Design-Synthesis Approach to Transit Planning

Mark H. Scheibe,* Puget Sound Council of Governments, Seattle
Gordon W. Schultz, R. H. Pratt Associates, Inc., Kensington, Maryland

Transportation system design should be oriented toward meeting specific local and regional objectives. In most current planning, objectives are used only to evaluate selected alternatives. This paper presents a design-synthesis approach to transit planning, which allows objectives to be input directly to the process and generates a transit system incorporating characteristics that are selected to optimize the attainment of specific service and cost objectives. The design-synthesis technique specifies transit service in the abstract so that characteristics of service such as frequency, headway, travel speed, and fare can be examined individually without being constrained to a specific system alternative. The paper reports successful applications of the approach in (a) identifying short-range transit improvements for San Diego and Denver and (b) designing long-range transit alternatives for Denver.

In design-synthesis planning, the community objectives that transportation service is provided to meet explicitly propel the transportation system design process. Design-synthesis planning consists of a three-step process (Figure 1).

First, a set of regional and local transportation objectives are determined that typically fall into two categories: service and cost. Service objectives define a minimum or (less likely) maximum desired level of transportation service for a particular geographic or socioeconomic area of the region. Criteria used to measure whether the objective is achieved could include, for example, the percentage of regional employment locations that can be reached in a certain travel time and the level of transit service provided to the area, defined by areawide average excess time (in this case the average time spent walking to a transit stop plus the average time spent waiting for a transit vehicle).

Cost objectives, on the other hand, typically take the form of constraints defining the maximum resources available for providing transportation service. The criteria used to measure the attainment of the objective generally are defined either by the total operating or amortized annual cost of providing transportation or by a productivity criterion. This criterion could be defined, for example, by transit trips per bus kilometer supplied to a given area or by a rate of transit subsidy available to offset operating losses.

In addition to defining transportation objectives and criteria, this first step in the design-synthesis process should also determine the relative weighting of the objectives. Because a transportation service standard cannot usually be met without exceeding a transportation cost standard, it is necessary to define an equilibrium position between supplying service and expending resources by relatively weighting the different objectives.

The second step in design-synthesis planning is to determine the system characteristics necessary to meet the objectives. By use of a mathematical programming approach, a wide range of system characteristics can be examined simultaneously and the best combination selected. This approach, which can be costly depending on the number of feasible options, is best oriented toward minimizing cost in the planning process (for instance, to determine which links should be added to a highway network system). A more heuristic approach would involve examining the characteristics of individual components of a transportation system separately while maintaining a constant level for the other system components, e.g., holding system characteristics such as speed and fare constant while examining the impact of different levels of service coverage and frequency or holding service and speed constant while considering different fare levels. Such an approach is more cost-effective and allows the planner an active role in balancing different system components.

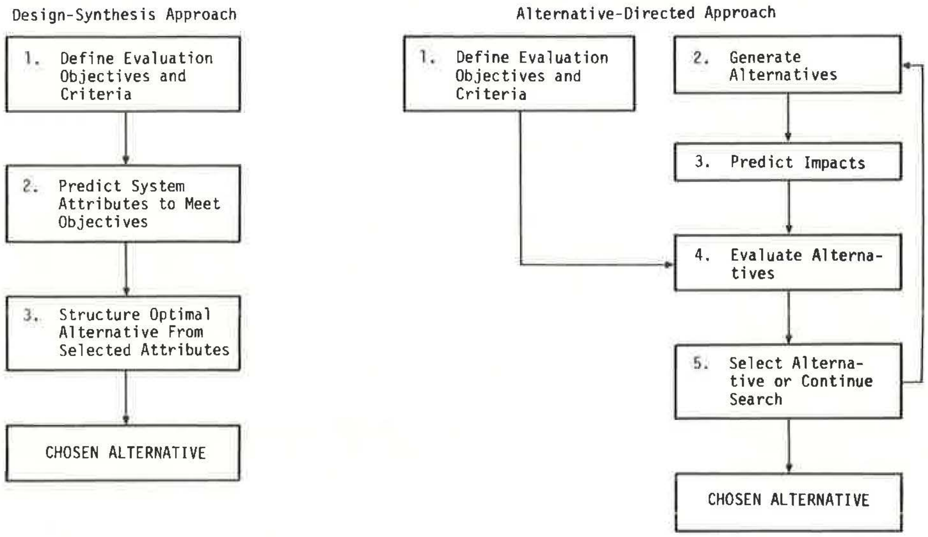
The final step in design-synthesis planning is to design a system incorporating the optimal characteristics obtained in the previous step. If the planning project involves deciding which links should be added to the highway network, this step is straightforward. For the heuristic approach, however, where the intermediate-phase output might be definitions of the level of transit service to be supplied to different subareas of a region, this step might involve locating transit routes to provide service efficiently while maintaining route and system continuity.

