CRITICAL DECISIONS IN THE RAPID TRANSIT PLANNING PROCESS

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This paper shows how financial, attitudinal, and physical factors influence decisions on whether to build a rapid transit facility and how much to build. The authors discuss the need for a more rigorous planning process that will discriminate among projects considered for financial assistance. They note the inadequacies of aggregate criteria and suggest that cost per passenger mile (kilometer) is a useful but incomplete measure. Results of benefit-cost analysis for major systems are compared, and specifications are suggested to increase the usefulness of such an analysis. Standardized estimates of benefits and costs, although inadequate in isolation, can make a useful contribution to the analysis process.

•THE DEBATE about new rapid transit facilities in U.S. cities is reaching billion dollar dimensions. More than 30 cities are considering the implementation of 1 or more rapid transit lines, and several of these cities are in the financing and final design stage. Yet, despite the stakes and the immediacy of the problem, criteria for decisions relating to such systems do not exist in a commonly accepted form. Overall goals of reducing congestion and energy consumption, making environmental improvements, and saving travel costs are accepted universally, but how to quantify these factors and their relative worth is not. How much is a city willing to pay for a 3 percent reduction in congestion on 10 percent of the streets? What is the value of a 5 percent reduction in air pollution on 3 percent of the streets 10 percent of the time? Adverse social and environmental impacts stemming from the transportation facilities themselves, evaluation of alternative modes, and impacts on overall city development also are involved. Elaborate planning methodologies involving massive direct involvement of citizens and elected officials are required and have been effective when transportation issues have been publicized and politicized usually as a result of intensive public controversies over alternative transportation policies (1). In most cities, however, the planning process is not so visible because it must compete with other issues, and the public is not capable of being intimately involved in all issues simultaneously. In any case, despite the best efforts in local processes, there remains the problem of consistently getting realistic and proper evaluation of alternatives at the local level when much of the money comes from the federal government. The 80 percent financing level of transit capital projects may prove too tempting, and, most likely, it will be necessary for the federal government to apply some criteria to discriminate among worthy and unworthy projects vying for limited federal dollars.

Rapid transit generally is defined as a transit system that operates at high speed through multiple corridors over a substantial length of exclusive rights-of-way. It generally is grade separated. Rapid transit is either a rail or bus system. This paper explores some of the issues used in determining whether rapid transit is appropriate. It explores the factors that will influence the planning process. It also suggests a simplified approach for federal review to discriminate among projects.

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One can group the influences on rapid transit planning into the following 3 classes:

1. Planning and financial factors, which are those institutional arrangements that dictate the constraints within which the system is to be planned and financed;
2. Attitude factors, which are those predispositions of the community that exist independent of the plan and planning process associated with rapid transit development; and
3. Physical factors, which are those analytical factors involving the physical layout of the system and its costs, performance, patronage, analysis of benefits, and interaction with other elements of the transportation system.

PLANNING AND FINANCING FACTORS

To understand the factors influencing the decision to build or not build a project of the monumental proportions normally a part of a rapid transit system, one must have some understanding of the motivation of the agency charged with implementing the project. Usually, the substantive beginning of the project will have originated elsewhere (such as a regional planning commission, a council of governments transportation plan, or a comprehensive transportation planning process). Recommendations for rapid transit construction as part of a long-range transportation plan for the area and for the formation of an agency to begin work on it will have been made. Often the date that the plan is to be completed, what type of vehicles (rail or bus) will be involved, and locational details are included only in schematic form. The legislature acts on the strength of this general recommendation to enact legislation for the formation of an authority to plan, design, build, and operate a rapid transit system, and it does so without much fanfare or debate because it usually makes the issue of money for implementation contingent on a successful bond referendum.

The newly formed transit authority quickly perceives that its success will be judged by how quickly it can get a system planned, financed, designed, and under way. It also knows that getting anything built will require a successful bond referendum, which, in turn, is most easily achieved with a system that is big, bold, glamorous, fast, extensive, and, above all, appears to serve as much of the affected area as possible from the day the system first opens. Because even a small start on 1 short line most likely will be the biggest public works project in the history of an area, it is much easier to sell the full system if it appears to serve more people. In short, selling a billion dollar project is easier than selling a hundred million dollar project.

