Public Transportation Decision-Making: A Case Analysis of the Memphis Light Rail Corridor and Route Selection with Analytic Hierarchy Process[1]

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Abstract

The Federal Transit Administration (FTA) New Starts process involves multiple criteria to assess funding eligibility for local public transit investments. In this article a multicriteria method–Analytic Hierarchy Process (AHP)—is used to assess light rail transit (LRT) corridor and route alternatives. Although the focus is on the current LRT corridor and route selection process in Memphis, Tennessee, the AHP-aided procedure is intended to facilitate the public transportation decision-making process generically, reflective of federal New Starts guidelines as well as local priorities and preferences. Each alternative corridor and route is assessed functionally with respect to site-specific ratings of the criteria and subcriteria in a unified framework. This framework contains the goal, participant groups, criteria, subcriteria, and alternatives as various elements of a public transportation decision process with relative influence on the outcome. The best corridor and route alignment alternative is identified by a composite score on the AHP ratio scale. Finally, with sensitivity analysis, it is

shown how a change on the importance of the criteria or participant group priority influences the trade-offs among the criteria and the outcome. The article concludes with a retrospective, reflective discussion of the planning process as a whole.

Introduction

Throughout North America, investment in rail transit by cities continues to increase while federal, state, and local funding sources decline due to budget constraints and the recent economic downturn and shifting of funding priorities to defense and homeland security. Cities and regional metropolitan planning organizations have included rail transit as an element of their federally-required, 20-year long-range transportation plans as a means to meet future air quality standards. This trend is highlighted by the increasing number of projects entering the Federal Transit Administration (FTA) New Starts pipeline.[2] New Starts project justification and financial criteria are used by the FTA to recommend projects for funding. As projects are developed and proceed through the planning process, they are evaluated by the statutory criteria, FTA U.S.C. 5309 (e) (6), which requires that a summary rating of "highly recommended," "recommended," or "not recommended" be assigned to each project. The multiple criteria range from mobility to land use, environmental impact, and financial efficiency. These projects vary from a minimum capital cost of $25 million, which are exempt from the New Starts ratings, to an estimated 4.35 billion for the New York/East Side Access project. Each new extension to an existing system must go through this process.

The current light rail transit (LRT) corridor and route selection process in Memphis, Tennessee, under federal New Starts funding consideration, is the motivation for this article (Figure 1). The Analytic Hierarch Process (AHP) is used to describe the structure of the planning and decision-making process involving LRT corridor and route selection. The appeal of AHP as an *ex ante* method of forecasting and decision making in a wide variety of applications is the accuracy of the predictions and decision outcomes that turn out to be true when events become known later. Thus, there is a growing interest in AHP as a predictive as well as multicriteria decision analysis method used in transportation among many applications, with forecasts that are validated with later known outcomes. The AHP application in this article provides a further test of the method in the prediction a LRT corridor selection decision outcome.

Figure 1. LRT Corridor and Route Alternatives, Memphis
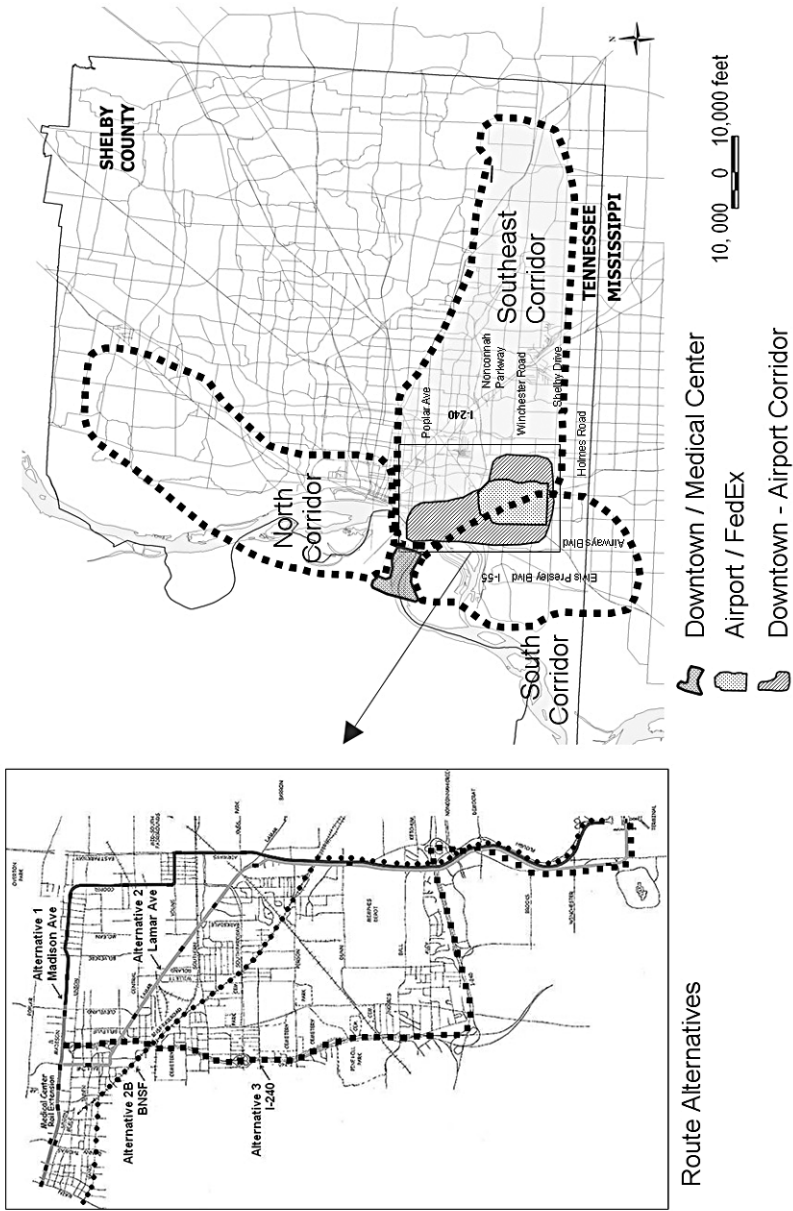
Source: Adapted from MATA. 1997. Alternatives Analysis Study.