A design-synthesis planning approach has several advantages over the most commonly used approach, alternative-directed planning. Alternative-directed planning consists of a five-step iterative process (Figure 1), which begins, like the design-synthesis process, with a definition of transportation objectives. The objectives, however, are ignored in the next two steps, in which the planner generates a number of alternative system configurations and forecasts their impacts. These impacts are then compared to the criteria used to measure attainment of the objectives, and the best alternative is finally chosen. If no alternative is acceptable, additional alternatives are devised and the process is repeated. In spite of its disadvantages, alternative-directed planning is most often used in current transportation planning because design-synthesis models are generally more difficult to construct, particularly those models using mathematical programming.

In contrast to alternative-directed planning, design-synthesis planning requires only a single pass through the process. A single, optimal alternative is generated that incorporates the system attributes devised to meet the criteria defined by the transportation objectives. This single process allows more efficient use of time and cost resources. Another advantage of a design-synthesis approach is that objectives are made active rather than passive by being input explicitly into the procedure. This is particularly important as planning becomes more oriented toward serving a wide variety of regional, social, and environmental objectives. Finally, by designing a system to meet certain demands rather than designing a system before the demands are known, it is possible to provide the appropriate combination of modes, submodes, and services for the specific situation.

This paper describes an efficient and rational approach to design-synthesis planning that has been successfully applied to transit planning in the San Diego and Denver regions. It is presently applicable only to transit planning but is being expanded to consider other high-occupancy modes. The technique predicts and evaluates the impacts of different levels of transit service characteristics without having to consider the characteristics

Figure 1. Design-synthesis and alternative-directed approaches to transit planning.



in the context of a specific transit system alternative. The approach produces information that can determine feasible transit areas and corridors and associate them with the level of transit service needed to produce a required level of patronage or to meet regional transit criteria.