At this point, the authority must simultaneously court the favor of 2 masters, each of which has different tastes. The local one desires or requires, if it is to be stimulated at all, an extensive system. The other one, which includes the senior governments being called on to finance much of the project, requires a truncated, less costly project. The senior government knows that it cannot get enough money to fund all of the systems being planned and suspects that good transportation planning, economic analysis, and common sense would dictate a plan that begins small and develops over time. These 2 masters spend much time during the planning period demanding changes to the plan to better conform to their individual constraints. An understanding of this decision-making environment is essential if one is to comprehend how planning for rapid transit is conducted.

The dominance of financial influence on planning decisions can be seen in actual cases. Toronto began its rapid transit with surplus money. Therefore, no referendum was required. The first section was only 4 miles (6.4 km) long. Baltimore obtained financing for its system through state legislation. Again no referendum was required. Baltimore is beginning with 1 line. Buffalo is starting with a single line under similar circumstances. However, Washington, D.C.; San Francisco; Atlanta; Seattle; and Los Angeles required referenda and proposed multiple-line total systems to be completed as a package so that all parts of their metropolitan areas would receive service almost simultaneously.

ATTITUDE FACTORS

Decisions relating to the building of rapid transit as well as to the type of system being planned are influenced heavily by local attitudes and preconceived notions about the importance of transit improvements quite apart from the analytical presentations of the feasibility study. All the larger cities of the United States had comprehensive transportation studies performed as part of the requirements of the Federal-Aid Highway Act of 1956, and most of these recommended a much more modest role for transit than is often the case now. The same analytical techniques are still being applied. The basic differences now are related to the values of the citizenry. Major concern for the urban environment, energy consumption, and social issues has surfaced since 1956. Therefore, assumptions and analysis lean more toward rapid transit than toward highways.

Often the attitude is not so much in favor of rapid transit as it is against highways or automobiles. San Francisco passed its successful rapid transit bond issue several years ago in the heat of the freeway revolt in that city. Washington, D.C.; Baltimore; Boston; and other cities also have experienced freeway revolt symptoms that have helped promote the cause of rapid transit. Concern for the environment was perhaps the factor that was uppermost in the minds of the voters in the Denver area last year when they approved the development of a system to cost more than $1 billion before being presented with details of system hardware, performance, or required time for development.

Civic boosterism is a motivating factor especially when 2 cities that have a tradition of rivalry consider development of rapid transit systems.

For years, the federal government has promoted the concept that transportation planning be carried out at the local level and that local planning officials be responsible for the outcome. It is therefore inevitable and perhaps even desirable for each group to develop criteria that are responsive to its unique values and aspirations. The problem comes when the criteria are not physically or economically realistic. No matter what one's aspirations are, building a $100 million rapid transit system to carry 5,000 passengers/day makes no economic sense especially if one is asking for financial assistance from another agency or level of government.

PHYSICAL FACTORS

Regardless of attitudes or institutional arrangements in a community, the physical relationships of activities and topography either lend themselves to the type of service that rapid transit provides or they do not. These physical factors are the dominant influence on the ultimate cost of constructing the system and how many riders over which the cost can be distributed.

Efforts to measure city attributes in ways that will quickly identify those that can justify rapid transit have been numerous. Table 1 gives a listing of several of these. Most are related directly to measures of potential passenger demand, and many could be accepted as valid for most cases. However, criteria related to corridor flows, city center density, or central buisiness district (CBD) size have limited value because the definition of a corridor or what constitutes a CBD or the boundaries of the city center varies among urban areas. Then, some cities are exceptions to almost all measures.

One major factor often neglected in lists of aggregate criteria is city configuration. Figure 1 shows 4 typical city configurations. Figure 1b shows a typical community with a CBD in the center and the urban area spread in a 360-deg pattern around it. A rapid transit system serving such an area would require 8 spokes with 45-deg angles between each spoke. Denver, Washington, and Baltimore are 360-deg cities. A city such as that shown in Figure 1c would have the same population as that shown in Figure 1b but would require only 5 spokes to provide the same service. Each spoke would carry heavier volumes. Toronto and Chicago are 180-deg cities. A city such as that shown in Figure 1d with the same population as that of the cities in Figures 1b and 1c could be served with only 2 spokes, each of which would carry very heavy volumes. Honolulu and