The AHP model used in this article describes a framework of the actual planning process implemented in Memphis by the public transit planning authority. The model is a case-specific mapping of the actual light rail decision making in the city. But more importantly, AHP informs as well as is informed by the decision-making and planning processes in the city. Viewed methodologically, the procedure is intended to facilitate the public transportation decision-making process generically, reflective of federal New Starts guidelines as well as local priorities and preferences of multiple participant groups. Instead of being viewed as yet another AHP application in transportation, this article is intended as a contribution toward the development of a streamlined and unified procedural framework for the purposes of federally-sponsored local public transit decision making and planning with a potential for systematic comparison of similar experiences in different cities. Thus, this article is a case analysis with a general procedural implication for public transportation decision making. A brief description of AHP follows with particular reference to applications in transportation. The article concludes with reflections on the case-specific planning process.

Multicriteria Public Transportation Decision Making: The Analytic Hierarchy Process

Planners confront complex multicriteria decisions related to alignment alternatives, different transit mode-choice, and air quality and environmental impacts. The decisions commonly involve various interest groups as well as elected officials, governmental agencies, and the general public (see also Meyer and Miller 2001). The decision criteria can be mixed with tangibles and intangibles. Commentators have observed public transportation decision making as both a technical and political process (Wachs 1985). Transportation decision making is also characterized as a process involving multiple participants or "stakeholders" (e.g., Hall 1980; Levin et al. 1999). AHP has emerged as a versatile decision support and evaluation methodology with wide-ranging applications. Transportation planning applications are equally as prolific and diverse: stakeholder preference assessment in transportation planning (Levin et al. 1999), transit market priority analysis (Khasnabis and Chaudhry 1994), transportation system improvement projects (Tabucanon and Lee 1995), and carrier selection (Bagchi 1989). Recent applications include AHP in conjunction with a geographic information system in transit-oriented development (TOD) and in freight terminal location (Banai 2000; Dantas et al. 2001; see also Saaty [1995, 1997] for a review of progress in development and

applications of AHP). AHP provides a tool to help planners structure a complex, multifaceted decision-making process.

In contrast to multicriteria or multiattribute evaluation methods, AHP is a hierarchic, systems-oriented or holistic methodology useful in defining a characteristically multilayered public transportation problem. A typical AHP hierarchy is structured by the relationship of the elements in various levels. The overarching goal is stated at the first level, followed in subsequent levels by the criteria and alternatives. When group participation is essential, the participant groups are specified explicitly as described below. A versatile ratio scale is used to compare elements pairwise for all the levels of the hierarchy—systematically comparing the elements of a level with each of the elements of the previous level, starting with each level subsequent to the goal and ending with alternatives—to compute a composite score of the alternatives. For a thorough account of the underpinning philosophy, measurement theory, and methodology of AHP, see Saaty (1996), Forman (1993), and Saaty and Vargas (2001). The transportation planning application described here uses a commercially available software for AHP, Expert Choice (2000). The criteria to assess LRT corridors and routes are varied, and thus the measurement of the intensity of the multiple criteria involves different rating, step, and utility functional types that are supported by the software and shown later in this article. A simple example of the rating methods of AHP is given to determine best LRT corridor and route alternative (Figure 2). The larger application of AHP is given below.

Figure 2. A Simple Hierarchy for Determining Best LRT Corridor, with Linear (L) and Rating (R) Functions
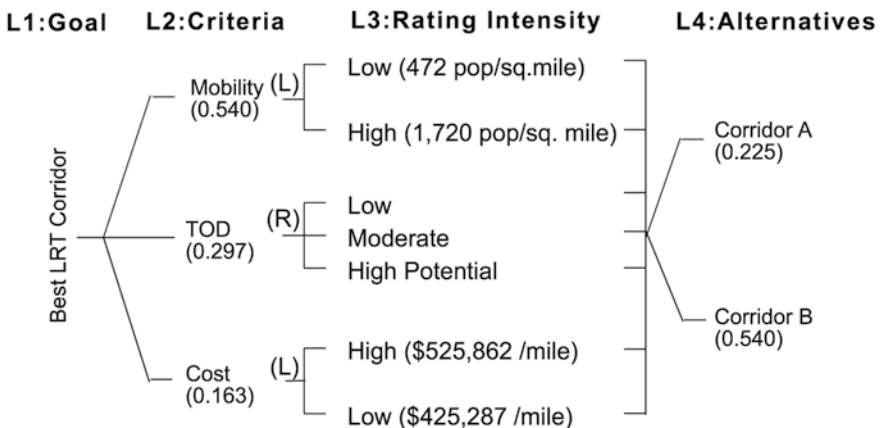
In Figure 2, three criteria are used to determine the best LRT corridor alternative: mobility to job centers, TOD impact, and (operating) cost. First, the relative importance of the criteria is determined. A rating scale is then developed to evaluate alternatives. The relative importance of the criteria is determined though the paired comparison method of AHP. We use the nine-point (1–9) numerical scale of AHP, defined as: equal importance, when two activities contribute equally to the objective (1); moderate importance of one over another (3); essential or strong importance (5); very strong importance (7); extreme importance (9). Intermediate values between two adjacent judgments are 2, 4, 6, 8, or finer ones using decimals, for example 1.1, 1.2, … ,1.9.