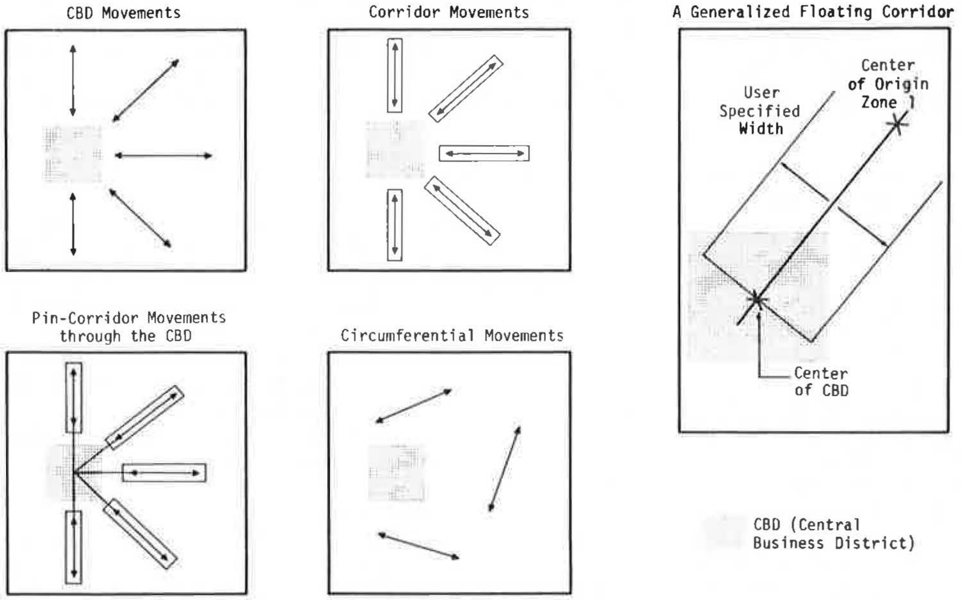
The design process is based on three premises: (a) The entire travel market should be considered in planning a transit system; (b) the planning process should be as free as possible, at least in the initial phases, from prejudicial routing assumptions; and (c) the specification of transit service should be based on policy service levels rather than on specific transit route spacing and headways. The second and third premises are made operational by using the concept of a ubiquitous bus system capable of directly serving each potential transit trip with a single ride from trip origin to trip destination along the shortest available highway route. Obviously such transit service cannot normally be provided, but the assumption of ubiquity aids in systematic analysis by defining the system abstractly instead of specifying alternative routes. Only the concept of ubiquity contradicts the characteristics of regular transit service. All other standard transit trip characteristics are considered in the analysis, including walk to and from the bus, wait for the bus, transit speed, and transit fare. Transit service time defines the walk to and from the bus and the wait for the bus. Transit fare and speed are included in the analysis as exogenous variables. The first premise of design-synthesis planning, that of considering the entire travel market, is handled by using a travel-demand chain of models that forecast trip generation, trip distribution, and mode choice based on socioeconomic and transportation system data.

In order to compare the amount of transit ridership at a given service level with the associated cost, the methodology must estimate cost. Although many elements affect operating cost, one of the more important is the number of bus kilometers operated. The minimum number of bus kilometers needed to provide a specific level of service is considered a surrogate for transit service cost.

The design process is used in the following fashion. The impacts of several levels of transit system characteristics such as service time or transit speed are forecast and defined in terms of the study criteria. For instance, if the objective is a minimum level of transit accessibility at the lowest cost in bus kilometers, the evaluation data produced for each travel-analysis zone would be the transit accessibility at each of several service times and the cost in bus kilometers to provide each level of service. For each individual zone then, the appropriate service time would be that which exceeds the minimum accessibility standard at the least cost in bus kilometers. The output on a regional scale would be a designation for each zone of the level of transit service that should be provided to meet regional transportation objectives. This information could then be used as a foundation for the route-specific design of a transit system.

This approach has been used successfully in several cases. An earlier version of the procedure was used to identify feasible service areas and establish a basic system operating pattern for north suburban Chicago (1, 2). The version of the process discussed here was first used to identify transit service and routing improvements to be included in the 5-year transit development plan for the San Diego region (3, 4). The improvements were primarily designed to meet regional objectives of transit accessibility. The process was next used as part of the Denver Long-Range Transit Analysis sponsored by the Denver Regional Transportation District (5, 6, 7, 8). In that analysis three "year 2000" bus networks were designed. One network, designed to provide the existing level of transit service, served as a base case in the analysis of alternative transit modes. A second network, designed for a substantially better level of transit service but still relying on on-street bus operations, served as a background bus system for the fixed-guideway alternatives being considered and also as a base for the third network. The third network used buses only but included fixed-busway facilities and was designed to provide service comparable to that of the other fixed-guideway systems. The design process also assisted in route selection for the other fixed-guideway systems. The most recent use of the design-synthesis procedure was in the generation of a transit development program for Denver under the auspices of the Regional Transportation District (9). The method was used to define transit service improvements to be included in the program and to identify appropriate areas for internal circulator transit service.

Figure 2. Four types of transit movements and the floating-corridor concept.



DETAILS OF THE METHODOLOGY

A more detailed examination of the design-synthesis methodology is needed to understand how it can be applied. The crucial concept of ubiquity has already been discussed. To complete the specification of transit service, travel orientation of potential transit trips, the definition of walk and wait times with respect to service times, and the specification of other service characteristics, i.e., transit speed and transit fare, must also be discussed.