Caracas, Venezuela, are corridor cities. The proposed Honolulu system is projected to carry peak-line volumes of up to 15,000 passengers/h even though the area population is expected to be only about 500,000 persons. The worst situation would be a city such as that shown in Figure 1a where 16 spokes would be required to serve the area. Minneapolis-Saint Paul and Dallas-Forth Worth are twin cities. Clearly, the systems shown for each area decrease in price from Figure 1a to Figure 1d. Also the level of service increases from Figure 1a to Figure 1d because requirements for passenger transfers decrease. In a 180-deg city, no one would have to transfer within the rapid transit portion of the system, and the number of passengers for a given line would increase. The capacity and congestion problems of automobile transportation increase from Figure 1a to Figure 1d because all travel is concentrated into fewer corridors. The configuration factor is one of the major reasons why Honolulu is seriously considering rapid transit with a population of 0.5 million while the Twin Cities with a population of 2.5 million is vacillating. It also suggests that cities that do not recognize the configuration factor in their aggregate criteria will find themselves faced with many exceptions to the criteria.

Another factor that causes cities to be exceptions to identifying measures is the availability of cheap rights-of-way. If the rapid transit system can be built on the surface, say in the median strip of a highway, then construction costs (including those for right-of-way) typically might run $5 million/route mile ($3 million/route km). If the line is required to run in tunnel, costs for subway construction easily might be 10 times this amount. Cleveland, Ohio, built its modest but effective rail system even though patronage is only 3,000 to 4,000 persons/h on 1 of its lines. Such a low patronage on a rail system makes sense only because of the very low cost of $4 million/route mile ($2.6 million/route km) for the system when it was built in 1955. Such low costs were possible only because of the availability of an inexpensive right-of-way along existing railroad lines, which meant that no tunneling and very little elevated construction were required. Clearly, the availability of suitable right-of-way is a site-specific characteristic that is not considered in aggregate criteria. When it influences construction costs by a factor of 10, it must be considered in decisions concerning the feasibility of a rapid transit system.

Figure 2 shows the importance of construction costs in determining the total cost of hauling people. It must be observed that costs per passenger mile exceeding 15 to 20 cents (9.4 to 12.5 cents/passenger km) are likely to be in excess of the costs of transporting people in cars or buses. From Figure 2 it can be seen that 15,000 passengers/day might be all that is required to maintain 20 cents/passenger mile (12.5 cents/passenger km) of the system can be built for $5 million/mile ($3 million/km). However, if costs reach $15 million/mile ($9.4 million/km), then patronage must be more than 45,000/day, and, if costs are $35 million/mile ($22 million/km), then patronage must be more than 100,000/day.

The major issue concerning physical factors is reduced then to 1 question: What is it going to cost per passenger mile (kilometer) to haul people? If this cost exceeds the costs of other modes by a significant amount, then justification, if any, in terms of overall community benefits must be examined more critically before an affirmative decision is made. For example, if a proposed system would produce costs greater than, say, $1.00 to $1.50/passenger mile ($0.625 to $0.94/passenger km), then the cost of a chauffered limousine surely deserves added scrutiny. On the other hand, if the cost is equal to or less than that of other existing modes, then an affirmative decision can be made more easily. Unfortunately, the question of the cost effectiveness of proposed U.S. transit systems, both rail and bus, in terms of ultimate product—passenger mile (passenger kilometer)—often is not presented. Table 2, however, gives data that show the costs of several rail systems as of several years ago before the latest round of cost escalations. The data in this table suggest that, when cost per passenger mile (passenger kilometer) exceeds that of automobile costs by very much, questions of feasibility become much more critical.

Table 1. Criteria used in selected studies (2).

Criterion	Threshold Value: Desired	Threshold Value: Minimum
City center population density, persons/mile^2	14,000 to 15,000	10,000 to 12,000
Passenger flow/corridor, persons/h	30,000 to 40,000	30,000 to 40,000
Urban area population	2,000,000	1,000,000
City center population	700,000	500,000
CBD floor space, feet^2	50,000,000	25,000,000
CBD destinations/mile^2	300,000	150,000
Peak-hour cordon count, persons in CBD	100,000	70,000
Daily CBD destinations/corridor	70,000	40,000

Figure 1. Configurations of typical cities with equal populations.

