8	68	96	12	0.63	0.26
	3	0.19	0.00	0.07	0.22	0.07	0.08					
H	1	56	16	18	51	20	3					
	2	140	16	52	36	8	8	261	523	50	0.46	0.36
	3	0.24	0.03	0.09	0.06	0.01	0.02					
I	1	6	2	3	19	11	2					
	2	16	2	8	13	5	6	49	95	8	0.48	0.25
	3	0.16	0.02	0.08	0.13	0.05	0.05					
J	1	24	3	3	36	19	5					
	2	59	3	9	26	8	14	119	131	20	0.79	0.48
	3	0.40	0.02	0.06	0.17	0.05	0.09					
K	1	14	1	3	69	68	4					
	2	34	1	9	49	28	11	132	161	14	0.76	0.25
	3	0.19	0.01	0.05	0.28	0.16	0.06					
L	1	22	9	2	15	8	1					
	2	56	9	7	11	3	3	89	100	11	0.80	0.65
	3	0.50	0.09	0.06	0.10	0.03	0.03					
M	1	26	5	3	26	17	6					
	2	65	5	7	18	7	17	119	107	13	0.99	0.64
	3	0.54	0.04	0.06	0.15	0.06	0.14					
N	1	9	0	3	14	8	2					
	2	22	0	9	10	3	5	50	69	9	0.65	0.40
	3	0.29	0.00	0.11	0.13	0.04	0.07					
O	1	25	10	6	48	27	1					
	2	63	10	17	34	11	3	138	149	18	0.83	0.54
	3	0.38	0.06	0.10	0.20	0.07	0.02					
P	1	16	4	2	106	41	3					
	2	39	4	4	75	17	8	148	174	18	0.77	0.25
	3	0.21	0.02	0.02	0.39	0.09	0.04					
Q	1	9	0	2	49	16	5					
	2	22	0	6	35	7	14	85	157	11	0.50	0.17
	3	0.13	0.00	0.04	0.21	0.04	0.08					

[a]1 = units of benefits; 2 = total dollar equivalent of benefits in millions; and 3 = percentage of cost covered by benefits.

comparing the results of applying several different weights to the community benefits as a percentage of user benefits and different weights to one type of community benefit versus another. Unit values for the 2 community benefits, promoting desired development patterns and increasing interaction opportunities, were computed for each set of weights by using index A, index B, and other benefit ratings of 1 base corridor. These unit values were than consistently applied to all the other corridors to obtain a dollar equivalent for community benefits. Adding user and community benefits and dividing by estimated freeway costs gave effectiveness-cost ratios (Table 2). A sensitivity analysis indicated that other corridors could have been used as the base without substantially changing the corridor ranking.

Different proportioning among the community goals did not materially affect the ratios. Selection of the appropriate weight of community benefits versus user benefits proved to be far more difficult. There are few available research findings that can be applied in making this selection; therefore, the implications of different proportions were examined more carefully.

It is immediately apparent that, when community benefits are equal to 50 percent of user benefits for base corridor A, no routes would be selected. At 75 percent, 2 routes have an effectiveness-cost ratio of nearly one or greater. This implies an expressway program of $230 million. Forty-one percent of this cost, or $94.3 million, would be justified on the basis of hoped-for community benefits. On the other hand, the assumption that community benefits are equal to 100 percent of user benefits implies a $664 million program, 56 percent of which, or $370 million, would be justified on the basis of community benefits. Furthermore, some of the routes in the larger program require that community benefits justify more than 74 percent of the cost. Although it is generally acknowledged that community benefits contribute to the justification of intercity freeways, it is difficult to justify such a major proportion of their cost without far more concrete research supporting the relation between accessibility-related measures and hoped-for community benefits. This problem, and the more manageable size of the program implied by weighting community benefits at 75 percent of user benefits (for the base corridor), led to the selection of that ratio for further analysis.