Travel Orientation

To efficiently design a transit system, the analyst should have information for at least the following four types of transit movements (Figure 2):

1. CBD movements—movements to or from the CBD,
2. Corridor movements—movements occurring within a CBD-focused corridor,
3. Pin-corridor movements—movements that have the potential for transferring in the CBD, and
4. Circumferential movements—all other movements.

The need to investigate the potential of travel to the CBD is obvious, and most conventional transit planning is focused on this trip movement. Corridor trips and trips that transfer in the CBD also play an important role in transit planning because they (a) are normally large in number, (b) can make use of CBD-focused transit routes, and (c) tend to reinforce the CBD routes. The first three trip patterns can all be considered radial; the only difference among them is destination location. The fourth category, circumferential movements, is normally given little attention in transit planning because such movements are difficult to serve. A preliminary investigation, however, will show a high proportion of trips in this category; the ability of transit to serve these movements should thus not be neglected.

Part of the methodology of system design is to define these four movements and use them as categories in reporting results. CBD movements are easily defined: The analyst need only define the CBD (normally as a range of traffic analysis zones) and all trips to and from this area as CBD movements. The definition of corridor movements is more difficult. Instead of a concept of specific corridors based on the geography of the region and the existing transportation system, the concept of floating corridors is used. In this concept, each origin zone has its own unique corridor defined as a rectangular area extending from the origin zone to the CBD (Figure 2). The mathematical definition of this corridor consists of

1. The center line of the rectangle as defined by coordinates of the origin zone centroid and the centroid of the CBD,
2. The slope of the sides of the corridor as defined by the slope of the center line, and
3. The width of the corridor, which is user-defined but has typically been assumed as 1.6 km (1 mile).

The floating-corridor concept defines a corridor movement as any interchange movement from an origin zone that ends within the corridor. For computer analysis, the beginning and end points of an interchange are described by the X and Y coordinates of the zone centroids (i.e., the geographic center of the zones).

Any movement that is not a CBD or corridor movement can be either a pin-corridor or circumferential movement. The distinction between these two movements must be based on transit travel times. A trip is a pin-corridor movement if it can be made more quickly by going to the CBD and then transferring to another radial line; otherwise, the trip is a circumferential movement. Obviously the circumferential movement is always quicker than the pin-corridor movement if both have the same level of service. It is therefore necessary to define two types of service times: one for radial movements (CBD, corridor, and pin-corridor) and one for circumferential movements.

Walk and Wait Times

In the estimation of transit trips by mode-choice models, the time spent walking to and waiting for a transit vehicle (excess time) is an extremely significant variable. It is important, therefore, to specify transit excess time realistically. The assumptions made in the methodology are that (a) walking time is related to the average transit line spacing and (b) waiting time is related to transit line headways. These assumptions are logical and realistic, although they may not apply in certain unique situations.

Values for the walk to the transit line can be derived from transit line spacing. The walk distance is one-quarter the transit spacing. For example, in an area with 1.6-km (1-mile) spacing, the average resident would walk 0.4 km (0.25 mile) to reach a bus line. Normally the average wait time is a simple function of headway. In this paper it is assumed that the walk time for a given travel-analysis zone can be calculated by using the average distance and a walking speed of 4.8 km/h (3 mph). It is also assumed that the average wait time is equal to half the headway. Other assumptions could also be used with this design approach, including ones that assign nonlinear relationships between average walk time and walk distance and between average wait time and headway.

As noted earlier, this design approach uses the concept of transit service time, which is equated to the sum of the average walk time and the average wait time for a given zone. This service time, rather than the individual values of walk and wait time, is the transit characteristic to be optimized. This concept requires the assumption that walk and wait times are equally weighted in travel decisions and also that the service level can be broken down into its spacing and headway components in the design phase.

