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Abridgment

Methods for Identifying Transportation Alternatives

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This paper describes a four-step alternatives generation methodology for use in urban transportation planning. The four steps are (a) assess costs of any contemplated high-capital transit alternatives using locale-specific descriptors and apply capital cost feasibility tests, (b) identify generic alternatives that are responsive in the local context, (c) generate responsive site-specific configurations of selected generic alternatives, and (d) test for operational feasibility to ensure internally consistent and workable alternatives for later analysis. Overall, the process combines efficiency, ease of use, and responsiveness of output to produce alternatives for the planning process. The four steps are designed to minimize the information output and testing necessary for producing a responsive set of alternatives. These alternatives are described in sufficient detail so that they may be distinguished by their expected impacts, on the basis of which appointed and elected officials and the public will eventually make decisions.

Historically, transportation planning has lacked a rigorous methodology for proceeding from goals to specific alternatives. For the most part, alternatives appear to be a direct product of the planner's imagination. This does not assure alternatives that encompass the most cost-effective trade-offs in goal achievement. This lack of methodology is a serious problem because multibillion dollar investment decisions depend ultimately on the credibility of the generation process.

Fortunately, there are relatively few design principles to which an alternatives generation method must adhere. The first design "imperative" is that (a) the amount of money allocated to transit investments and projects cannot exceed available local and federal funding resources. Subordinate to this cost feasibility test is that (b) additional benefits commensurate with the additional cost of an alternative must be potentially realizable at the alternatives generation stage. Finally, from an engineering point of view, a third design principle exists--namely, to confirm these costs and benefits (c) alternatives must be tested to ensure that they are internally consistent and workable (i.e., operationally feasible). These three design principles lead to three distinct types of tests in a process of generating transportation alternatives that are politically, economically, and technologically relevant to the locale--cost-feasibility, cost effectiveness (additional net benefit commensurate with additional cost), and operational feasibility.

The proper ordering of these tests depends primarily on their information requirements. For economy of study effort, tests that require little information for their application should occur early in the process, while those that require detailed information should come later. In general, the detail required for application of these tests in developing and screening alternatives increases in the same order (a,b,c) as they were presented. Preliminary cost estimates can often be made on the basis of relatively few descriptors, while operational feasibility tests may require substantial engineering detail (e.g., operating plans are required to evaluate feasible headways and operating speeds). Cost-effectiveness assessments fall somewhere in the middle, requiring enough information to cover costs and a range of other impacts without considering detailed operation.

Based on these considerations, a four-step alternatives generation methodology has been developed. Each of the four steps is described below.

STEP 1: ASSESS COSTS OF CONTEMPLATED HIGH-CAPITAL TRANSIT ALTERNATIVES

Step 1 is designed to eliminate high-capital transit alternatives from further consideration if they are not financially feasible at the local and federal levels. The generic alternatives that should be articulated in step 1 are only those high-capital alternatives that the local area has a political predisposition toward, or which local and/or federal planners or planning requirements suggest should be studied as a set (e.g., if rail, then also express bus).

The approach recommended for assessing costs is based on the decision tree type of structure. Given a generic alternative (e.g., light rail, busway, etc.), sequential consideration of the descriptors needed to define it for cost estimation allows a comprehensive and efficient determination to be made of the configurations that are worthy of further analysis. The process begins in the given (a) corridor of interest for the given (b) generic alternatives of interest. The specification of these two descriptors emerges from the regional 3C planning process and local political and institutional factors.

These two descriptors begin the series of descriptors for each alternative that must be specified. Cost descriptors of high-capital alternatives include corridor; generic alternative--wheel/guideway technology, guidance and control, development risk; segment length; extension of existing technology; previous use of right-of-way; map-based alignment; vertical alignment; major new construction involved; number of stations; and station parking.

The specification of these descriptors is made on the basis of relevance, local conditions, and attainment of goals.