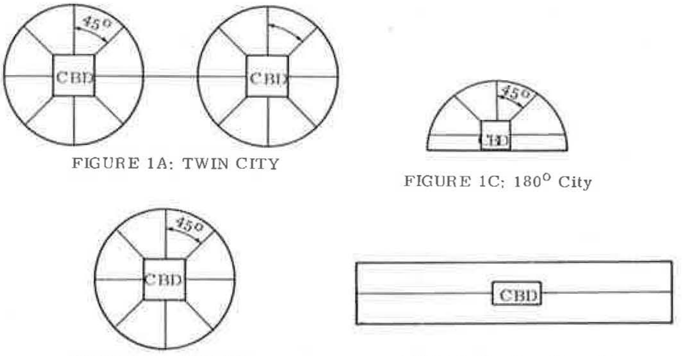


Figure 2. Cost per passenger mile (kilometer) versus daily patronage.

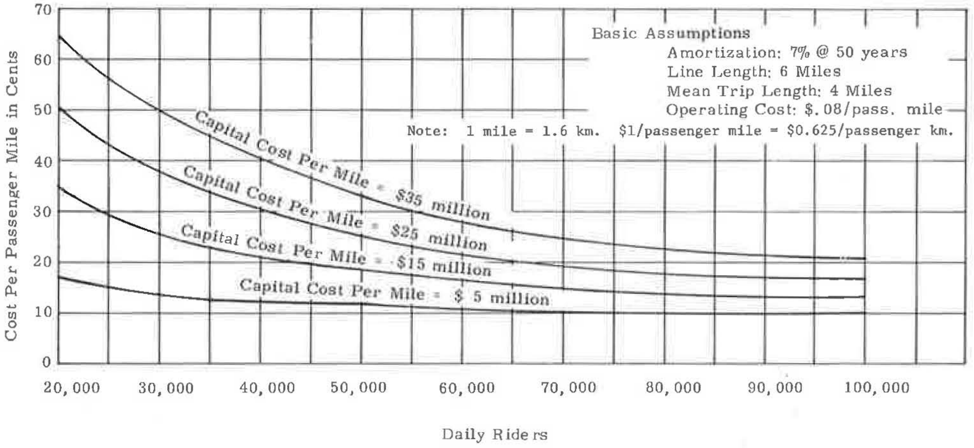


Table 2. Costs for several U.S. rapid transit systems (3).

Location	Annual Patronage (millions of dollars)	Capital Costs (millions of dollars)	Annual Costs (millions of dollars): Capital	Annual Costs: Operating	Annual Costs: Total	Costs/ Passenger Trip (dollars)	Average Trip Length (miles)	Costs/ Passenger-Mile (dollars)
Twin Cities	101	923	61.3	34.6	95.9	0.95	5.5	0.17
Atlanta	102	475	31.6	44.9	76.5	0.75	7.5	0.10
Washington, D.C.	327	1,828	121.5	90.0	211.5	0.65	7.1	0.09
Baltimore	141	1,117	74.5	43.2	117.4	0.83	5.7	0.15
Los Angeles	236	1,788	119.2	103.0	222.2	0.94	8.5	0.11
San Francisco	202	1,200	79.8	74.2	154.0	0.76	8.0	0.10

Note: 1 mile = 1.6 km. $1/passenger mile = $0.625/passenger km.

ECONOMIC ANALYSIS

Any serious economic work on how much transit makes sense for an area usually is dismissed for 2 reasons.

1. The authority responsible for building the system must get voter support from the entire area if it is to build anything. Amount of investment, then, is a function of what it costs to cover the area, and investment analysis thus becomes irrelevant in such an environment.
2. Economic analysis of benefits and costs is in disrepute in the United States partly because it must necessarily depend on some heroic and less than totally agreed on assumptions and partly because it has been bent unsuccessfully by authorities who used it as a tool for justifying actions they fervently desired to take for other reasons.

The lack of standardized methodologies for such studies has further lowered the repute of benefit-cost analysis because the need for system justification motivates the analyst to add benefits from as many sources as his or her imagination can produce. That some categories are simply alternate ways of counting the same benefits does not matter because no one is really serious about it anyway.

Table 3 gives a comparison of benefits estimated for several selected rapid transit proposals. The table has grouped all benefits into 3 categories.

1. Transportation (direct) benefits include travel time and operating cost savings for various classes of users of the transport system for all modes.
2. Community (indirect) benefits include those other benefits deemed by the analyst to be quantifiable but that stem from secondary effects of transportation improvement.
3. Miscellaneous benefits include items not conveniently classed into the other 2 categories.