Once average walk and wait times, stratified by radial and circumferential movements, have been calculated for all travel-analysis zones, the total excess time for any zone-to-zone transit trip can easily be obtained given the trip-orientation assumptions discussed earlier. For CBD and corridor movements, the excess time for a trip from zone X to zone Y equals the sum of the radial walk times for zones X and Y plus the larger of the two radial wait times. For pin-corridor movements, which assume a transfer in the CBD, the total excess time equals the sum of the radial walk times and radial wait times for both zones. The excess time for circumferential trips equals the sum of the two circumferential walk times plus the larger of the two circumferential wait times.

Other Service Characteristics

Two other important characteristics of transit service are running time and fare. Transit running time is calculated by dividing the trip distance by the speed. As mentioned previously, trip distances by transit are considered equal to the minimum-path highway distances for the same movements. Transit speed can be input as a systemwide value as in the Denver studies, stratified by trip type as in the San Diego study, or further stratified by trip location within the region, depending on operating conditions in the study region. Because this procedure deals with transit trips on a zone-to-zone interchange basis, the technique for dealing with transit fares is the same in this as in any other methodology. In all applications of the approach, transit fares have been set and held constant by public policy; thus, impacts of fare changes have not been examined.

Travel Demand

The design-synthesis approach is not dependent on specific travel-demand models. In both San Diego and Denver local travel-demand models were used. Of course, demand estimation is a necessity. At a minimum, a matrix of person trips, a modal-split model, and the socioeconomic and highway system data required for the modal-split model are needed in addition to the transit service specification data produced by the design methodology.

Evaluation Data

The evaluation data produced by the methodology are a function of the criteria used in the particular study. In the Denver and San Diego studies, three main criteria were considered: a transit cost criterion, expressed in terms of bus kilometers; a transit productivity criterion, expressed as the number of transit trips produced per bus kilometer of service provided; and a transit accessibility criterion, expressed as the percentage of regional employment attractions that could be reached in a given travel time by transit. These criteria seem to be applicable in most transit design circumstances although their relative weightings may vary.

Given zone-to-zone transit times and zonal employment attractions, transit accessibility can easily be calculated. Similarly, the transit trips portion of the criterion for trips per bus kilometer is directly output from the travel-demand calculation. But the calculation of bus kilometers, which is crucial because bus kilometers are used as a surrogate for transit cost in the design approach, is not so obvious.

For a given area, the number of bus kilometers is calculated by multiplying the number of bus lines per kilometer—the average transit spacing—by the number of bus lines per hour—the transit line frequency—times a unit distance of 1.6 km (1 mile). Multiplying this by the area of a particular travel-analysis zone gives the number of bus kilometers for the peak hour (assuming peak-hour spacing and headway) in one direction provided to the zone. For a total cost, this calculation must be applied to both radial and circumferential movements. Peak-hour data are used for compatibility with most other modeling processes, but off-peak data could also be used. For comparison purposes, peak-hour, one-direction bus kilometers can be used, but a simple factor from local transit system operating data can be applied to yield daily or annual bus kilometers.

Using the assumptions described earlier that relate walk time and spacing and wait time and headway, bus kilometers can be directly calculated from zonal walk and wait times and zonal service times. One-way hourly bus kilometers per square kilometer equal the reciprocal of the spacing times frequency times a unit distance. Average walk distance is one-quarter the transit spacing, and walk time equals distance divided by average walk speed; the spacing is therefore 4.0 times the product of average walk time and walk speed. Assuming a walk speed of 4.83 km/h (3 mph) [0.8 km/min (0.05 miles/min)],

$$S = 4.0 \times 0.08 \times WK = 0.32 \times WK \qquad (1)$$

where

S = transit spacing (km) and
WK = average walk time (min).

Assuming that the average wait time equals half the headway and frequency (in buses per hour) equals 60 divided by the headway (in minutes),

$$F = 60.0/2.0 \times WT = 30.0/WT \qquad (2)$$

where

F = transit frequency in buses per hour and
WT = average wait time in minutes.

Thus,

$$BM = 1/S \times 1.0 \times F = (3.11/WK) \times (30.0/WT) = 93.17/(WK \times WT) \quad (3)$$

where BM = one-way hourly bus kilometers per square kilometer.