Mobility is given near moderate importance (2) in comparison to TOD, and moderate importance (3) when compared with cost. Finally, TOD is given near-moderate importance compared to operating cost, shown in the paired comparison matrix in Table 1.

Table 1. Deriving the Relative Importance of the Criteria with Respect to Goal: Best LRT Corridor

Best LRT Corridor	Mobility	TOD	Cost	Weight
Mobility	1	2.0	3.0	0.540
TOD	1/2	1	2.0	0.297
Cost	1/3	1/2	1	0.163
Consistency ratio = 0.01				

The reciprocal values are automatically determined, since the paired comparison method in AHP is with a reciprocal matrix. The relative importance or weight of the criteria is determined with the robust method of estimation in AHP (eigenvector, or characteristic root method; see Saaty 1996, Saaty and Hu 1998) also shown in Table 1, with mobility as the most important (0.540), followed by TOD (0.297), and cost (0.163). Furthermore, the paired comparisons of the factors are done with good consistency (Table 1). When consistency ratio CR exceeds 10 percent, the comparisons should be reconsidered so as to improve upon logical consistency (see Saaty 1996). However, inconsistency is an indicator of transitivity in judgments, which arises naturally in decision making, particularly in situations when the criteria are diverse and there is uncertainty in the environment of deci-

sion making. AHP is the only multicriteria evaluation method with which the error in judging the relative importance of factors by means of relative measurement can be detected and corrected with new observation, reflection, and discussion. Thus, the potential contribution of the AHP in transit planning is suggested as: (1) decisions involve multiple criteria or objectives; (2) the criteria are mixed tangibles and intangibles, some of which—tangibles—have no underlying scales; and (3) the relative importance or priority of the criteria represents preferences and priorities of multiple participants or "stakeholders" in the planning process through observation, reflection, communication, and negotiation.

If the criteria are "abstract" or ambiguous, they are made "concrete" in a specific context with subcriteria rating scales. The rating intensity scales indicate the desirable thresholds of the criteria that must be met in accordance with local priorities and site-specific conditions. In the example presented in Figure 2, they are shown as the subcriteria of mobility (low, high), TOD (low, moderate, high), and cost (high, low). The subcriteria are stated with a semantic scale that uses words (e.g., low, high). The intensity of the ratings is determined by paired comparisons (relative measurement). Thus, even the semantic scale is a ratio scale (not an ordinal scale), making arithmetic operations meaningful in a spreadsheet that contains mixed criteria with data values that require different functional types, ratings, utilities, or priorities entered directly to determine the total score of alternatives. The score of the alternatives is determined in a weighted linear summation method. The total score of each alternative (rows) is the weighted sum of the rating scores for the alternative across all the criteria (columns). The weighted linear summation calculation is aided in the AHP software with its spreadsheet function called "data grid." The scores of the alternative corridors (A and B) are shown (Figure 2), with corridor B as the better choice. Since we are using a ratio scale, we can determine the rank (ordinal) as well as interval, namely that corridor B is 2.4 times better than corridor A (ratio).

In this simple example, two different types of rating intensity scale functions are used: (1) linear function and (2) rating function (denoted by L and R, respectively, in Figure 2). The choice of function types reflects the type of criteria as well as the available data on the criteria to be measured. In the measurement of mobility, for example, an increasing linear function is used, with upper and lower bounds that are determined in context. In the example above, the higher (utility or satisfaction) value of mobility is determined by the increasing value of density (pop/sq. mile), which is catered to by a LRT corridor.

Conversely, the higher utility of operating cost ($/mile) is determined by a decreasing function. The land-use criterion, TOD impact of LRT corridor alternatives, is measured by three ratings (low, moderate, high potential) with increasing utility. The existing transit planning study in the city used a similar scale for rating alternative corridors. In the larger application that follows later in this article, three types of functions—linear, step, and ratings—corresponding to different criteria and subcriteria are used (Figure 3). For example, a step function is used in the measure of percent of population in poverty. As noted above, the choice of rating functions (discrete or continuous) is determined by the type of criteria, available data, as well as empirical studies (for example, see Pushkarev and Zupan 1977; and Davis and Seskin 1996 for discussion of density function). The paired comparisons method is used even when factors or criteria require ratings. In such cases, the paired comparison method determines the ratings intensity scales, which are derived by paired comparison of the criteria on a ratio scale. Thus, the various scaling methods applied to the multiple criteria have a common ratio scale (0–100 percent) with which the total score of each alternative weighted by the importance of criteria can be determined, all on a common ratio rather than ordinal scale. AHP provides a multicriteria evaluation with a robust ratio scale method that is helpful in land-use transportation planning decisions with multiple and diverse criteria, like the LRT corridor selection problem. In addition to the flexibility of a robust ratio-scale, AHP is a multicriteria evaluation method with a structural (hierarchical) property that aids in the challenging and creative part of a complex, multifaceted land-use transportation problem: formulation.