The direct benefits included for various studies seem to be the most uniform in concept. Most components of direct benefits were included in most studies. Some analysts seem to be guilty of double counting by including both accident and insurance cost reductions.

Indirect benefits seem to vary widely. Analysts seem to have reached little agreement on which items to include, and values vary surprisingly. Little is known about estimating secondary benefits, and analysts use widely differing methodologies. Many of the benefit categories included under indirect benefits in Table 3 are most likely the same items with different labels. Even if the analysts accurately measure the items, they may be involved in some form of multiple counting especially if the direct benefits have been tallied.

Miscellaneous benefits may represent further departures from rigorous benefit-cost methodologies. For example, including savings from transport investments no longer required implies that one is comparing the improved system (one in which rapid transit is built) with something other than a null system (one in which only committed additional investments will be made in transportation improvements). Savings in fare expenditures are also a questionable benefit because such savings to riders must mean an added cost to taxpayers when systems operate at a deficit. Beyond that, savings in fare expenditures are simply revenue reductions, and system revenue has no place in the analysis because it is neither a benefit nor a cost but a component of system financing. Savings in bus system operating costs, for uniformity, should be regarded as a reduction in system cost (in the denominator of the benefit-cost ratio) rather than as a benefit (in the numerator).

The following gives estimated total benefit-cost ratios for the system according to the data in Table 3:

Metropolitan Area	Benefit-Cost Ratio
Buffalo	1.15
Atlanta	2.79
Baltimore	1.31
Honolulu	3.80
Los Angeles	1.87
Washington, D.C.	3.17
Cleveland	1.23

Table 4 is similar to Table 3 except that all the values have been normalized by dividing the benefits by the number of transit system riders in the design year. Because almost all transit system benefits are correlated highly with the number of riders the system carries (more precisely, most benefits are related to the number of additional riders the system attracts above the null system), one would expect to see some similarity in benefits per rider obtained in different categories. Unfortunately, this is not the case. Here even the direct benefits vary widely in value. Operating cost savings per person diverted to the improved transit system vary from more than $6.90 for Honolulu and Los Angeles to only $0.74 in Atlanta. Time savings (due to reduced highway congestion) for trips that continue to use automobiles after transit improvement vary from Honolulu's $16.14 to Baltimore's $0.40.

Table 5 and Figure 3 summarize the values and distributions of direct, indirect, and miscellaneous benefits for different cities. The absolute value of total benefits per design year rider varies from Baltimore's $41.34 to Buffalo's $4.86. Why there is a 10-fold difference is difficult to explain. The proportion of all benefits related to direct transportation benefits varies even more, from more than 100 percent in Buffalo and Honolulu to only 36 percent in Baltimore.

The data given in Table 6 suggest some of the reasons for such wide variations. The discount rate, which is the presumed time value of money used to discount the value of future benefits and costs to present worth, is a critical assumption used in benefit-cost analysis and can cause a big difference in the results when one compares systems with different degrees of capital intensiveness. As shown in Table 6, this value varies by 50 percent between studies (discount rate is 4 percent for Buffalo and 6 percent for Atlanta). The value of travel time savings has varied from $0.60 to $3.60/h. The bottom row in Table 5 shows the proportional effect on total benefits of the direct transportation benefits as estimated in various studies. Clearly, the relative value of such systems cannot even be hinted at when input assumptions vary so much.

It is believed that studies could be much improved and be more useful if certain aspects were prescribed and standardized. The U.S. Department of Transportation should require studies of rapid transit feasibility to meet such standards before applications for federal funds are made. Development of standards for transportation (direct) benefits should be simple. Development of standards for community (indirect) benefits will be more difficult, but separate identification of these at least will allow the reviewer to see the extent to which system justification depends on these less precise measures.

ITEMS TO BE STANDARDIZED IN AN ECONOMIC ANALYSIS

This section contains a partial list of items to be standardized.

1. Alternative improved system will be compared to a null system. The null system is the transit system in the target year that provides essentially the same level of service that the current system does. This means that it is a system that uses the same equipment, fares, frequency, and routes as the current system does together with expansions or alternations to provide for expected changes in population and land use.
2. All benefits will be classified into direct transportation benefits and indirect

Table 3. Benefits estimated for selected rapid transit proposals (4, 5, 6, 7, 8, 9, 10, 11).