Therefore, bus kilometers provided to a zone can be directly calculated from the walk and wait times for the zone. Further, Equation 3 shows that bus kilometers, and thus transit cost, are inversely proportional to the product of the walk and wait times. The maximum product of walk and wait times would thus be the least cost combination for a given transit service time. This maximum product occurs when walk equals wait time; therefore, the minimum cost for a given service time to a zone is achieved when the average walk time equals the average wait time equals half the service time. (In this case the previously mentioned relationships of walk time to spacing and wait time to headway are assumed. Other least cost solutions are found for other assumptions.)

In the design-synthesis approach it is assumed that, given several alternatives that provide identical service times, the least cost alternative will always be selected. Thus, each unique service time for a particular zone has associated with it a unique number of bus kilometers. Walk and wait times need not be considered individually.

Other evaluation data can also be produced by this methodology. For the Denver and San Diego studies, the other data included transit trip density measures, i.e., trips produced per household and per square kilometer and trips attracted per square kilometer and per employee.

Transit Design Process

We have discussed how the design methodology can be used to specify transit service in the abstract and forecast impacts as measured by various criteria. The precise way in which localized system characteristics that provide information for route-specific design are then determined varies as a function of the criteria used. Following is an example of a design exercise intended to meet the service objective of maximizing patronage within a regional budget constraint. This objective can be measured by using a transit productivity criterion of trips produced per bus kilometer.

Transit operators have observed that the highest transit productivity often occurs with low patronage and few bus kilometers (such a phenomenon was forecast for Denver and San Diego). Logically, as service increases, bus kilometers rise more rapidly than patronage. From Equation 3 it can be seen that they increase inversely to the product of the walk and wait times. As almost any modal-split model will show, a 1 percent decrease in excess time will result in a less than 1 percent increase in patronage, except perhaps for conditions of high initial excess times. Thus, for several alternatives that at least meet a selected productivity standard, the option that produces the largest patronage would have the lowest productivity above the standard.

Determining the optimal level of service to be provided to each zone is a multistep process. First, productivity is predicted by zone and obtained for each of several service times. Next, an interim productivity standard is set. Then, for each zone, the service time is chosen that has the lowest productivity but still exceeds the standard. Total regional bus kilometers are then calculated by using the selected zonal service times and are compared to the regional bus-kilometer constraint. If total bus kilometers do not approximate the constraint, the selection process is repeated. If the allocated bus kilometers are too few, the productivity standard is lowered; if too many, the productivity standard is raised. Our experience has shown that, within two or three iterations, a set of zonal service times can be selected that utilize the available regional bus kilometers and that, because of the process, produce the maximum possible patronage. These iterations involve only the selection step and do not require additional forecasts of impacts. For a complete regional system, this selection process would be done separately for radial and circumferential service.

The output of this process is the designation of the optimal transit service time to be provided to each travel-analysis zone in the region. This information can be used to design a route-specific transit network that provides those service times by translating service time to its walk and wait components and then to transit spacing and headway. This process usually results in some areas receiving better service than was originally selected for them, to maintain route and system continuity. These unproductive kilometers, which must be considered in setting a regional constraint, should constitute between 10 and 30 percent of the regional total, depending on local geography and topography.

Service-time data are helpful in setting short-range policies for a transit system as well as in designing a complete future-year system. Such data show the type of service various areas can support within the selected transportation objectives. This can be compared to the service currently being provided to locate candidate areas for service improvement.

APPLICATIONS OF THE METHODOLOGY

San Diego Study

The San Diego Short-Range Transit Study was the first application of the design-synthesis approach to transit planning. The first step was to attempt to validate the transit-service specification and demand-forecasting capabilities of the methodology. The existing San Diego transit system was simulated by coding zonal radial and circumferential walk and wait times based on the frequency of service and the coverage provided to each zone by the various transit lines in the system. Zone-to-zone transit travel times were then estimated by the design-synthesis procedure and input into the San Diego model (10) to forecast expected regional transit trips. Regional bus kilometers were also calculated from the walk and wait times. The results were that regional transit riders were underestimated by 8 percent, regional bus kilometers by 6 percent, and regional average trips per bus kilometer by 2 percent. The range of error was felt to be extremely small considering (a) the amount of detail needed to specify a transit system and (b) that the design-synthesis approach is intended as a tool to aid in systematic design and not as a replacement for other, more sophisticated network simulation programs.

