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A COMPARISON OF METHODS FOR EVALUATING URBAN TRANSPORTATION ALTERNATIVES

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16. Abstract

The objective of this report was to compare five alternative methods for evaluating urban transportation improvement options: unaided judgemental evaluation, cost-benefit analysis, cost-effectiveness analysis based on a single measure of effectiveness, cost-effectiveness analysis based on multiple measures of effectiveness, and scoring function methods. Each method was assessed within the framework of eight methodological criteria relating to the three major concerns of feasibility, reviewability, and relevancy. The following conclusions were drawn: (1) the judgemental method is satisfactory in several important respects, but its subjectivity and lack of specificity might create difficulties in a federal review of the local decision process; (2) of the systematic evaluation methods, cost-effectiveness analysis based on multiple measures of effectiveness poses the fewest difficulties in simultaneously serving the local and federal purposes.

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PREFACE

This report was written during the fall of 1974 by the Applications Division, Transportation Systems Center, under the sponsorship of the Office of Program Planning, Urban Mass Transportation Administration.

The motivation for the report was based on the emerging U.M.T.A. requirement that urban areas perform an alternatives analysis to be eligible for the discretionary funds provided in the 1974 National Mass Transportation Assistance Act. The report has sought to spell out the issues associated with five candidate evaluation methods which have been considered for use in the alternatives analysis process. The conclusions are intended to serve as a basis for further discussion.

EXECUTIVE SUMMARY

This report compares five possible methods for evaluating urban transportation alternatives. These methods include:

1) Unaided judgmental evaluation: The raw impact predictions are subjectively weighed to decide the relative merits of the alternatives.

2) Cost-benefit analysis: Monetary values of costs and benefits are aggregated to decide the relative desirability of the alternatives.

3) Cost-effectiveness analysis based on a single measure of effectiveness: A single standard of performance is declared in advance and alternatives are compared based on their cost of meeting that standard.

4) Cost-effectiveness analysis based on multiple measures of effectiveness: a set of several standards of performance is declared in advance, and alternatives are compared based on their cost of meeting all the standards simultaneously.

5) Scoring function methods: Subjectively derived weights, which represent the importance of each impact, are explicitly declared. The weighted cost and benefits are then aggregated into a single score which is used to judge the relative merits of the alternatives.

The last four of these represent <u>systematic</u> methods of evaluation, in contrast to the first. The report considers whether any of the systematic methods offer an improvement over judgmental evaluation, both from the viewpoint of the locality seeking to strengthen its planning process, and from the viewpoint of the Federal government attempting to review the local analysis and compare it with that of other cities.

The most important attributes of a "good" evaluation method are taken to be feasibility, reviewability, and relevancy. These broad attributes are reduced to the following operational criteria, on which the five methods are compared:

a) Feasibility of required quantification;

b) Degree of analytical skill required;

c) Reliability and credibility of the numerical data generated in the evaluation;

d) Integrability of the evaluation method with the political process by which public approval of the project is sought;

e) Treatment of distributional issues: who gains and loses as a result of the project;

f) Ease of detecting analytical biases;

g) Usefulness of generated information for a review of the local evaluation based on Federal criteria;

h) Usefulness of information for intercity comparisons.

A comparison of the five evaluation methods according to these eight criteria is presented in summary form in Table 1 (see Comparisons and Conclusions section).

Conclusions: The judgmental method is considered satisfactory in several important respects, but its subjectivity and lack of specificity might create difficulties in Federal review of the local decision purpose.

Of the systematic evaluation methods, cost-benefit is considered unsatisfactory because of its dependence on the ability to place monetary values on benefits and impacts, and its tendency to favor a concentration of benefits among higher income groups. (However, it is recognized that cost-benefit may be an important source of information which may provide a partial basis for the final choice.) Scoring functions also entail great technical complexity, and require the analyst to make some overt and probably controversial value judgments.

The best alternative to judgmental evaluation therefore appears to be some form of cost-effectiveness analysis. However, the use of a single measure of effectiveness can easily result in too great an oversimplification of the disparate goals and objectives of the community and the Federal government. It appears, then, that cost-effectiveness based on multiple measures of effectiveness poses fewer difficulties than any other systematic procedure in simultaneously serving the local and Federal purposes.

CONTENTS

1. INTRODUCTION

1.1 OVERVIEW

The National Mass Transportation Assistance Act of 1974 states that "it is in the national interest to encourage and promote the development of transportation systems, embracing various modes of transport in a manner that will serve the States and communities efficiently and effectively." It is incumbent upon D.O.T., therefore, in order to meet these Congressional objectives, to assure that the discretionary funds apportioned to Federal Urban Transportation Programs are directed toward the most effective solutions.

Since each urban area is unique, there is no satisfactory formula based on characteristics such as population, density, or corridor travel volume that can predetermine the transportation facility needs of a community. The Federal Urban Transportation Programs must therefore respond flexibly, relying primarily on the local ability to assess present and anticipated problems and requirements, and to identify and evaluate alternative courses of action for improvement.

Therefore, D.O.T. will require localities to perform an analysis of transportation alternatives as a formal condition of eligibility for Federal assistance for all major transportation projects. Such an analysis is intended to serve two objectives: to enable the identification of the alternative which is most appropriate for each city, and to provide a basis for the Federal Government to compare the merits of investment alternatives from different cities.

As currently conceived, alternatives analysis will likely include the following phases:

1) Generation of alternatives: Developing and preliminary screening a set of investment alternatives, to produce a set which reflects different technologies and operational modes, but which is addressed to the same broad set of objectives.

2) Prediction of impacts: Forecasting, in quantitative terms where possible, the impacts of each alternative on the nation or locality as a whole, and on particular neighborhood and interest groups. This phase includes cost estimation.

3) Evaluation: Assessing the relative desirability of the alternatives, using the predicted impacts as inputs; attempting to determine the extent to which each alternative meets the overall objectives in which either the locality or the Federal government is interested.

This report focuses on the third stage of this process. It addresses two questions:

a) Is there any formal, systematic procedure for evaluating, ranking, scoring, or comparing alternatives which represents an improvement over unaided intuitive judgment based on the impact data?

b) If so, what evaluation methods are available, and what are the consequences of using each of them?

Five evaluation methods are considered: unaided judgmental evaluation, cost-benefit analysis, two forms of cost-effectiveness analysis, and a family of techniques based on scoring functions. They are compared on the basis of the following eight criteria, which are intended to capture the three primary concerns of feasibility, reviewability, and relevancy:

1. Feasibility of required quantification.
2. Degree of analytical skill required.
3. Reliability and credibility of the numbers generated.
4. Treatment of distributional issues: which groups gain and lose.
5. Integrability with the political process by which public approval is sought.
6. Ease of detecting analytical biases.
7. Usefulness of information for Federal review of the locality's alternatives based on Federal as well as local policy objectives.
8. Usefulness of information for making intercity comparisons.