AHP was recently introduced to the FTA as an executive decision-making tool for the resource allocation of contract funding totaling approximately $40 million for the U.S. DOT/FTA Capital Project Management Oversight (CPMO) program (Rye and Haider 2000). The result of the study indicated that the FTA did not use a structured process "or methodology to measure or quantify benefits in their decision making." The study concluded "…such a situation can impede sound decision making for resource allocation issues" (p. 15). The FTA's comments and feedback for not using AHP in decision making were:

> *…FTA decisions often involve ambiguity, conflicting goals due to the multiple objectives, trade-offs and frequently more than one decision-maker. [The direc-tor] further states that in governmental or public service domains, the objectives can be more social or political rather than financial or functional. The director indicated that when making important FTA decisions, all objectives are typically*

Figure 3. A Unified Framework for Multicriteria Public Transportation Decision Making, with Linear (L), Rating (R), and Step (S) Functions
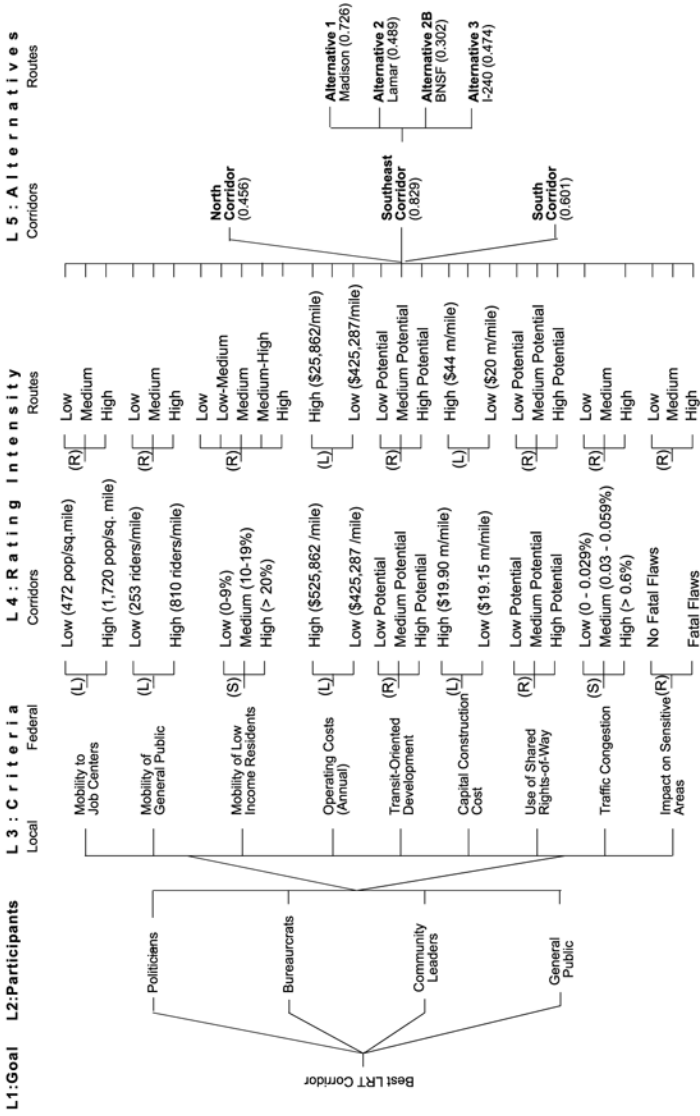
Note: The two columns of ratings for corridors and routes shown together in this figure are modeled separately in the AHP software to determine the scores of the alternative corridors and routes.

> *considered to have equal value of importance in order to compromise dissimilar beliefs and opinions.* (Rye and Haider 2000, p. 16)

Decisions at the local level also encounter a similar context of multiplicity of objectives and of participants, as the currently ongoing Memphis corridor and route selection process suggests. The increasing popularity of AHP as a multicriteria evaluation methodology is attributed to its flexibility to deal with ambiguity of multiobjectives, with mixed tangible and intangible criteria or objectives (social, political, financial, functional), and group decision making (see, for example, Forman and Selley 2000). Thus, AHP provided a plausible methodology for our case study. AHP is used to show how complex multilayered public transit planning and decision making is unified to account for federal and local criteria, different participants, and trade-offs among multiple, diverse criteria, and choice of corridor and route alternatives.

A Unified Framework for Multicriteria Public Transportation Decision Making: The Corridor and Route Selection Process

An AHP model of a LRT corridor and route selection process is shown in Figure 3. The goal of the process is to select the best corridor and route (Figure 1). Participants include politicians, bureaucrats, community leaders, and the general public. The criteria used in the FTA New Starts rating process are incorporated. The continuum local and federal (under the criteria) connotes the notion of adaptation of New Starts general criteria in response to local context. The general criteria formed the basis for the selection of factors used in a questionnaire to solicit inputs from participant groups. The regional transit plan (1997) provided a local context. NHRCP (1999) best practice guidelines were considered also. The general criteria were ranked based on the priorities of local decision-makers. AHP is used to show how the relative importance or weights of the criteria determine corridor and route alternatives selection. The overarching purpose of the model is to help planners to structure and unify the transit planning decision-making process, to derive priorities locally in relation to federal criteria, to ensure that local decisions made are consistent with the criteria in a transparent process, and to make certain that different interest groups are equally represented. The model is intended to facilitate efficient decision making at the local level while a project is competing nationally for federal funding.

Participant Group

The account of the London Motorways in the 1960s and 1970s in Peter Hall's (1980) *Great Planning Disasters* is instructive in the present context. In retrospect—traceable to Abercrombie's plans—Hall shows how the outcome of the transportation planning process is influenced by decisions and actions of multiple participants—experts, politicians, and community residents—and how specific transportation solutions, like highways or public transit systems, give rise to controversy and uncertainty when viewed from multiple policy objectives. Abercrombie's famous plan, for example, involved multiple mobility, land-use, and environmental quality objectives. Hall (1980) generalized various sources of uncertainty that arises in collective decision making: the uncertainty about the planning environment, about value judgments, and about decisions of participants.