1. Relevance of Descriptors--Certain descriptor values are not relevant to or consistent with given generic alternatives. For example, heavy rail "generically" uses steel wheels on steel rails and has many past applications, so no other possible values for "wheel/guideway technology" and "development risk" need be considered in the heavy rail branches of the tree.
2. Local Conditions--Descriptor values that generally are possible for a generic alternative may be impractical for site-specific reasons. For example, in a dense downtown area it may not be practical to place fixed-guideway systems at grade. Another example is if an alternative is an extension of an existing fixed guideway, one end of the map-based alignment is fixed.
3. Attainment of Goals--Both cost minimization and attainment of other goals through development of responsive alternatives are referred to here. Cost minimization is a clear goal and can be implemented by using information on the costs associated with different descriptor values. Generic alternatives should be designed fairly modestly so as not to rule them out prematurely on a cost basis.

Each tree-building process for each generic alternative in a particular corridor may result in one to possibly five or more fully described alternatives. Multiple alternatives result from branching, most likely on the value of segment length and map-based alignment. Single values of most of the other descriptors normally follow from engineering considerations.

After each "articulation" of each high-interest, high-capital generic alternative has been costed, it must be subjected to cost feasibility tests. The capital costs of each are matched against available dollars from a variety of local, state, and federal funding sources to determine cost feasibility. Some early and realistic assessments of the political feasibility of raising money from each potential source must be made.

At the end of the three relatively distinct procedures in Step 1, three important products emerge:

1. A set of high-capital transit alternatives that appear at least feasible from a capital cost point of view,
2. Important site-specific information on these high-capital alternatives, and
3. A preliminary sense of the non-cost-related goals that motivate consideration of these remaining high-capital transit alternatives.

These three products of step 1 form highly important input to the next step in alternatives generation.

STEP 2: IDENTIFY GENERIC ALTERNATIVES RESPONSIVE IN LOCAL CONTEXT

Step 2 is a decision table method that allows explicit and documented use of a range of local and national goals to produce a small set of the most responsive generic alternatives for local conditions. It achieves this by eliminating information at the descriptor level entirely and by defining site-specific (e.g., corridor) goal achievement as a result only of the named generic alternative. A large set of alternatives can therefore be eliminated on the basis of a very limited amount of technical analysis. Step 2 uses as input the non-eliminated high-capital alternatives from step 1, as well as all other possible (low-capital) technological, operational, and regulatory alternatives. It is important to distinguish at this stage that the result of step 2 is not a set of site-specific configurations of alternatives. Site-specific detail is left to step 3.

The number of alternatives that are available for input to step 2 may be very large. At least 74 generic alternatives have been identified that should be considered at least implicitly in the process of alternatives generation (1). Although consideration of a comprehensive set of alternatives in the alternatives generation process imposes some practical problems, it is essential if the process is to produce valid results. This is due to the fact that if the set of alternatives under examination does not include the most productive ones available, no amount of refinement through sophisticated impact forecasting techniques and/or community participation can produce the most cost-effective possible solution.

The key to step 2 is the production and use of a table or matrix relating potentially attainable goal achievement results to individual generic alternatives. Because expected results will vary depending on site-specific factors, the matrix should contain ranges of possible goal attainment. The elements of the matrix therefore consist of high and low "scores" for each alternative in each goal area.

It is recommended that the table of site-specific goal attainment for each generic alternative be developed by using a "delphi-type" technique to incorporate the opinions of several transportation professionals. This approach uses an iterative framework whereby the opinions of individuals may change over time as the merits of different hypotheses are tested, eventually resulting in group consensus. The table can be improved on the basis of studies of previous implementations, demonstrations, etc. In this manner, the accumulated experience concerning transportation systems effects can be explicitly brought to bear on the alternatives generation process. [A multistep process of delphi evaluation was used successfully in the Priority Engineering and Operational Analysis (October 1976), part of the Miami alternatives analysis process. That study used the delphi method to estimate goal attainment for 30 alternatives (heavy or light rail in different configurations). Weights on different goals that were at least partially derived through direct citizen participation were then applied to find preferred alternatives.]