Benefit	Metropolitan Area: Buffalo	Atlanta	Baltimore	Honolulu	Los Angeles	Washington, D.C.	Cleveland
Transportation (direct)							
Savings for trips diverted from automobiles							
Operating costs	39	120	539	699	956	246	
Parking costs	52	114	155	317	516	324	
Automobile insurance costs	10	25	26	29	—	46	333
Additional vehicle costs	55	177	169	580	78	376	
Reduction in accident costs	—	818	—	60	107	—	
Time	100	241	132	175		211	618
Time savings for continuing transit trips		353	235	354	941	1,753	
Savings for continuing automobile trips							
Time	—	1,365	43	1,629		697	205
Operating costs	—	—	117	—	102	—	—
Savings to trucking industry	—	752	182	—	28	88	—
Community (indirect)							
Employee parking cost savings to suburban employers	—	29	—	—	—	73	—
Increases							
Construction employment during project	—	—	109	272	545	—	—
Economic output	—	—	44	22	682	—	—
Business productivity	—	—	—	—	341	—	—
Government tax receipts	—	—	136	—	—	—	—
Destination opportunities	—	—	—	—	568	—	—
Transit services	—	—	—	—	—	—	110
Decrease in government expenditures	—	—	40	—	341	—	156
Miscellaneous							
Savings in transit fare expenditures	-90	—	—	-743	-798	—	341
Savings from transport investments no longer required	—	—	2,553	—	—	—	—
Savings in bus system operation costs	50	64	—	—	—	—	—

Note: Entries are in millions of 1973 dollars after discounting to net present value.

Table 4. Benefits per design year rider for selected rapid transit proposals (4, 5, 6, 7, 8, 9, 10, 11).

Benefit	Metropolitan Area: Buffalo[a]	Atlanta[b]	Baltimore[c]	Honolulu[d]	Los Angeles[e]	Washington, D.C.[f]	Cleveland[g]
Transportation (direct)							
Savings for trips diverted from automobiles							
Operating costs	0.88	0.74	5.03	6.93	6.91	0.84	
Parking costs	1.16	0.70	1.45	3.14	3.73	1.11	
Automobile insurance costs	0.23	0.15	0.24	0.28	—	0.16	2.61
Additional vehicle costs	1.24	1.08	1.58	5.75	0.56	1.28	
Reduction in accident costs	—	5.01	—	0.59	0.78	—	
Time	2.25	1.48	1.23	1.74		0.72	4.85
Time savings for continuing transit trips		2.16	2.20	3.51	6.81	5.99	
Savings for continuing automobile trips							
Time	—	8.36	0.40	16.14		2.38	1.61
Operating costs	—	—	1.10	—	0.74	—	—
Savings to trucking industry	—	4.61	1.70	—	0.20	0.30	—
Community (indirect)							
Employee parking cost savings to suburban employers	—	0.17	—	—	—	0.25	—
Increases							
Construction employment during project	—	—	1.01	2.70	3.94	—	—
Economic output	—	—	0.41	0.21	4.93	—	—
Business productivity	—	—	—	—	2.47	—	—
Government tax receipts	—	—	1.27	—	—	—	—
Destination opportunities	—	—	—	—	4.11	—	—
Transit services	—	—	—	—	—	—	0.86
Decrease in government expenditures	—	—	0.38	—	2.47	—	1.22
Miscellaneous							
Savings in transit fare expenditures	-2.04	—	—	-7.36	-5.77	—	2.67
Savings from transport investments no longer required	—	—	23.84	—	—	—	—
Savings in bus system operating costs	1.14	0.39	—	—	—	—	—
Total	4.86	24.85	41.84	33.63	31.88	13.03	13.82

Note: Entries are net present values of benefits in 1973 dollars divided by design year riders.

[a]Design year is 1995. Annual patronage in design year is 44 million.
[b]Design year is 1995. Annual patronage in design year is 163 million.
[c]Design year is 1985. Annual patronage in design year is 107 million.
[d]Design year is 1995. Annual patronage in design year is 101 million.
[e]Design year is 1980. Annual patronage in design year is 138 million.
[f]Design year is 1990. Annual patronage in design year is 293 million.
[g]Design year is 1985. Annual patronage in design year is 128 million.

Table 5. Table 4 totals.