1.2 EVALUATION VERSUS PREDICTION

The distinction between prediction and evaluation is important in defining the scope of this report. Prediction, as used here, refers to the process by which the positive and negative impacts of any proposal are discovered and estimated. It includes cost and

revenue forecasts, ridership and modal split predictions, effects of the proposal on travel times, roadway congestion, air quality, energy consumption, neighborhood cohesion, and other such factors. In theory, if not in practice, it is a value-neutral activity. It is concerned with questions of the form, "What will happen if we implement system X?"

The evaluation process uses as input the outputs of the prediction process. Unlike prediction, evaluation cannot be (even theoretically) a value-neutral undertaking. In this stage, the analyst, the political decision-maker, and the community jointly attempt to address questions like, "On what criteria do we decide which alternative should be selected? Which alternative, given the impacts predicted for it, comes closest to meeting the objectives we are seeking?"

Cost-benefit, cost-effectiveness, and scoring functions represent systematic methods of reaching answers to these questions in contrast to the unsystematic judgmental approach.

They are designed to rank alternatives on the basis of specified criteria. For instance, cost-benefit analysis ranks proposals on the basis of their effect on overall economic efficiency. Therefore, a decision-maker who uses the results of a cost-benefit analysis as an important guide to his choice among alternatives inevitably makes a value judgment that it is desirable in the case at hand to improve economic efficiency.

It follows that if the evaluation is to be relevant to the final choice, the value judgments which are made in the evaluation process must be consistent with those which influence the final decision. One of the questions which this report addresses is whether the value judgments which are subsumed in each evaluation method are likely to be compatible with those of local and Federal decision-makers.

One possible source of value discrepancy between the local and Federal government perspectives is in the definition of cost. From a purely economic standpoint, it is appropriate for a local government to weigh all of the consequences of an alternative against only the financial costs incurred by the locality, which would be typically 20 percent of the capital costs and 50 percent or more of the operating costs (depending on the Federal contribution). However, the Federal government

would tend to view the full costs associated with implementing the alternative. This discrepancy between local and Federal objectives creates the possibility that a locality might choose an alternative which would not be an effective utilization of Federal funds. Hence, a major concern in setting standards for alternatives evaluation is to require localities to report enough information for the Federal government to independently review the local evaluation from the viewpoint of Federal objectives.

1.3 DEVELOPMENT OF THE IMPACT TABLEAUS

Clearly, no evaluation can be more credible or persuasive than the impact predictions on which it is based. The most important problems in the prediction phase are likely to be:

a) Difficulty in estimating certain impacts, such as changes in land use.
b) Difficulty in detecting concealed analytical biasis, or implausible assumptions which are required to apply the available models.
c) Non-uniformity between cities in the variables being predicted and the prediction methods utilized.

Errors or biases which result from these problems are additional to any problems which are created by the evaluation method which is employed.

The final output of the prediction phase, as it is defined here, is an "impact tableau" which indicates the effect of each

alternative on each policy goal or value which is being considered. Whenever possible, the prediction should be quantitative, in units which are appropriate for the impact being measured (e.g., BTU consumption to measure energy-efficiency, or person-hours to measure travel time). When quantitative predictions are not feasible, qualitative forecasts should be made, such as "more severe visual intrusion." It is important that the impact tableaus include predictions of impacts on particular communities or citizen groups, as well as aggregate predictions. Ideally, some indication of the confidence which can be placed in the prediction should be given.

It is assumed here that this entire set of predictions is available at the beginning of the evaluation process, even though in practice the evaluation is likely to have a feedback effect, by revealing new goals and stimulating efforts to predict different impacts.

2. UNAIDED JUDGMENTAL EVALUATION BASED ON THE IMPACT DATA

Description: This is the "null case" against which all of the systematic alternatives are compared. In this procedure, the decision-maker (which may be a planning body, an elected board,or a community referendum as well as a single official) receives the data on predicted impacts, weighs it as he deems appropriate, and evaluates the relative merits of the alternatives. He may choose to ignore some data, or to regard other data as completely decisive. Possibly he may offer some public explanation of his conclusions, but there will be no way of reviewing his method and judging its "correctness" or even its internal consistency.

One consequence of avoiding any summary or analysis of the impact data is that none of the data is classified under "cost" or "benefit." Hence, the problems of defining what constitutes a cost or a benefit do not arise.

Evaluation: By avoiding any attempt to aggregate or summarize the array of impact data, this method tends to prevent the interests of particular groups from being overlooked in aggregate statistics such as benefit-cost margins. None of the complexity of the issue is concealed from the

decision-maker. This complexity is a disadvantage as well as an advantage, since decision-makers may find it difficult to cope with such a disparate body of numbers and predictions.

With respect to the eight comparison criteria announced above, the following conclusions can be drawn concerning this method:

1) Feasibility of required quantification. In the judgmental approach, no effort is made to calculate summary statistics or to attach dollar values to impacts which have been either left unmeasured, or measured only in physical units such as person-hours saved. Hence, no additional problems of quantifiability are raised beyond those which must be confronted while assembling the impact tableaus.

2) Degree of analytical skill required. Since there is no objectively specifiable method for evaluating the impact data, there is no standard by which "correct" use of the method can be judged. Hence, it is not meaningful to assess the degree of skill needed to use the method "correctly."

3) Reliability and credibility of numbers generated. Since the method does not require the generation of any statistics beyond those in the impact tableaus, no problems arise with respect to the credibility of these statistics.

4) Treatment of distributional issues. Because the impacts on individual groups are not summarized away, the consideration given to interest-group level impacts can be fairly good. Precisely because no quantitative measure of overall desirability is developed, the desirability of the various alternatives for individual groups is highlighted.

5) Integrability with political process. In this method, there is no consideration given to any technical calculation which purports to show which alternative is "optimal" or "most efficient" or "most cost-effective." It is left to the local political process to provide an operational definition of "best alternative." Since there is no technical distillation of the raw information generated in the impact prediction process, the evaluation process is entirely political.

It should be noted that the Federal government as well as the locality will have to justify their eventual choice on the basis of admittedly subjective judgment, if there is no technical basis for identifying the "most beneficial" or "most cost-effective" alternative. The political nature of this judgment will have to be openly recognized.