The (hierarchical) structural property of AHP frames public transportation planning generally in such a way that alternative transportation choices are determined by the relative importance given to a set of criteria (policy objectives) by participants in a collective decision-making process. Although multicriteria methods are increasing used in transportation planning, AHP provides a technique effective in decision making in the face of uncertainty, ambiguity, and limitation of information (Forman and Seeley 2000; for a review of multicriteria methods, see Nijkamp and Voogd 1983; Yoon and Hwang 1995).

The nine criteria that were ranked independently by separate members of a regional rail steering committee (MATA 2001) are incorporated in the unified AHP framework (Figure 3). Since politicians and decision makers like the flexibility to have an input on criteria weights and may not necessarily understand the complex nuances of the AHP—or any other modeling steps or procedures of transportation planning—the planner can assume the role of facilitator in the decision-making process, which is rational and structured as well as transparent and which can identify possible inconsistencies in assessing criteria, or detect if a special interest group is influencing a collective decision process in such a way that favors one group over others. Thus, a unified AHP framework of multicriteria decision making potentially guides and informs a collective decision-making process that aims toward a consensus on decisions. In addition, AHP can be used as a public educational tool to structure and facilitate complex multicriteria decision making.

The local transit authority held several public meetings and presentations in which public comments were solicited. Written comments were also encouraged to be

submitted. The relative weights of the criteria are commonly derived through paired comparison in AHP (as in the simple example above). Furthermore, to facilitate the comparisons, AHP protocol calls for the criteria to be grouped within a limit of 7+/- 2. This limit serves a practical purpose to avoid confusions in paired comparisons of criteria factors when considered simultaneously (see Saaty 1996; Simon 1981; Miller 1956). This step was skipped in this case because a question-naire with the same upper- (10) and lower-bound values (1) to the AHP scale was already used by the local transit authority to determine criteria ranking. The ratings were converted to a scale of relative importance of the criteria expressed in percentage (0–100%), similar to the AHP ratio scale. However, the AHP has a robust ratio scale that is a natural method of ranking criteria (paired comparisons) than the weaker ordinal scale used in the questionnaire. Above all, with the AHP method the inconsistencies within the decision-making process arising in rank-ing of the criteria are gauged, and the means to address the incontinences are provided through observation with new information, reflection, deliberation, and communication. The AHP framework facilitates a rational planning process that is observational, reflective, deliberative, and communicative.

The importance of the criteria as seen by participant groups is shown in Figure 4. Criteria rankings are close among the various groups, with a consensus on corridor choice (Figure 5). The relative weights of the criteria were next used to assess the subcriteria and alternative corridors (Figure 6).

Southeast is the best corridor, with a score of 0.829 (Figure 6). The screen cap-ture shown is the spreadsheet platform (data grid) of the AHP software (Expert Choice). The various rating functions used (increasing, step, decreasing, and the like, also graphed) are shown as the column headings. The "local" weights of the criteria (denoted by L) are shown for one group of participants: politicians. The "Total" column gives the score of each alternative (corridor) in a weighted linear summation: The rating scores of each alterative are multiplied by the weights of the criteria and the results summed across all the criteria. The "Ideal mode" of syn-thesis is used when we are interested in a choice of one—and only one—in a set of alternatives, and the remaining alternatives are considered as irrelevant. (For a discussion of the alternative modes of synthesis in AHP, see Saaty 1996.)
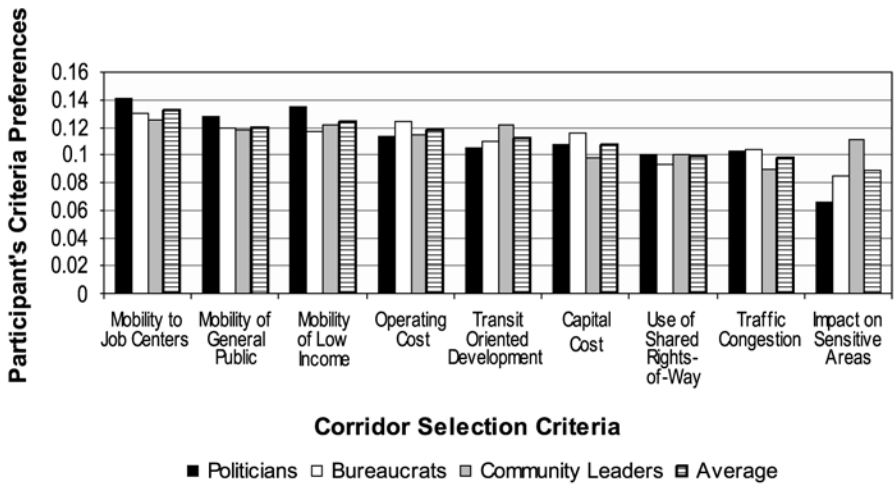
Figure 4. Criteria Rankings by Participant Group

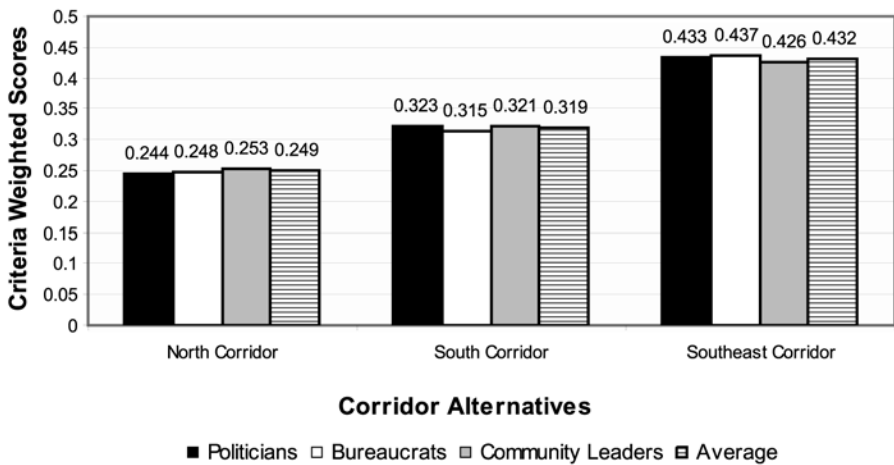## Figure 5. Scores of Alternative Corridors by Participant Group