Benefit	Metropolitan Area: Buffalo	Atlanta	Baltimore	Honolulu	Los Angeles	Washington, D.C.	Cleveland
Transportation (direct)	5.76	24.29	14.93	38.08	19.73	12.78	9.07
Community (indirect)	0	0.17	3.07	2.91	17.92	0.25	2.08
Miscellaneous	-0.90	0.39	23.84	-7.36	-5.77	0	2.67
Total	4.86	24.85	41.84	33.63	31.88	13.03	13.82

Note: Entries are net present values of benefits in 1973 dollars divided by design year riders.

community benefits and will be carried separately through the analysis in such fashion. The direct benefits also will be classified and identified according to the following outline:

1. Time savings to transit riders who use transit system in both null and improved states
2. Savings to riders diverted from automobiles by improved system
    a. Time
    b. Automobile operating costs
    c. Parking costs
    d. Accident costs
    e. Additional vehicle costs (selling second automobile)
3. Savings to travelers who use automobiles whether transit system is improved or is not improved
    a. Time
    b. Automobile operating costs
    c. Accident costs
4. Savings on truck and goods movement
    a. Operating costs (including savings in driver time)
    b. Capital costs (fleet reduction resulting from higher speeds)

3. A consistent set of travel time values should be specified to cover the range of likely values. Benefits and costs will be calculated for each to see whether the conclusions are dependent on the value chosen.

4. A specified discount rate will be used.

5. Components to include in estimating automobile operating costs and major values of use will be specified.

6. Revenues from the transit system will be ignored in the analysis although the fares assumed in the patronage estimate must be consistent with those assumed in the financial plan. Revenues are not part of the benefit-cost analysis because they operate merely as an internal transfer of values from the users to the suppliers of transit within the system.

7. All analysis will be done in constant dollars of the year the analysis is performed (or the next previous year if later data are not available). No escalation will be assumed on anything, including construction costs, operating costs, and benefits. Sensitivity analysis on the effects of differential escalation on different components can be specified if desired.

8. Any benefits from the system beyond a fixed point, say, 35 to 40 years away, will not be allowed. The present values of benefits in the distant future tend to be small anyway. Some studies, however, have assumed that benefits will continue to grow indefinitely. This obtains significant present values from benefits so far removed into the future as to be beyond reckoning.

9. Land use assumptions should be explicit, and at least 1 analysis that assumes that land use is identical for all systems will be performed. This will allow one to note the extent to which system justification depends on land use shifts, which only can be grossly estimated at best.

10. The challenge match method to compare alternatives will be used. Figure 4 shows such a strategy. System X is a moderate cost system giving moderate benefits, and system Y is a much more costly system giving greater benefits. Is the extra investment $C_Y - C_X$ worth making? Compared to the null system, system X is better. But, when system Y is compared to system X, the extra investment in system Y is still returning larger benefits than the extra investment in system X is and thus is worth building. [An alternative is simply to subtract the present worth of the costs from the benefits, which yields present value of net benefits, B_n. The analysis then can focus solely on maximizing B_n within the overall financial constraints.]

Such a standardized approach should be applied to total systems and to those system segments that represent viable operating entities independent of other parts and thus represent staging increments.

Clearly, benefit-cost analysis is not a substitute for good sense. Other unquantifiable but nonetheless important factors also are at work and must be evaluated. It

Figure 3. Benefits per design year rider.