6) Ease of detecting analytical bias. Since the analysis stops with impact prediction, there is no opportunity for analytical bias in the procedure by which these empirical predictions are processed in reaching a decision. Any bias on the part of the decision-maker who judges the impact data is, however, very difficult to detect, since there are no objective, reviewable steps which he must follow.

7) Usefulness for Federal review of local evaluation process. The lack of a specified or reviewable evaluation procedure prevents the Federal government from determining (except by inference) what goals were considered, how they were weighed, and whether the trade-offs between costs and impacts, or between the interests of different groups, were compatible with Federal priorities. Hence, the use of a purely judgmental evaluation method creates problems for Federal review beyond those which are inherent in the development of the impact predictions themselves. In particular, it will not be clear whether the goals which are of greater interest to the Federal government than to the locality (such as the Federal interest in economizing on capital costs) have been given due consideration.

8) Usefulness of generated information for intercity comparisons. It is possible for the Federal government to require certain impacts to be considered in the impact tableaus. This would mean that every city's application would provide at least a subset of comparable information. Beyond this, since different cities will be concerned with different impacts, serious and unavoidable problems of comparability will arise.

Summary: Unaided judgmental evaluation is attractive within a local political context because no issues are hidden in aggregate statistics. However, an unaided judgment of the large body of information generated in the prediction phase is essentially subjective and hence imposes problems for Federal review.

3. COST-BENEFIT ANALYSIS

Description: Cost-benefit analysis is a systematic method for determining the extent to which the benefits of a project exceed its costs. This method extracts from the set of predicted impacts those for which realistic monetary values can be obtained or estimated. Positive monetary values are assigned to "benefits" which consist of those impacts which citizens would be willing to pay for if they could be purchased in some market. Negative monetary values are assigned to "costs" which consist of the value of resources consumed in the implementation and operation of a transportation system plus those adverse impacts which the citizens would be willing to pay to avoid. The "net value" of a transportation alternative is the algebraic sum of the positive and negative values of its impacts. If this sum is positive, and if all impacts have been included, then it is possible to adopt the alternative and fully compensate everyone who "loses" as a result of it, while still leaving the "winners" better off than they were prior to the implementation of the project. Cost-benefit would have the decision-maker choose the project which yields the maximum net value subject to the constraint of financial feasibility.

Although most discussions of cost-benefit analysis focus on the difficulty of measuring benefits, the method requires a somewhat unique definition of "costs" as well. Since the method

is intended to measure costs to society rather than costs to the government, it draws a distinction between resource purchases and transfer payments. If governmental funds are used to purchase an economically valuable resource (a ton of steel, or a laborer's work), this is an economic cost to society because the resource could have been used for another economically valuable purpose, i.e., an opportunity cost is incurred in the use of the resource. However, if the government spends money for a resource which has no alternate use, i.e., an opportunity cost of zero, then it has simply transferred income from the taxpayers to the recipient of the payment. This is not an economic cost in strict cost-benefit analysis, even though it represents a claim on the governmental budget.*

Also, cost-benefit analysis requires that costs to the community which do not represent claims on government funds (i.e., uncompensated adverse impacts) be included as costs. For example, any expense which is incurred for soundproofing by homeowners adjacent to a right-of-way is included in the

* This point is relevant to fixed-facility transportation investments in cities with high unemployment, since a substantial portion of the wage payments for the construction may go to workers who would otherwise be unemployed. In this case, the economic cost to society of these payments is zero, since the resources (labor) which they attracted would not have produced anything economically valuable in the absence of the project. Strictly speaking, these wages should not be included in the costs of the projects.

cost of building the right-of-way, even though the cost is not borne by the government.

Of course, a governmental body may wish to count only its own costs in allocating its funds. In that case, impacts such as the noise adjacent to the right-of-way may be treated as "negative benefits." This change of label will not affect the results, since the monetary values for both "costs" and "negative benefits" will be added together to arrive at the "net value" of the investment. However, if the government decides to include transfer payments in its definition of costs, the final result will be affected, since otherwise these payments would not be included as either benefits or costs.

Evaluation: The challenge in cost-benefit analysis is in determining the monetary values which are to be assigned to the impacts of the transportation alternatives. Many of these cannot be determined directly from prices in the market, and so must be inferred by the analyst. The method for imputing values which is most easily incorporated into existing economic theory is the "willingness to pay" principle, which states that the value of a benefit to an individual is the amount that he would be willing to pay for that level of the benefit. The value of the benefit to society is the sum of its value to all individuals.

This approach presents several problems. It tends to give greater weight to the preferences of richer people, and it introduces serious difficulties of quantification. These problems are treated below in detail. If the analyst attempts to avoid these problems by using a valuation method other than willingness-to-pay, he is choosing to use what we have called a scoring function. This approch is treated in Section V.

Additionally, since the analysis focuses solely on monetarizable impacts, cost-benefit may have the result of downgrading the importance of non-monetarizable impacts.

In the context of the eight criteria mentioned in the Introduction, the following comments can be made about cost-benefit analysis:

1) Feasibility of required quantification. A comprehensive cost benefit analysis requires that monetary values be assigned to all known impacts. However, impacts such as air and noise pollution, or improvements in accessibility and mobility, although quantifiable in physical units, cannot easily be assigned dollar values. Other impacts such as neighborhood cohesion and aesthetic attractiveness cannot reasonably be quantified in any units. For many cities, it is those impacts to which monetary values cannot be assigned that will likely be most important in the choice of alternatives.

The usefulness of cost-benefit analysis thus depends on the importance of the monetarizable impacts relative to the total impacts. Sometimes a cost-benefit analysis can serve to eliminate an alternative from further consideration. If the monetary costs of one investment exceed its monetarizable benefits, and there is another alternative with a positive net monetary value and comparable or "better" non-monetarizable effects, then the first alternative can be eliminated from consideration. If the non-monetarizable effects of the second alternative are significantly "worse", however, cost-benefit analysis will be inconclusive.

2) Degree of analytical skill required. The imputation of market prices to benefits whose market value cannot be directly observed is a difficult analytical task. Also, there are numerous pitfalls in distinguishing costs from transfer payments, and in selecting a discount rate to compare present and future impacts, which require considerable analytical skill to detect and avoid. Many times the results will depend on assumptions which have been made at a very detailed level of the analysis.

3) Reliability and credibility of numbers generated. When market prices can be observed directly, they

are reliable and credible when used in an analysis. When they must be inferred, there is a wide latitude for difference between imputed values. This results from the complexity of the methodology used to make the inference. Equally qualified analysts might make widely varying estimates.