Figure 6. Assessing LRT Corridor Alternatives with Various Criteria Scaling Functions of AHP in a Data Grid, Ideal Mode (screen shots)

Ideal mode		INCR	INCR	STEP	DECR	RATINGS
Alternative	Total	Politicians Mobility to Job Centers (L:.141)	Politicians Mobility of General Public (L:.120)	Politicians Mobility of Low Income Residents (L:.135)	Politicians Operating Costs (Annual) (L:.113)	Politicians Transit-Oriented Development (L:.105)
North	.456	472	253	25.2	425287	Low
Southeast	.829	1720	818	12.2	476190	High
South Corridor	.601	1571	759	26.3	525862	Medium

Ranking Corridor Alternatives with Data Grid in Ideal Mode
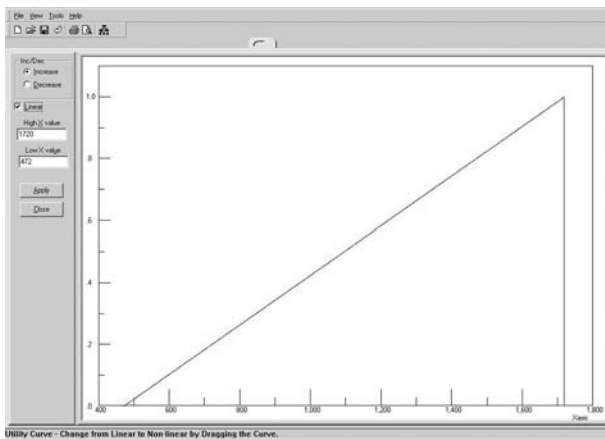
Mobility to Job Centers (Increasing Function)
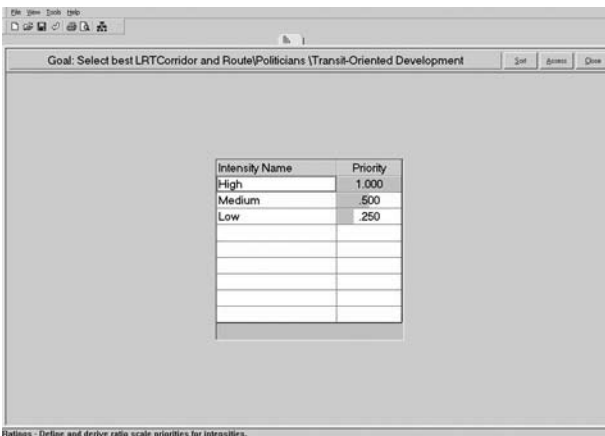
Transit-Oriented Development (Rating Function)

Scenarios

The local importance of the criteria is now known; however, the importance potentially given to the criteria by THE FTA New Starts program is unknown (see GAO 2005). To deal with the uncertainty, a sensitivity analysis is performed to determine possible effects of weighing FTA criteria differently and the influence on outcome. Initially, all federal criteria are assumed as equally important based on a view of an administrator noted above. What if, for example, costs and land use are given strongly more importance (weight)? Knowledge of impact on outcome can help localities prepare strategically should any of the multiple criteria be given increased scrutiny or priority due to budgetary constrains or competition.

We used scenarios to examine the impact of the varying importance of the criteria on the ranking of the corridors. The relative importance of the criteria is changed in a scenario to reflect the increased weight (from 11.8% to 29.6%) given to TOD with a dynamic sensitivity analysis. This increase in the priority of TOD criterion results in decreases in the weight of mobility to job centers (from 13.2% to 10.6%), and mobility of low-income residents (12.4% to 11.5%). The results merit further investigation of the corridor alternatives to determine the proportion of jobs relative to housing in a TOD; that is, whether TODs are predominantly locations in which to live or to work. The weight of mobility of general public (from 12.1% to 20.4%) is increased, whereas, the decreased relative importance of mobility to jobs (centers) conforms to the definition of TODs as locations with both housing and jobs. The impact of the increased priority of TOD on the rest of the criteria and the rank order of alternatives are as follows:

- Mobility to jobs (13.2% to 10.6%)
- Mobility of general public (12.1% to 20.4%)
- Mobility of low-income residents (12.4% to 11.5%)
- TOD (11.8% to 29.6%)
- Operating costs (11.2% to 6.2%)
- Capital construction costs (10.8% to 6.4%)
- Use of shared rights-of-way (9.9% to 3.8%)
- Traffic congestion (9.8% to 7.6%)
- Impact on sensitive areas (8.8% to 4.0%)

The results in rank order are: southeast (47.0%), south (34.1%), and north (18.9%) corridors. Even in alternative scenarios in which the priority of low-income resi-

dents and operating cost are doubled to 23.6 percent and, 21.7 percent, respectively, or the priority of operating and capital construction cost are doubled, the southeast preserves its rank as the best corridor, followed by the south and north corridors. Other scenarios could address the impact of the state growth plan legislation, parking restrictions, local area or district plans, zoning regulations with land-use/transit joint development strategies, and cost effectiveness.