With community benefits weighted at 75 percent of user benefits, the distribution of 60 percent to the goal of promoting the state development plan, 20 percent to increasing interaction opportunities, and 20 percent to other benefits was selected. The reason for the dominant weight given to promotion of the state development plan is that this plan already reflects a number of important social, environmental, and economic state goals. Figure 2 shows the corridor ranking with these weights according to the effectiveness-cost ratio obtained by combining the separate measures of user and community benefits for each corridor. Community benefits were found to vary greatly among corridors, both in relation to one another and as a percentage of user benefits.

Should other weights be considered more appropriate, only minor adjustments would be needed to reflect them in the final plan. It should be remembered, however, that any selection of weights implies a definite set of projects in the final plan and that the selection of any project would logically require the selection of all projects having a higher effectiveness-cost ratio.

Table 3 gives in more detail the benefits and cost of each corridor in terms of the level of goal achievement, the estimated benefit value per unit of goal achievement, and the estimated dollar equivalent and amount of each dollar invested that is covered by the achievement of each goal. The figures shown are based on a weighting of community benefits at 75 percent of user benefits for corridor A. Measure weights are as follows:

User benefits
- Reduced travel time: millions of hours, $2.50/hour
- Reduced operating cost: millions of dollars, 1.00
- Increased safety: thousands of accidents, $2,920/accident

Community benefits
- Promotion of development plan: index A, millions, 0.71
- Increased interaction opportunities: index B, millions, 0.41
- Other benefits: 0 to 10 scale, millions, 2.77

Before a final corridor recommendation could be made, it was necessary to analyze each section of routes having a high effectiveness-cost ratio. In some cases, where construction of the entire route is not required for system continuity, individual sections may be justified even if the entire route is not. A user benefit-cost analysis was performed for each section with both 1975 and 1985 as possible construction dates. The resulting benefit-cost ratios, shown in Figure 3, were found to increase as construction was delayed, primarily because of increased travel volumes.

On the basis of total route evaluation and benefit-cost evaluation of each route section, only part of 1 corridor was recommended for construction between 1975 and 1980, and only 2 additional corridors were found to justify freeway construction between 1980 and 1990. For each of these, further detailed analysis will be undertaken to determine whether full freeway improvement is justified. This analysis will compare the incremental benefits over improvements to less than full freeway standards with incremental costs.

CONCLUSION

It should be emphasized here that the justification of any or all of the recommended routes has not been proved, for the dollar value of community benefits has no empirical basis. If, however, the proportion of the total freeway program justified by community benefits is accepted as reasonable, corridor ranking and selection are objective and consistent.

The evaluation of possible new freeways in New York State (capacity increases on existing freeways were not considered) led to very limited recommendations for possible additions to the existing or committed freeway system. In less densely populated states, similar results may be expected. The small number of recommended corridors does not, however, mean that improvements to the intercity highway system should be discontinued; it indicates, rather, that there should be a shift in emphasis toward the arterial system. Intercity and rural travel is served by both the freeway and the arterial systems, and this combined system must be improved to serve the increasing travel demand safely and efficiently. Once the freeway system is completed, a major effort will be needed to upgrade the system of principal and minor arterials. This improvement, although not justified to full freeway standards, may require standards superior to those currently used for the arterial system and may include continuous improvement to expressway (as opposed to freeway) standards on some facilities and construction of limited-access bypasses for small communities, lane additions or widenings, grade-separation structures, and traffic-control improvements on others. In many areas, such improvements will permit travel at nearly expressway speeds at a fraction of expressway cost.

The methodology described in this paper was developed under severe limitations on time and manpower resources. However, it is felt that the evaluation procedure will give a logically based and reasonable ranking of alternatives that is of considerable value in deciding on the magnitude and nature of a freeway program.

The measures used for indicating the relative impact of alternate freeways on community goals need to be further examined for general validity. Furthermore, the appropriate weight to be given to community-benefit measures must be explored through detailed economic analysis of selected corridors. (A preliminary comparison with ongoing analyses of this type was indeed possible for 2 of the corridors and showed acceptable results.) A number of such comparisons will be needed to ascertain generally applicable weights and, consequently, to reliably predict community benefits of freeways.

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