4) Treatment of distributional issues. By valuing benefits based on willingness to pay, cost-benefit is inherently concerned with the incidence of impacts. However, the cost-benefit method inevitably gives greater weight to the preferences of those whose income or wealth enables them to pay more for what they want. Thus, a transportation system which saved 10,000 person-hours per day for low-income travelers would be judged as less beneficial than one which saved the same amount of time for high-income travelers, since the latter group would be willing to pay more for this amount of time saving. Cost-benefit analysis, like the market itself, tends to identify as "efficient" those projects whose benefits accrue largely to those who are already privileged.

Theoretically, any undesired redistributive effects which result from this tendency can be offset by requiring the high-income "gainers" to compensate the low-income "losers" in cash for their losses. In practice, there is obviously no guarantee that such a requirment will be imposed.

Finally, because it is limited to monetarizable impacts, cost-benefit can make no assessment of the redistributive effects of the non-monetarizable impacts. It adds nothing to the decision-maker's unaided judgment about the incidence of these effects.

5) Integrability with the political process. Since the market values are intended as "objective" measures of the relative importance of the monetarizable effects of the investment, cost-benefit analysis cannot consistently accept community input concerning what these values should be. The only theoretically acceptable way for the public to influence the valuation would be to change their purchasing behavior (through a boycott, for instance) sufficiently to change the analyst's empirical estimate of their willingness to pay. Any community concern over non-monetarizable effects might serve to lessen the relevance of the analysis to the decision-maker.

6) Ease of detecting analytical biases. The intricacy of the method, and the number of empirical assumptions which must ordinarily be made to obtain monetary values, create plentiful opportunities for introducing biases into the analysis. Such matters as the choice of a discount rate, a time horizon, and similar technical choices can all be made in such a way as

to bias the analysis severely. These choices can be questioned only be a reviewer whose knowledge of the data and the method is nearly as detailed as the analyst's.

7) Usefulness for Federal review of local evaluation process. If the Federal government intends to allocate its funds so as to maximize the net market-determined value to society of the projects which it supports, and if the local analysis does not contain any undiscovered analytical errors, then cost-benefit analyses are extremely pertinent and even essential. If, however, the Federal criteria differ in any way from the market valuations of the impacts, then the cost-benefit analysis will not be very helpful, since it will not ordinarily indicate how the results would be affected if any of the valuations were changed.

The ability of Federal reviewers to determine which local alternative is most desirable from a Federal perspective is limited by cost-benefit evaluations to the extent that non-monetarizable impacts represent significant Federal objectives.

8) Usefulness for intercity comparisons. If the Federal allocation criteria are exactly those which are measurable in cost-benefit analysis, then the analyses will present the most relevant data which can be obtained. Otherwise, the cost-benefit information will not be decisive, but

may nonetheless be useful in assuring the Federal government that it is not funding projects which are expected to be a net economic loss. If the Federal government wishes to consider non-monetarizable impacts, cost-benefit analysis will not be more informative than the impact tableaus themselves.

It should be noted that if cities perform cost-benefit analyses they will presumably include in their analyses all impacts which have a non-zero market value. This eliminates one problem of intercity comparability which arises when cities subjectively decide to consider some goals and not others. Any impact which is omitted from a city's cost-benefit analysis would presumably have a market value of zero in the locality.

Summary: Cost-benefit is theoretically attractive, since it purports to indicate which of the alternatives under consideration will yield to greatest net economic benefit. Unfortunately, the effort to impute realistic monetary values to all impacts and benefits create a series of unwieldy technical complexities which limit the method's practical value. Also, a successful application of the method would tend to reproduce the distributional outcomes of the market as well as its efficiency. These outcomes, tending to favor those already well-situated, may not be considered appropriate

for public projects. Additionally, non-monetarizable impacts which may be significant in the selection of an alternative, are not integrable into a cost-benefit framework.

4. COST-EFFECTIVENESS ANALYSIS

General Description: Among systematic evaluation procedures, the chief alternative to cost-benefit is some form of cost-effectiveness analysis. The distinguishing feature of cost-effectiveness is that the decision-maker determines in advance some "level of effectiveness" which the chosen alternative must achieve. Alternatives are then evaluated and compared on the basis of the cost of achieving the declared level of effectiveness.

The various forms of cost-effectiveness differ primarily according to the dimensionality of the level of effectiveness. The level of effectiveness can have a single dimension or it can be multi-dimensional. Both possibilities are considered in this section.

Cost-effectiveness analyses may also differ according to the defintion of "cost." Costs may be defined as the financial cost of the alternative (capital, relocation payments, operating) or the equivalent monetary value of all impacts of the project (except those included in the measure of effectiveness), whether positive or negative.

If the latter definition is used, the method becomes similar to cost-benefit analysis in approach, although the outcome need not be the same. The discussion contained in the previous section is applicable to this definition of cost. The discussion in this section assumes the financial definition of cost.

General Evaluation: The main advantage for using cost-effectiveness instead of cost-benefit is that no dollar values need be assigned to the benefits and impacts. In defining levels of effectiveness, it is acceptable to use physical dimensions for measurements. For example, one may compare investments on the basis of their cost to achieve given concentrations of hydrocarbon pollutants, without attempting to assign a dollar value to the reduction in pollution. Consequently, cost-effectiveness can integrate into the analysis impacts and benefits which would be non-integrable in a cost-benefit framework.

In the context of a political process, an advantage of cost-effectiveness is that the standards of performance which a system is required to meet are specified in physical terms, and may therefore be readily comprehensible

to community groups. Another advantage is that cost-effectiveness gives structure to the analysis at the outset, thereby economizing on planning resources by telling analysts which variables to focus on, and insuring that issues of interest are covered.

The problems with cost-effectiveness, in any form, occur at both the procedural and the technical level.

At the technical level, setting a numerical "standard of effectiveness" which systems must meet has the effect of giving no consideration at all to benefits in excess of the declared standard. Thus, for example, if it is decided (following a cost-effectiveness procedure) to adopt the cheapest transportation system which will provide average peak hour door-to-door travel speeds of at least 20 miles per hour, then a system which offers travel speeds of 20.1 mph will be equally acceptable from a performance standpoint to one which moves people at 30 mph. If the latter system costs only slightly more, it will be considered less desirable even though the minor increase in expenditure will provide a 50 percent increase in average travel speed.

A related technical problem is that since cost-effectiveness makes no attempt to estimate the value of the benefit, it does not provide any basis for the claim that the benefit has a greater value than the cost. Cost-effectiveness is not designed to answer a question like, "Is the specified level of effectiveness worth achieving at all?" The method only finds the cheapest way of achieving the effectiveness goal. The question of whether the goal is worth the cost of the cheapest alternative can only be decided on a subjective basis.