Discussion

This section provides a brief reflection on the application of the overall framework described by AHP. The purpose of this case analysis was to develop a transparent structural framework that unifies as well reflects the discrete steps of a public transportation decision-making process. Furthermore, this framework could be used repeatedly by others doing similar project planning, albeit with different priorities reflecting conditions in different contexts. Arguably, there are variations across cities reflecting differences in politics, economics, institutions, and spatial form (e.g., density). Knowledge of the differences and the effect on outcome is important in itself in a systematic comparison among the cities by using the unified, multicriteria framework of public transportation decision making to reveal different local priorities and influences notwithstanding FTA guidelines. In effect, the unified framework would reveal the differences among the cities owing to the uniqueness of the local context even when the same federal guidelines are used. In addition, the framework may be used in the city longitudinally to track changes in the priorities reflecting the environment of public decision making, political, economic, and institutional dynamics. Thus, the framework would aid in institutional learning and streamlining the planning process with each subsequent formulation and implementation. Since the basic idea of the framework was to provide a "mapping" of LRT decision making throughout the planning process, we give a brief outline of the steps in context.

Goal

The community's goal stated in the region's long-range plan is to improve the quality of life through the use of LRT. For purposes of transportation planning, the region is divided into corridors, and the goals and objectives of the community are transformed into a set of criteria. The criteria are then used to evaluate the corridors, based on a set of objectives and further refined to make specific decisions as to the best alternative routes within a corridor. The structural property of AHP is helpful here since, by definition, a hierarchy is comprised of a set of levels that

begins (atop) with the general or abstract elements (goals) and ends (at the lowest level) with the concrete or specific elements, which are the alternatives (corridors and routes in our case analysis). Commentators generally characterize this process as ill-defined, technical, and political, noting the challenges of translating the general community's goals into specific transportation alternatives and policies. As noted above, the process involves consideration of mixed tangible and intangible factors, and requires the flexibility of a multicriteria evaluation method with a structural property helpful in problem formulation.

Participants

The planning process requires local participation in public transportation decisions. Ideally, every participant group has an equal voice in a collective decision process. But if the process is skewed in favor of one group without benefit to another, it is desirable to map the unequal weights of different groups in a transparent planning process.

During the planning process, some groups could exert an unfair influence and cause an "irrational" decision not in the public interest. In our case analysis, small business owners were opposed to the short-term construction impacts and even threatened legal action to stop an alternative (LRT route) in their "backyard." Interestingly, the AHP model predicts Alternative 1 (Madison Ave.) as the best LRT route. The affected parties can influence local politicians and decision-makers who, in turn, can affect the outcome of the decisions. The rational framework and process of the AHP model allows for an account of the power (weights) of the influences of different parties. Group dynamics—within and between group discussions—and relationships could be similarly mapped while discerning an emerging consensus or divergence of group objectives and preferences.

Criteria

The criteria are multifaceted, derived from local and federal goals and objectives that satisfy the problems and needs of the metropolitan community and the region, ranging from transportation to land use and to the environment. The rational framework accommodates the multiplicity of goals and the intensity of their diversity. A practical consideration is the question of how to assess the criteria and how to gauge discussion of "what is important" to the decision-makers. More discussion and dialogue of what is important (relative importance of criteria) is helpful with the (questionnaire) survey of participants, elected officials, expert groups within city agencies, community leaders, public-private business representatives, and the general public. Committee membership changes, while long-term

projects are in the planning process. Periodically, the purpose and requirements of the transportation program/project should be reexamined in relationship to the criteria and the ratings (weights). The facilitator has a pivotal role in encouraging interaction and communication among the decision makers. Communication is important to address any inherent problem due to the abstract nature of the goals that are translated into criteria and which are ultimately used to evaluate performance.

Rating Intensity

Good, reliable data are not always readily obtained due to limited coordination with multiple participants, consultants, and other agencies involved in public transportation planning. This is especially true with complex, technically demanding data and computational requirements of travel demand forecasting and standard evaluating procedures. The AHP framework provides an alternative forecasting and evaluation methodology effective in the face of uncertainty. Specifically, the paired comparison approach with alternative rating scales surmounts the limitations encountered in data availability. We used verbal rating scales instead of step or linear function types to compensate for the vagueness of the available estimates inherent in the variable measured. One example is the measure of an alternative corridor for TOD potential, which used a rating function, in contrast to Mobility to Job Centers criterion that used a linear function with estimate of the population density (pop/sq. mile; see Figures 3 and 6). The number of households may be known for certain corridor or mode-specific alignment with precedent or baseline data but unknown for still others, contributing to the uncertainty in forecasting. Even in situations where data are available, judgment and experience play a role in the interpretation and assessment of brute data. Paired comparisons are done to determine the intensity of the (verbal) ratings on a ratio scale (0–1) comparable to fuzzy methods of deriving membership (functional) values (see Banai 1993). Thus, even verbal rating scales have numerical values that are quantified on ratio scales. Experience shows that information is not always available or may be incomplete. Alternative rating methods of AHP allow the flexibility of estimation in the face of incomplete information.
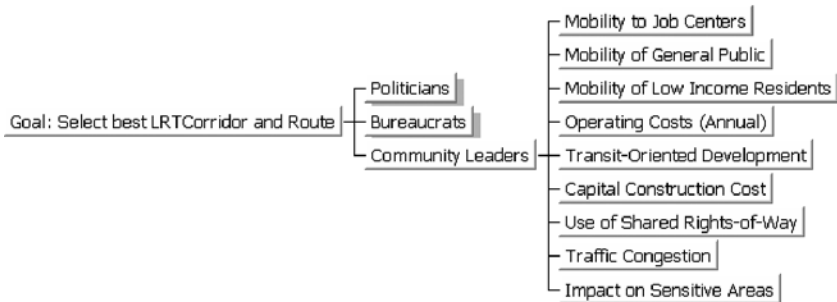
Alternatives