In this study a set of transit objectives and criteria were developed for San Diego that defined the amount and quality of service that should be provided to various parts of the region. The most significant criteria defined levels of minimum accessibility to be provided by transit. The accessibility standards were stratified by location and by a socioeconomic indicator. The design-synthesis approach was used to identify service improvements that would enable the accessibility standards to be met. Five route extensions, four new routes, and nine headway reductions on existing routes were proposed to enable all of the standards to be exceeded or at least nearly met. In two instances, only 98 percent and 97 percent of standards were achieved.

The San Diego study demonstrated the feasibility of design-synthesis planning. The methodology for transit-service specification produced a reasonable replicate of reality. Most important, the output of the process identified specific service improvements that would bring the transit system closer to its objectives and thus was found to be applicable to the needs of transit operators.

Denver Long-Range Transit Analysis

The purpose of the Denver Long-Range Transit Analysis was to design a complete future-year transit system rather than, as in San Diego, to identify specific improvements to existing service. As mentioned earlier, three transit system alternatives were designed: a local service alternative at the current level of service, a local system providing slightly more than twice as much service as the first alternative, and a local and express service using exclusive busway facilities. All three systems were designed to maximize patronage.

An interesting aspect of this study was the identification of appropriate corridors for exclusive busway facilities. Corridors were also identified for fixed-guideway facilities proposed as part of other system alternatives. Corridors were identified by examining the impacts on system utilization of changes in transit operating speed. Forecasts were made for a particular set of service times and transit speeds of 19.3 and 38.6 km/h (12 and 24 mph). The difference between the two output transit trip matrixes yielded a matrix of trips attracted to transit by the speed increase. When this matrix was assigned to a highway network, portions of the region were located that had the largest transit trip increases resulting from bus-priority treatments. Potential corridors for exclusive transit facilities were identified as those highway links with the largest numbers of assigned trips.

This study demonstrated that the transit design-synthesis approach can assist planners in specifying optimum future transit system alternatives. It also expanded the scope of the approach beyond application to local bus operations and design.

Denver Short-Range Transit Study

The application of the design-synthesis approach in the Denver Short-Range Transit Study was similar in scope to its application in the San Diego study. First, the existing system was simulated. The design approach underestimated patronage by 4 percent, regional bus kilometers by 1 percent, and regional average trips per bus kilometer by 2 percent. The results were even better than those obtained in San Diego.

More complicated criteria were used in Denver than in San Diego. A productivity criterion was used to identify areas where additional service could be provided to increase patronage and still maintain a standard level of trips per bus kilometer. An accessibility criterion identified areas that required additional service to meet standards, and an additional criterion identified the minimum transit travel times necessary to reach a major shopping center and a general hospital.

The service improvements identified by this approach included 21 frequency improvements, 2 route extensions, 1 additional radial route, and 9 areas for intra-area circulator systems. Identification of areas that warrant circulator systems is generally difficult and was made possible in this case by a separate analysis of radial and circumferential trips. Various areas in the region showed a potential for producing significant numbers of circumferential transit trips, and it was found that the majority of these trips were destined for attractions near their points of origin. The most promising of these areas were selected to receive circulator transit service.

This most recent application once again demonstrated the utility and flexibility of the design-synthesis approach. After the impacts were forecast, most of the design effort was undertaken by staff of the Denver Regional Transportation District.