At a practical level, the main problem with cost-effectiveness is that the choice of levels of effectiveness can easily be made after, rather than before, the consideration of alternatives. A locality which has decided in advance that it wants a particular system can always declare effectiveness constraints which rule out all other alternatives. The method does not provide a justification for the choice of goals or of related effectiveness measures, and there appears to be no systematic way of justifying the choice of goals within a cost-effectiveness framework.

4.1 COST-EFFECTIVENESS ANALYSIS BASED ON A SINGLE MEASURE OF EFFECTIVENESS

Description: This is the simplest variety of cost-effectiveness analysis. In this procedure, the decision-maker declares a single, usually numerical, standard which the system is to meet, expressed in units of some physical variable.

An example would be to compare urban transit alternatives on the basis of which was the cheapest way to move N thousand people per hour from point A to point B at an average speed of x miles per hour.

In principle, the goal to be achieved, the variable to be measured, and the required numerical standard, may each be chosen at either the local or the Federal level. The following hypothetical possibilities illustrate some of the different policy arrangements:

a) The Federal government requires all localities to evaluate their alternatives based on any single effectiveness measure which describes the level-of-service provided by the systems being evaluated.

b) The Federal government requires all localities to evaluate their alternatives based on one specific level-of-service effectiveness measure: average door-to-door travel speed in miles per hour.

c) The Federal government requires all localities to base the evaluation of alternatives on a level-of-service standard of 20 mph door-to-door travel speed.

d) The Federal government requires all localities to base the evaluation of alternatives on a single effectiveness measure associated with any policy goal which localities consider important.

e) The Federal government requires all localities to base the evaluation of alternatives on a single effectiveness measure associated with any policy goal which localities consider important, but if they choose to evaluate alternatives on the basis of the level-of-service (this being one particular objective; pollution abatement and energy conservation are other possible policy goals), then door-to-door travel speed must be used as the measure of level-of-service effectiveness.

f) Same as e), except that if level-of-service is the goal by which effectiveness is to be measured, then the specific variable of average door-to-door travel speed must be used and the specfic value of 20 mph must be used.

This range of possibilities arises because there are several goals which a transportation system might achieve; for each goal, there are likely to be several variables which would be reasonable measures of the achievement of the goal; and for each variable there is a range of numerical values which may be selected as the standard.

Evaluation: The multiplicity of possible goals presents the main problem with this version of cost-effectiveness. If the Federal government specifies the goal to be achieved, as in possibilities (a)-(c) above, then it will effectively require an irrelevant analysis from those localities whose transportation system is intended primarily to achieve other goals. If this analysis is then used to decide which system is "the cost-effective alternative," localities will be required to achieve goals which they consider relatively less important, in order to avoid being at a disadvantage in obtaining Federal assistance. If, on the other hand, localities are permitted to evaluate alternatives with reference to locally selected goals, the Federal government may receive entirely noncomparable evaluations from different localities.

With respect to the criteria of evaluation specified in the Introduction, the following comments may be made concerning this form of cost-effectiveness analysis:

1) Feasibility of required quantification. This is ordinarily not a serious problem with cost-effectiveness in this form, since the effectiveness can be directly measured

if a suitable variable is chosen, and no attempt is made to convert this measurement to dollars or to any abstract valuation scale.

2) Degree of analytical skill required. Ordinarily, this evaluation procedure requires only data produced by preliminary engineering studies with virtually no special requirement for additional analysis at a highly technical level.

3) Reliability and credibility of numbers generated: Little data is generated when only one measure of performance is required, and since the measure is in physical dimensions, it should be reasonably credible.

4) Treatment of distributional issues. Ordinarily, any attempt to discover the performance of a system with respect to several different interest groups, even when performance is measured along one dimension, will require several different numbers. Door-to-door travel speed may be very different for elderly and handicapped, or for low-income reverse commuters, than for peak-hour suburban commuters, for instance. Hence, a single measure of effectiveness cannot enhance a decision-maker's knowledge of the incidence of impacts. This knowledge would have to be obtained

subjectively by examining the impact tableus generated in the prediction process.

5) Integrability with political process. If the choice of goals and measures is left to localities, then local interest groups can exercise considerable influence in the choice of the single goal which will guide the evaluation. However, it is unlikely that all significant community goals and values will be integrable into a single measure of effectiveness. Hence, interaction with the community would have to be based primarily on information outside the cost-effectiveness framework, i.e., on a subjective assessment of the raw information generated in the impact prediction process.

6) Ease of detecting analytical biases. If the Federal government defines the process tightly by specifying the variable by which effectiveness is to be measured, then the only way for localities to bias the results would be to distort the predictions of raw impacts, e.g., underestimate the number of houses to be taken. No evaluation technique can prevent distortion at this level. If localities are free to choose the variable of interest, then those who review the results must be aware of the exact definition

of the variable, and what factors it does and does not take account of. This creates somewhat more room for concealing biases.

7) Usefulness for Federal review of local evaluation process: If the Federal government could express all its significant transportation objectives in a single measure and require evaluations based on this single measure, this form of cost-effectiveness would enable a simple review of local alternatives. However, it is unlikely that Federal objectives will be summarizable in a single effectiveness measure. Hence, a cost-effectiveness evaluation of alternatives based on a single effectiveness measure will not be conducive to a thorough Federal review of the local planning effort.

8) Usefulness for intercity comparisons: If the Federal government specifies the goal, effectiveness measure, and numerical standard of performance, then the comparison process will be simple. However, it is valid only if the same goal, effectiveness measure and numerical standard are equally relevant for all the cities being compared. If localities are permitted to choose different goals, or even different variables to measure the effectiveness of achieving the same goal, then meaningful intercity comparison

by the Federal government becomes very difficult. If the goals and associated variables are the same but localities are permitted to chose the numerical standard, then comparison problems will be less acute.

Summary: This form of cost-effectiveness is relatively simple to implement and would not impose a large strain on local planning resources. However, a single effectiveness measure is unlikely to integrate the many community goals and values associated with transportation systems. Hence, a cost-effectiveness analysis based on a single measure of effectiveness, is likely to be irrelevant within the local political context. The reviewability of the local evaluation process from the Federal perspective is limited to the extent that Federal objectives can be summarized into a single measure. Intercity comparisons are difficult if cities choose their own effectiveness measures. If the Federal government specifies the effectiveness measure, intercity comparisons are only meaningful if the measure is equally relevant for all cities.