Given the production of a table relating goal attainment in the local context to the available generic alternatives, the process by which locally responsive alternatives are identified is quite simple and works as follows. First, it must be seen if there are alternatives that are totally dominated (i.e., best score on all measures of goal achievement is worse than some other alternative's worse scores). However, given the presence of a significant number of goals, dominance of this type is not likely to permit elimination of many alternatives from consideration at this point. In order to further reduce the set of alternatives, importance weights are applied to each of the goals relevant to the local setting. A variety of methods exist for determining such weights, including direct provision by the decisionmaker, analysis of trade-offs in goal attainment articulated as being desirable by the decisionmaker, and other utility assessment techniques. Weights uncovered in public participation, monetized values of the impacts, local priorities exhibited through previous expenditures to attain comparable ends, etc. should also be related to the weights actually used wherever possible.

For each alternative, the weights on each goal are applied to the appropriate entries in each cell for each alternative yielding "high" and "low" total scores. There will be at least one alternative for which the high total score is a maximum for all alternatives. This alternative becomes the standard against which all alternatives must be compared (i.e., the "current optimum"). If the high score of any alternative does not exceed the low score of the current optimum, it can be concluded that the alternative in question does not have any reasonable potential of meeting the goals relevant in the application setting better than the current optimum, and, therefore, does not warrant further analysis.

Overall, this second step in the process of transportation alternatives generation has several benefits.

1. It comprehensively considers all the possible effects of all the possible alternatives in a given local context. It therefore avoids the possibility of "missing" responsive alternatives.
2. It does not require the use of expensive assessment methodologies. Local information is input only as needed.
3. It makes the greatest possible use of past experience. Although the matrix elements are initially filled in on the basis of professional judgment, they are subject to modification and improvement on the basis of studies of previous implementations, demonstrations, etc.
4. It is not overly prescriptive because a local area can consider the widest possible range of cost-feasible alternatives that are of local interest.
5. The process is easily documented to respond to government requirements in the form of the goal attainment tables developed and used, the goal weights used, and the resulting goal attainment scores used to screen alternatives (also at successive iterations, if required).

STEP 3: GENERATE RESPONSIVE SITE-SPECIFIC CONFIGURATIONS OF SELECTED GENERIC ALTERNATIVES

Step 3 is a decision tree method that details all of the alternatives emerging from step 2 to maximize their contribution to the goals propelling their consideration. The output of step 3 for each alternative is a set of values for all of the descriptors needed for impact estimation and operational feasibility testing. While there may be a temptation to articulate alternatives in more detail so that they become more "real," the principal consideration must be to reduce the information load to the minimum amount necessary to discriminate between alternatives with respect to their expected impacts of interest at any step of the alternatives generation or evaluation process. The decision tree process for "fleshing out" generic alternatives in a given environment works as follows:

1. Select a descriptor;
2. Test for generic restrictions;
3. Test for site-specific restrictions;
4. By using all available information, test for goal attainment; and
5. If different values for the descriptor are still possible, add a set of branches to the decision tree corresponding to the different choices.

An ordering of descriptors that has been found to be successful for the most complicated high-capital alternatives is the following (corridor and generic alternatives are given):

wheel/guideway technology
guidance and control
development risk
routing policy
roadway use regulations
activity policy type
length
extension of existing technology
previous use of right-of-way
map-based alignment
vertical alignment
major new construction involved
scheduling policy
number of vehicles
vehicular capacity
distance between stations
number of stations
on/off-line stations
station parking
bus feeder provided
passenger protection from environment
passenger access to adjacent buildings
traffic separation
transfer-related factors
maintenance facilities
organization running operation
labor requirements
fare structure
average travel speed
average wait time

Note that some descriptors near the top of the list are seemingly less important than subsequent ones. This occurs because single values can generally be specified for each of these descriptors solely on the basis of the generic alternative. In this manner, they can be dealt with efficiently and gotten out of the way early in the process. In the event a lower-level descriptor significantly changes the goal achievement of an already selected higher-level descriptor value, the user should reassess the design beginning with the higher-level descriptor. Clearly, the ordering that is chosen will have an important effect on the efficiency of this process. There is no way to order the descriptors so that information generated lower in the tree never affects goal attainment higher in the tree for every possible generic alternative. A saving grace in this regard is that the great majority of low-capital generic alternatives is likely to involve a relatively small number of descriptors.