The three corridors were the result of an earlier screening process involving a larger number of corridors based on similar criteria. The AHP model described could be structured differently. Within each corridor, alternative transit modes as well as alternative routes could be examined. The criteria are then used to assess

alternative routes, shown in Figure 7, for further assessment. Similarly, the general structure can be modified to add another level, for example alternative modes, for further analytical consideration. Alternative alignments can be identified to discern which may be best based on criteria and relative weights, and scenarios can be developed to predict possible "what if" situations. New starts criteria can be set up to give an assessment of how particular projects fare when compared to one another based on similar criteria weighting assumptions.

A Task Force (1994) concluded that LRT was a feasible transportation solution for the community's problems.[3] However, this recommendation preempted consideration of alternatives such as monorail, bus rapid transit, or other transportation systems management (TSM) approaches. TSM alternatives should be considered early in the process. TSM is viable once the efficacy of the alternative routes is determined. Later planning studies considered alternatives required by FTA funding procedures, including monorail service on the I-240 right-of-way (see Figure 7). Public comments focused on enhanced bus service within a corridor as an incremental step toward LRT. The moral of the story: Don't rule out competing modes of transportation, and allow for inputs from the public with the discussion of alternatives. Concomitantly, a model of this process should include alternatives.

Figure 7. Determining the Best LRT Route Alternative

Ideal mode		RATINGS	RATINGS	RATINGS	STEP
Alternative	Total	Politicians Mobility to Job Centers (L:.141)	Politicians Mobility of General Public (L:.128)	Politicians Mobility of Low Income Residents (L:.135)	Politicians Operating Costs (Annual) (L:.113)
Alternative 1 (LRT on Madison Ave)	.726	High	High	High	193
Alternative 2 (LRT on Lamar Ave)	.489	Medium	High	Medium	208
Alternative 2B (LRT in BNSF Railroad ROW)	.302	Low	Low	Low-Medium	226
Alternative 3 (Monorail on I-240 ROW)	.474	Medium	Medium	Medium	228

Conclusion and Extensions

The AHP model for the selection of the top-priority corridor was completed in 2000. The model identified the southeast corridor as the best alternative. The AHP prediction later proved to be true when the southeast corridor was selected by the local transit authority board of commissioners (January 2001) based on the recommendation of the regional rail steering committee. The model was relatively easy to use even in the face of limited or incomplete information. The inductive methodology of AHP is useful in situations where deductive, predictive, observational techniques (e.g., regression analysis) encounter a limitation in the absence of precedence or with structural transformation, such as with introduction of a new public transit system. Furthermore, it provides flexibility in measurement that is helpful in situations, for example, FTA New Starts program, where multiple criteria with certain desirable thresholds of intensity must be considered strategically and adaptively responsive to local priorities and site-specific-conditions.

AHP is the only multicriteria method with a built-in procedure to account for the inconsistency of judgments of participants in the process of evaluation of a set of multiple criteria. A robust scientific framework is provided to gauge the consistency and efficacy of interpreting tangible and intangible data directly and inductively, rather than indirectly and deductively.

We then used AHP to predict the selection of the locally preferred alternative (LPA)—to use terms from FTA—best alternative alignment within the selected (southeast) corridor (Figure 7). The AHP model predicts alternative 1 (with a score of 0.726) as the best alignment selection. The LPA will be decided in the future by the local transit authority board of commissioners with concurrence from the city council and metropolitan planning organization.

The AHP-aided unified framework could be used for other public transportation planning purposes, such as in highway alignment, public transit mode-choice, and route selection decisions, which are increasing seen as a multicriteria decision-making process. By means of sensitivity analysis, alternative scenarios could be examined to determine outcomes based upon the relative importance of the criteria from local or federal agencies. Similarly, the influence of different participant groups involved in collective decision making on the selection of alternative alignments, modes, routes, and the like could be examined. The AHP prediction of such outcomes can be used as a basis for further negotiation and conflict resolution as well as for cost-benefit analysis and determination of trade-offs. Moreover, the inclusive decision-making framework allows for investigation of how different

groups' values commensurate or conflict with different goals. The valuation (qualitative and quantitative) based upon multiple criteria and revealed preferences (values) of different participants can fill a gap created by methods known with value distortions, with a single economic efficiency criterion (e.g., benefit-cost). However, standard benefit-cost analysis plausibly supplements, if included in, the unified AHP model above in a further detailed economic efficiency analysis of LRT alternatives.

Acknowledgments

Endnotes

[1] Research related to this article, including urban development sustainability analysis, can be viewed at http://www.people.memphis.edu/~rbanai.

[2] The FY2003 annual report on New Starts project status is as follows: 25 projects have full-funding grant agreements (FFGAs); 11, in final design; 39, in preliminary engineering; and 142, additional studies and projects authorized in TEA-21 in the early planning stages or alternatives analysis. As the competition for funds increases, project sponsors have increased local matching capital funds to 50 percent, instead of the past norm of a 20 percent local match with 80 percent from the FTA. The funding split for road and highway funds is still 80 percent federal and 20 percent local, provided the 20-year long-range transportation plan meets air quality guidelines (FTA 2002).

[3] The 1994 study assumed the economy of light rail with the use of the existing rail corridors. However, the Regional Rail Program (2001) raised the issue of existing right-of-way availability.

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