4.2 COST-EFFECTIVENESS ANALYSIS BASED ON MULTIPLE MEASURES OF EFFECTIVENESS SIMULTANEOUSLY ENFORCED AS CONSTRAINTS

Description: This is a more complex form of cost-effectiveness analysis. It is designed to enable the evaluation procedures to take account of multiple goals.

In this procedure, rather than declaring a single measure of effectiveness against which alternatives are evaluated, several variables (referring possibly to different goals) are simulataneously considered in the evaluation process. A numerical standard of achievement for each variable is declared and alternative transportation system are evaluated on the basis of which is the cheapest way to meet all the announced standards simultaneously.

An example would be to choose the alternative which minimizes the cost of meeting the following standards:

a) Average peak hour door-to-door travel speeds of 20 mph.

b) Enable elderly and handicapped riders to move on the average, 0.7 times as fast at all times as other riders.

c) No more than 200 residences dislocated.

d) Federal air pollution standards in all parts of the CBD.

Evaluation: Either the Federal government or the localities can determine any or all of the various goals, variables, and standards in the evaluation. The problems and consequences of splitting this responsibility in various ways between the two governmental levels, as discussed above with reference to a single goal, apply equally here. However, since a single goal is not being chosen, it may not be necessary for a locality to choose between its own goals and Federally mandated goals, since both can be included in the process. Generally, the cost of achieving both sets of goals will be greater than the cost of achieving either local or Federal goals only.

This version of cost-effectiveness may be evaluated as follows:

1) Feasibility of required quantification.

In common with other cost-effectiveness methods, this approach requires no conversion of physical quantities into value quantities such as dollars. Hence, the burden of quantification should usually be reasonable. However, some of the included goals may not be amenable to quantification, as for instance the minimization of visual intrusion.

Such goals can be included at the cost of introducing additional subjectivity into the evaluation process, since different observers will make different judgements about, for instance, whether the degree of visual intrusion imposed by an elevated right-of-way is "severe" or "moderate."

2) Degree of analytical skill required. As with other forms of cost-effectiveness, the units used in the evaluation are real physical quantities, so there are few opportunities for logical error in translating the physical impacts onto a value scale.

3) Reliability of numbers generated by process. This will depend on the ease of quantifying the goals which are considered in the process. If analysts avoid attempts to quantify impacts which are best described verbally, the numbers which are generated should be credible.

4) Treatment of distributional issues. It is possible to provide relatively good treatment of the impacts of alternative investments on subgroups if an additional constraint is added for each subgroup which is to be considered. Thus, one could require that travel speed for elderly and handicapped be x mph, travel speed for

low-income riders be y mph, and dislocation in neighborhood Z not exceed z households. The problem with this approach is that the restrictions become extremely numerous, and finding a solution at any cost becomes difficult.

5) Integrability with political process. Unless the Federal government imposes all the effectiveness standards, this evaluation procedure can interact with the local political process. Community groups can propose and negotiate over standards to be imposed, and analysts can interactively test the effects of enforcing different sets of constraints. As mentioned in the general discussion of cost-effectiveness, there will be a tendency for at least some of the performance standards to be decided upon during or after the consideration of some alternatives, rather than before. This need not be viewed as a disadvantage.

6) Ease of detecting analytical biases. There is a possibility for bias in the choice of standards. A locality which has decided on a particular alternative can develop enough constraints to rule out all but the desired choice. The only check on this is the reasonableness of the constraints as compared to those imposed by other cities.

7) Usefulness for Federal review of local evaluation process. This evaluation approach has the greatest potential for review of the local evaluation process from the Federal perspective. This would require that the evaluations performed by localities be structured to explicitly include Federally specified effectiveness measures. Presumably, Federal transportation objectives can be represented by a manageable set of effectiveness measures. If this presumption is wrong, and localities are free to declare any set of effectiveness measures, it could be rather difficult for a Federal reviewer to determine which local alternative is most desirable from the Federal perspective.

8) Usefulness for intercity comparisons. The net output of the process for the Federal government will be a list of standards which systems are expected to meet, possibly with a verbal explanation of why the locality decided to choose this particular set of requirements. Different cities will choose different goals; cities with common goals will choose different variables to measure effectiveness; and cities which use the same variables will choose different cutoff values as minimum standards.

Hence, the problems of comparability are potentially acute. The Federal government could simplify intercity comparisons by requiring that all cities consider certain goals as a minimum requirement (for instance, meeting air pollution regulations), and specifying common variables to measure these goals, and other goals as well if the locality chooses to consider them.

Summary: This form of cost-effectiveness has the advantage of including multiple goals in the evaluation, and hence, should yield a relevant analysis within a local political context. The analytical requirements should not impose an undue strain on local planning resources. The information provided to the Federal government by this method is potentially useful for assessing which local alternative is most desirable from a Federal perspective and providing a basis for allocating discretionary funds among cities. The usefulness of this method from a Federal perspective would seem to depend on whether Federal transportation objectives are specifiable and translatable into effectiveness measures.

5. SCORING FUNCTIONS

Description: This approach is an attempt to take account of multiple goals while preserving the conceptual simplicity and convenience of a single measure of effectiveness.

In this procedure, the decision-maker announces a list of goals which he considers relevant (the achievement of which must necessarily be quantitatively measurable, though not necessarily in dollars). Also, he announces a fully-specified criterion by which the relative importance of these goals is to be assessed. (For instance, he might say, "Every family dislocated by a project is to be weighted 4.3 times as heavily as each one thousand person-hours of travel time saved in 1980.")

The criterion need not incorporate constant relative weights, such as the "4.3" in the above example. To be realistic, it should probably allow for the weights attached to further increases in effectiveness on most goals to decline as the absolute level of satisfaction on those goals becomes higher. (E.g., "The second ten thousand person-hours saved will be weighed only half as heavily as the first ten thousand.")

Scoring functions can either be used in a cost-effectiveness framework to define a measure of effectiveness (so that the "score" of a particular alternative is a composite measure which replaces either the single or multiple

measures of effectiveness in the procedures described above), or in a quasi-cost-benefit framework as a substitute for dollar values in the evaluation of costs and benefits. In the latter case, capital and operating costs would be included as inputs to the scoring function (presumably with a negative weighting, so that increased costs with benefits held constant would lower the "score" of an alternative), and the most desirable alternative would be the one with the highest score.

Evaluation: This procedure offers the main benefits of cost-effectiveness (freedom from the requirements of finding and using market values, and from the necessity to consider all impacts), without the disadvantage of having either to overlook all but one goal or to impose a large number of absolute and possibly inconsistent effectiveness constraints. Its chief disadvantages are that it requires exact specification in advance of how all goals are to be traded off against each other, and that it introduces a set of dimensionless, hard-to-interpret "scores" into the evaluation procedure.