RECENT DEVELOPMENTS

The design-synthesis approach to transit planning is currently being incorporated, with improvements, into the urban transportation planning system (UTPS) of the Urban Mass Transportation Administration (UMTA) computer program battery as a part of the UMTA short-range planning software systems development program. The number of travel orientations is being expanded to handle express trips in designated corridors and various combinations of local and express trips such as those that occur with feeder service. The approach is also being expanded for use in car-pool priority system design and will be capable of specifying exclusive car-pool lanes having differential speeds and explicit entry requirements as well as differential parking costs and terminal times for car-pool vehicles. To analyze the impact of these specifications on mode choice, a default modal-choice model is being incorporated into the program. This model, which is a five-mode, work-purpose, multinomial logit model, can handle separately categories of one, two, three, and four or more persons per vehicle mode, as well as a transit-passenger mode, thus permitting different definitions as to how many riders constitute a car pool. The five-mode model does not need a model of automobile occupancy to predict the number of vehicle trips as does a two- or three-mode model.

The UMTA program, which is compatible with other UTPS programs, was scheduled to be released during 1977 and to be accompanied by a user's manual to serve as a guide for the use of the design-synthesis approach.

CONCLUSIONS

A design-synthesis approach in which transportation service is specified explicitly to meet transportation objectives is the most efficient one for the design and evaluation of transportation plans. It allows planners and policy makers to concentrate on the service desired for an urban area rather than on the specifics of transportation networks. Such an approach requires an abstract specification of transit service so that service characteristics such as frequency, headway, travel speed, and fare can be examined individually without being constrained to a specific system alternative.

The approach can be used to identify the levels of transit service that should be provided to various parts of a region to meet specific criteria. Accessibility and productivity criteria have been used, but other criteria can also be employed. (This process will be mechanized in the new UTPS program.) The concept is equally applicable to short- and long-range design applications and meshes easily with other existing transportation planning tools. It is not dependent on specific forecasting models but can use any available local models. Incorporation of the approach procedure into the UTPS program battery will allow easy access to the methodology by planners. The approach can then be used either through the UTPS program or individual user-coded computer programs.

The design-synthesis approach to transit planning is a useful tool in a structured framework for transit system planning and design, is applicable to a wide variety of planning situations, and is a step toward the development of more effective multimodal design-synthesis planning.

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**Mr. Scheibe was with R. H. Pratt Associates, Inc., when this research was performed.*

Accommodating Multiple Alternatives in Transportation Planning

Darwin G. Stuart, Barton-Aschman Associates, Inc., Evanston, Illinois
Warren D. Weber, California Department of Transportation, Sacramento

This paper, which is based on procedures used in the San Diego-Los Angeles Corridor Study, examines several methodological improvements that enable a wider range of multimodal alternatives to be included in the transportation planning process. Staging of the planning and evaluation processes is identified as a basic organizing strategy. The design of significantly different alternatives, in terms of primary service characteristics, is described, and alternative multimodal service combinations are emphasized. The paper discusses travel-demand analyses conducted at relatively low cost at a sketch-planning level of detail with multiple computer model runs and efficient model application. A goal-achievement-oriented evaluation framework is specified that permits the quantitative evaluation of a wide range of local and regional performance objectives. The role of judgmental assessment as well as several areas for additional methodological improvement is also discussed.

One of the more frequently expressed concerns in urban transportation planning involves the need for a wider range of alternatives (4, 8, 11). More alternatives are needed, for example, to explore greater variation in levels of transit service or to investigate additional right-of-way location opportunities. Incorporating a larger number of alternatives in the planning process will expand the level of effort involved. Improved methodologies must therefore be developed that better organize the sequence of planning and evaluation activities and accommodate a wider range of transportation planning alternatives.

Although multiple alternatives are important at each major planning level—corridor, subarea, regional system, interregional, state—the interregional planning level is used here for illustration. The general approach used to deal with the major methodological questions can be applied at other levels of planning. The San Diego-Los Angeles Corridor Study, sponsored cooperatively by the California Department of Transportation (CALTRANS), the Southern California Association of Governments (SCAG), and the Comprehensive Planning Organization of the San Diego Region (CPO), is used as a case study. The methodological topics addressed are (a) staging of the planning and evaluation process, (b) broad-brush design of alternatives, (c) travel-demand analysis (at a sketch-planning level of detail), and (d) goal-oriented evaluation of alternatives.