STEP 4: TEST FOR OPERATIONAL FEASIBILITY

The operational feasibility tests in step 4 represent a further progression in the process of selecting detailed descriptor values. That is, given a set of fully described and responsive alternatives that do not exceed cost limitations, it is necessary to ensure that they are internally consistent and workable before further analysis is warranted. At this alternatives generation stage, these tests should be based largely on intuition and hardware feasibility (e.g., headway capabilities). Operational feasibility tests should also concern aspects of the application setting (e.g., intensity of land use) as they affect descriptors of alternatives (e.g., station spacing). A detailed description of the operational feasibility tests that are appropriate for generation and other stages of analysis is, unfortunately, precluded by space limitations.

CONCLUSION

It is neither possible nor desirable to fully articulate prescribed courses of action in all possible scenarios. However, the described method has both the flexibility to incorporate site-specific conditions and goals and the power to guide the process of describing alternatives in detail. The result is a set of responsive configurations of generic alternatives described in the detail required for impact prediction appropriate to the current stage of local planning.

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Abridgment

Highway Program Performance Monitoring at PennDOT: An Overview

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An approach to developing a performance monitoring system is presented and illustrated with work conducted for the Pennsylvania Department of Transportation. A systems model is used to specify the logic underlying the Department's highway programs, and data sources and sets of performance indicators are developed to operationalize various aspects of the model. The measures reflect both efficiency and effectiveness criteria and are based as much as possible on existing data bases. Where necessary, new data sources, such as a road condition survey and a citizen survey, have been developed.

An integral part of the thrust toward improved management direction and control of state transportation programs is performance monitoring--i.e., developing systematic and periodic information on the progress and outcomes of program activities. This type of information feedback can be used to assess program effectiveness and to identify necessary improvements. One report on monitoring the effectiveness of state transportation services suggests several uses of this information: (a) review of progress and trends in the provision of transportation services, (b) provision of guidance for resource allocation decisions, (c) budget formulation and justification, (d) in-depth program evaluation and program analysis, (e) encouragement of employee motivation, (f) assessment of the performance of contractors, (g) provision of quality control checks on efficiency measurements, and (h) improved communication between citizens and government officials (1).

This paper outlines the development of performance indicators for the highway programs of the Pennsylvania Department of Transportation (PennDOT) and presents a conceptual base and analytical approach that can be applied by other departments of transportation and in other program areas. The primary purpose was to provide various levels of management with information to help them operate programs more effectively. Second, stemming from the report-card concept proposed by the earlier fiscal review (2), the indicators are designed to communicate selected key indicators to external audiences, such as the legislature, the Governor's Budget Office, and the public, to document the Department's track record.

Performance monitoring systems consist of three basic components: a data collection component, a processing and analysis component, and an action component (3). The basic approach to developing a monitoring system proceeds through the following five steps: (a) identify the program's objectives and outline the program design, (b) determine what kinds of measures would be most suitable as performance indicators, (c) identify potential data sources within and outside the Department and assess their quality and appropriateness, (d) begin data processing and/or reformatting to obtain initial output and assess the appropriateness and workability of those particular indicators, and (e) refine these data elements and develop the overall performance monitoring system in terms of data processing, frequency of reporting, channels of communication, and intended use. The primary strategy employed was to rely on existing departmental data bases as much as possible. State transportation departments generate vast quantities of data and typically maintain many large record keeping systems, but often there are few linkages among them. Part of the effort lies in evaluating the potential worth of existing data sources and ways of improving the use of information they contain. Where necessary, however, new data-collection procedures have been devised, as discussed below. The development and evaluation of specific measures was based on the following considerations: (a) reliability--how dependable and consistent are the procedures for collecting data; (b) validity--how accurately and directly does the proposed measure represent that aspect of performance being examined; and (c) sensitivity--how responsive is the measurement scale to what may be small but real changes in actual performance (4)?

OVERVIEW OF PROGRAM LOGIC

The design of the performance monitoring system stresses the importance of end results, and thus indicators of effectiveness (i.e., Are programs achieving their objectives?) are of central concern, as well as the more customary "process" measures concerned with efficiency. Figure 1 outlines the logic of the Department's overall highway program, including the three major components: maintenance, highway construction, and safety construction. The