Another problem when the scoring function is used as an effectiveness measure in a cost-effectiveness analysis, is the choice of a minimum score which a system must achieve to be "effective." Since the score is not measured in any recognizable dimensions (such as the number of dislocations or the concentrations of pollutants), and since, moreover,

a given score can be achieved in many different ways by systems which have entirely different impacts on the community, the choice of a "minimum acceptable score" is even more arbitrary than the choice of effectiveness standards in other versions of cost-effectiveness analysis. It is possible that an alternative with an acceptable score will perform so poorly on a few particular criteria that it will not be acceptable, despite doing well enough on other criteria to compensate mathematically for poor performance on some of the input variables.

Another characteristic of a scoring function that is both an advantage and a disadvantage is that its use ordinarily prevents any single goal from assuming "absolute" importance, since, as noted above, relatively poor performance on one variable can be compensated by relatively good performance on others. This is an advantage in that it introduces flexibility into the planning process and incorporates the idea of goal trade-offs, but it can be a disadvantage as well for the reasons noted above.

The following remarks can be made about the scoring function technique:

1) Feasibility of required quantification. The measurement of the physical impacts which are input to the function is ordinarily feasible. Scoring functions have been developed and used in practice. However, these scoring

functions typically embrace only the values of the decision maker. The feasibility of developing scoring functions that represent the many diverse values extant within the community is uncertain.

2) Degree of analytical skill required. Considerable skill is required to comprehend the mathematical behavior of the function, which determines how the "score" will be affected by perturbing the input parameters.

3) Reliability and credibility of the numbers generated. The technical problems associated with formulating the scoring function, and the communication problems involved in negotiating over it, would combine to reduce the credibility of the dimensionless number which emerged as the score of a particular alternative. It would quickly be observed that minor changes in formulation would occasionally lead to enormous changes in this score, making it an attractive target for whatever interest group objected to the conclusions.

4) Treatment of distributional issues. Variables measuring the achievement of distributional goals can be included as inputs to the scoring function, and thereby included in the evaluation process. However, serious political problems could be created by openly declaring the relative importance

of the impacts on different interest groups. ("White suburbanites' benefits will be counted twice as heavily as costs incurred by inner-city blacks" is not a statement that a political leader can make.) Furthermore, the aggregation of impacts into a total score hides the incidence of impacts so that a decision-maker basing his choice on a total score would be unaware of the distributional consequences of an alternative.

5) Integrability with political process. The technical formulation of the scoring function could be so cumbersome as to impede debate. Community representatives would need their own analysts to translate their demands into a revision of the function, or even to determine how a particular function affects them. Negotiation between conflicting interests would be difficult to implement.

6) Ease of detecting bias. Analysts who wish to bias the process can easily do so by changing the formulation of the scoring function. Reviewers would then have to decipher the mathematical formulation to unravel how the goals were really being traded off, and what assumptions were incorporated into the definition of the function.

7) Usefulness for Federal review of local evaluation process. The complexity of the scoring functions would seem to impose an obstacle to Federal review of the local evaluation

process. Federal reviewers would have to decipher the formulation of a locality's scoring function in order to determine how compatible with Federal criteria are the subjective weights assigned to different impacts.

8) Usefulness for intercity comparisons. If each city formulated its own scoring function (as the previous discussion has assumed), different localities would attach different weights to some goals, and some might exclude goals which others consider. Also, there would be no reason to expect uniformity in the mathematical form of the functions. Hence, the problems of intercity comparability would be acute.

Federal mandate of a single scoring function for all cities might alleviate this difficulty, but would probably be unacceptable since it could hardly account for differences in climate, structure, economic health, ethnic composition, and existing transportation facilities among cities.

Summary: Scoring functions purport to combine the conceptual simplicity of a single measure cost-effectiveness analysis with the comprehensiveness of a cost-benefit or multiple-measure cost-effectiveness analysis. However, their complexity detracts from their usefulness within a local political context. Additionally, Federal review of a local evaluation based on scoring functions would be difficult and the problem of making intercity comparisons would also be severe.

6. COMPARISONS AND CONCLUSIONS

Table 1 provides a summary comparison of the five evaluation methods. The methods are ranked according to the eight comparison criteria identified in the report. Since each evaluation method is unique and has its own characteristic assumptions, the mere description of each method may not adequately define the exact points of contrast between the methods. The following specific contrasts deserve special emphasis:

a) Form of data. Cost-effectiveness analysis, except when used with scoring functions, preserves the physical dimensions in which the impacts were originally predicted. The other methods convert these physical measures (micrograms of pollution, BTUs of energy consumption) onto a "value" scale.

b) Concept of cost. The methods differ sharply in their definition and treatment of "costs." In the pure form of scoring functions, the dollar costs as well as all the other negative impacts can be fed into the scoring function, so that no conceptual distinction is drawn between costs and other effects. In cost-effectiveness, the definition of cost is somewhat arbitrary, but is usually restricted to dollar claims on governmental budgets. Cost-benefit analysis requires the most complex treatment of the cost concept, by distinguishing between resource purchases and transfer