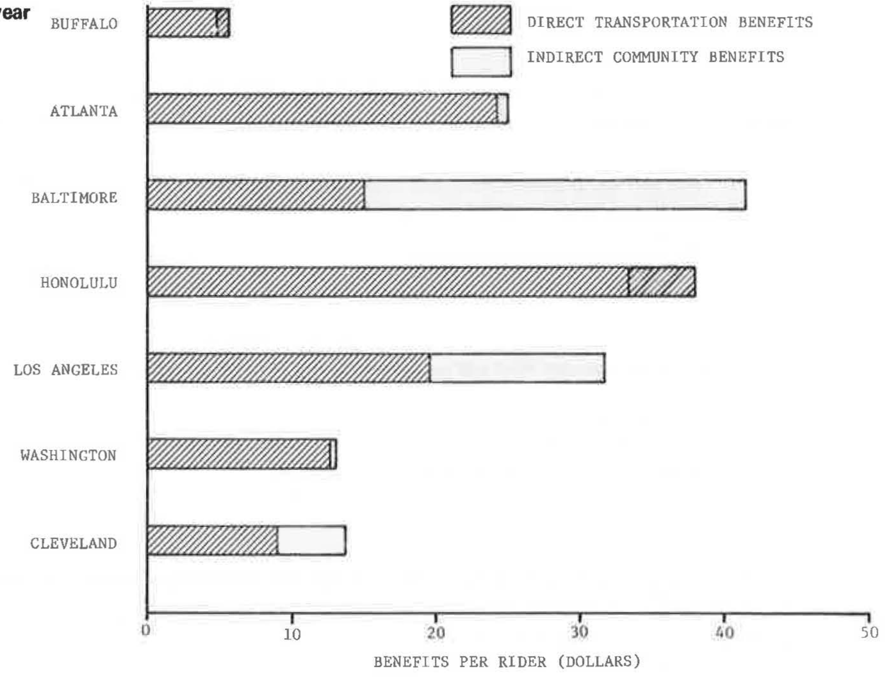
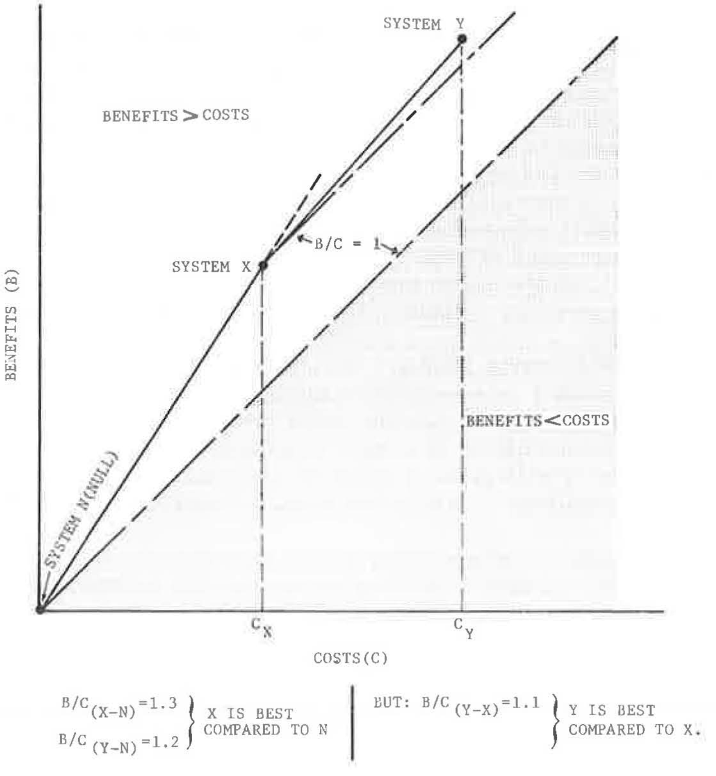


Table 6. Selected differences in benefit-cost assumptions.

Metropolitan Area	Discount Rate (percent)	Value of Time (dollars/h)	Direct Benefits as Percentage of Total
Buffalo	4	1.72	119
Atlanta	6	3.00	98
Baltimore	4	0.60	36
Honolulu	5	3.19	113
Los Angeles	6	3.60	62
Washington, D.C.	4	2.95	98
Cleveland	6	2.80	66

Figure 4. Challenge match method of comparing alternatives.



would seem, however, that consistent measuring of those elements that are measurable would be of assistance and at least would serve as a warning in the case of a very low benefit-cost ratio (less than, say, 0.8 or 0.6) that other nonmeasurable factors must be weighted more heavily in the final evaluation if the system is to be justified.

CONCLUSIONS

It may be concluded that the planning and financial context within which local decisions concerning rapid transit investments are made has a substantial influence over the decision-making process as do preconceived notions about the effectiveness of rapid transit. High proportions of federal financing also can distort local decisions. The need for some consistent process for federal review of applications for limited funds has been identified and 2 measures suggested:

1. Costs per passenger mile (kilometer) estimated in a consistent fashion with guidelines suggesting some upper limit; and
2. Benefit-cost analysis prepared in a prescribed fashion in which benefits are limited to direct transportation benefits and guidelines that require more intensive justification for projects that show benefit-cost ratios lower than some minimum, say, 0.8.

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