TABLE 1: SUMMARY COMPARISON OF EVALUATION METHODS

EVALUATION METHOD \ CRITERIA OF COMPARISON (RANKING IN PARENTHESES; 1-BEST 5-WORST)	FEASIBILITY OF REQUIRED QUANTIFICATION	DEGREE OF ANALYTICAL SKILL	RELIABILITY AND CREDIBILITY OF NUMBERS GENERATED	TREATMENT OF DISTRIBUTIONAL ISSUES	INTEGRABILITY WITH POLITICAL PROCESS	EASE OF DETECTING ANALYTICAL BIASES	USEFULNESS FOR FEDERAL REVIEW OF LOCAL EVALUATION PROCESS	USEFULNESS FOR INTERCITY COMPARISONS
UNAIDED JUDGEMENTAL EVALUATION BASED ON THE IMPACT DATA	NO QUANTIFICATION REQUIRED BEYOND THE IMPACT PREDICTIONS (I)	NO ANALYTICAL EFFORT REQUIRED IN EVALUATION (I)	BEST SINCE NO NUMBERS ARE GENERATED BEYOND THE IMPACT PREDICTIONS (1)	BEST SINCE ISSUES ARE NOT OBSCURED BY SUMMARY STATISTICS (I)	BEST SINCE EVALUATION IS ENTIRELY POLITICAL (I)	BEST SINCE NO ANALYTICAL INPUT INTO EVALUATION (1)	NOT VERY USEFUL SINCE UNABLE TO DETERMINE THE CONSIDERATION GIVEN TO FEDERAL OBJECTIVES (5)	NOT VERY USEFUL BECAUSE THERE IS NO OBJECTIVE BASIS FOR EVALUATION (5)
COST-BENEFIT ANALYSIS	MONETARIZATION OF IMPACTS CONSIDERED DIFFICULT (5)	REQUIRES THE GREATEST ANALYTICAL EFFORT (5)	DIFFICULT TO JUDGE CORRECTNESS OF MONETARY VALUES ASSIGNED TO IMPACTS (4)	INCIDENCE OF IMPACTS IS TREATED EXPLICITLY IN DETERMINATION OF MONETARY BENEFITS, HOWEVER, THIS INFORMATION HIDDEN IN THE AGGREGATION (3)	UNABLE TO INTEGRATE NON-MONETARIZABLE GOALS AND VALUES MAY CAUSE CONTROVERSY OVER ASSIGNED MONETARY VALUES (3)	MOST DIFFICULT BECAUSE OF PLENTIFUL OPPORTUNITIES FOR CONCEALING BIASES (5)	LIMITED TO THE EXTENT THAT FEDERAL OBJECTIVES ARE MONETARIZABLE (3)	USEFULNESS LIMITED TO THE EXTENT THAT IMPACTS CAN BE MONETARIZED (3)
COST-EFFECTIVENESS SINGLE MEASURE OF EFFECTIVENESS	NO SERIOUS QUANTIFICATION REQUIREMENTS (2)	ANALYTICAL REQUIREMENTS ARE SMALL (2)	RELATIVELY GOOD (2)	UNABLE TO CONSIDER THE DISTRIBUTION OF IMPACTS (5)	UNLIKELY THAT COMMUNITY GOALS AND VALUES CAN BE SUMMARIZED IN ONE EFFECTIVENESS MEASURE (5)	RELATIVELY EASY (2)	UNLIKELY THAT FEDERAL OBJECTIVES WILL BE SUMMARIZED BY SINGLE EFFECTIVENESS MEASURE (2)	USEFUL IF FEDERALLY DECLARED EFFECTIVENESS MEASURE LESS USEFUL IF LOCALLY DETERMINED MEASURES (2)
COST-EFFECTIVENESS MULTIPLE MEASURES OF EFFECTIVENESS	QUANTIFICATION REQUIREMENTS SHOULD BE REASONABLE (3)	ANALYTICAL REQUIREMENTS ARE REASONABLE (3)	ACCEPTABLE (3)	CAN TREAT DISTRIBUTION ISSUES EXPLICITLY (2)	GOOD ESPECIALLY IF COMMUNITY CAN IMPOSE CONSTRAINTS (2)	REASONABLY EASY (3)	MOST USEFUL IF FEDERAL OBJECTIVES ARE EXPLICITLY INCLUDED AS EFFECTIVENESS MEASURES (1)	MOST USEFUL BECAUSE FEDERAL AND LOCAL GOALS CAN BE CONSIDERED (1)
SCORING FUNCTIONS	SCORING FUNCTION CAN BE RATHER COMPLEX (4)	ANALYTICAL REQUIREMENTS CAN BE HIGH (4)	WORST BECAUSE OF SUBJECTIVITY OF SCORING FUNCTION (5)	DISTRIBUTIONAL ISSUES CAN BE WEIGHTED IN FUNCTION BUT THIS INFORMATION GETS LOST IN THE AGGREGATION (4)	COMPLEXITY OF SCORING FUNCTION MAY PREVENT INFORMED PUBLIC DEBATE (4)	SCORING FUNCTION CAN CONCEAL MANY BIASES (4)	COMPLEXITY OF FUNCTIONS MAY OBSCURE PERFORMANCE ON FEDERAL CRITERIA (4)	COMPLEXITY OF FUNCTIONS MAKES COMPARISONS DIFFICULT (4)

payments (so that all governmental cash outlays are not costs), and by including costs to persons outside the governmental units.

c) Decision rule. Only the cost-benefit method and the similar technique using scoring functions attempt to establish that the total value of the benefits received exceeds the cost. All forms of cost-effectiveness analysis find the least costly way to reach a given objective, without addressing the question of whether the objective is worth at least this cost.

d) "Objectivity." In cost-benefit analysis, the weights attributed to the various impacts are supposed to be based on market valuations, and are therefore believed to have an "objectivity" which is lacking in the valuations made by other methods. Also, cost-benefit attempts to include all monetarizable impacts, rather than focusing on a subset selected in advance by the decision-maker. The other methods declare in advance which impacts are of interest, either by announcing effectiveness standards or by formulating the scoring function.

e) Noncomparable impacts. The problem of incorporating multiple and noncomparable impacts is treated, in the cost-

benefit and scoring function methods, by weighting the goals with a number reflecting their "value." In cost-effectiveness, no weighting is applied (unless a scoring function is used to provide the effectiveness measure), with the result that the achievement of the standards is given an "absolute" value in the analysis.

f) Strictness of performance standards. The techniques which employ weighting schemes allow a given "total value" to be achieved in many different ways, so that the performance of an alternative on any particular measure of effectiveness need not necessarily meet any standard. In cost-effectiveness, only those alternatives in which each performance standard is met are admitted for consideration.

g) Community input. Cost-benefit is less amenable than the other methods to the acceptance of community input and feedback, because it views community values as objectively measurable and unaffected by the political orientation or activity of the community. The other methods are open to changes in relative valuation of impacts resulting from interaction with the community.

h) Reviewability. The judgmental method is easier to apply than the systematic methods, and more flexible, but it hampers a meaningful review of the local decision process.

General Conclusions: If the Federal Government intends to make a serious review of the alternatives evaluations which are submitted to support capital grant requests, it appears that a more systematic procedure than unaided judgment must be required at the local level. One possibility within the unaided judgmental framework is to require all cities to consider a minimum set of impacts. This would improve the Federal ability to make intercity comparisons. From a theoretical standpoint, cost-benefit analysis would be most attractive, but the practical problems associated with monetarizing impacts, and the complexities of definition and method, seem to make it prohibitively difficult to apply. Scoring functions tend to be complex and abstract also, and the overt subjectivity to engender fruitless controversy. Cost-effectiveness has the attractive characteristics of feasibility and relative simplicity. However, the use of a single measure of effectiveness requires so many simplifications that any evaluation based on such a procedure runs the risk of being irrelevant to the final choice. The multiple-measure version of cost-effectiveness presents significant difficulties also, parti-

cularly of tractability when there are a large number of standards which must be met. Of the systematic procedures however, it appears to present the fewest difficuties in serving the local and Federal purposes simultaneously.

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