Abridgment

Decision Models for Transit Station Design

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Two types of decision problems in the station design process are addressed: (a) how to generate one or more candidate designs for a transit station at a particular site and (b) how to choose the best design from a set of alternatives. A description of the terminal planning and design process has been formulated that orders the steps involved and identifies the decisions required at each step. This description provides an efficient and nonrepetitive guide through the various design considerations. Results are presented from a survey of design practices administered to professionals involved in various aspects of transit station design. The respondents rated the priority they felt each of 16 design elements should have in the overall station design process and judged the relative importance of each of 19 criteria to the overall success of a station design. These judgments were used to derive estimates of parameters for two decision models.

Transit station planning and design involve decisionmaking at several levels:

1. The initial constraints or specifications (policy directives) for the station are generally decided prior to the design proper.
2. Particular station designs (configurations) are generated as a result of choices among alternative values for design variables (attributes).
3. The success or "goodness" of a particular design is evaluated by combining various performance and acceptance measures and taking account of their relative importance.
4. The choice of a particular design for eventual construction often follows from a process of trading off various alternative designs and political realities.

Thus, the decision levels can be characterized as involving (a) policy directives, (b) features or design variables, (c) criteria or evaluation variables, and (d) principles of choice or optimization (including trade-offs).

This paper focuses on the decision structure of the station design process. The four levels of decisionmaking cited above are combined into two primary decision procedures: the first for generating or developing one or more candidate designs for a transit station at a particular site and the second for choosing the best design from a set of candidates.

Ideally, decisions regarding the design of a particular transit station should follow from a detailed and complete understanding of the station design process. Available transit station design procedures assist the station developer in obtaining appropriate measures on the performance of different station components (1-7). This design methodology highlights the different decisions but does not directly address precedence, dominance, or dependence among station components. The study reported here represents an attempt to derive a more formal characterization of the transit station design process than those presented to date.

The primary station components addressed in the station design methodology are illustrated as an ordered sequence of steps in Figure 1. This general ordering of decisions may, in fact, vary among stations. Within each of the discrete steps shown in Figure 1, various specific design decisions are made.

DECISION MODELS

A sequential decisionmaking procedure is proposed for generating transit station designs (8,9). The quantification here is a set of priority weights to guide the ordered consideration of various decisions. The primary purpose of such a model is to facilitate the designer's consideration of the design issues in an optimal order. In such a scheme, choices or decisions made at early stages may constrain later ones. The earliest choices should be the most important or far reaching; less important choices should be made later in the process, with the recognition that these later choices may be less flexible. The ultimate form of such a model would be an interactive computer program that leads the designer through a sequence of decisions so as to optimize the design properties.

The evaluation of a particular station design or the comparison of alternative designs is accomplished by using rational linear equations. These equations involve additive combinations of many variables (or measures) and weights for each measure to reflect its relative importance. The variables in the model are the evaluation measures, which reflect either the performance (cost, passenger volume, etc.) or acceptance (security, comfort, environmental quality, etc.) of the station. Simple linear equations are used because (a) insufficient data exist to separate them from more complex models and (b) they will provide a good first approximation from which to develop subsequent, more elaborate models.

Although many types of decision models are available in the literature, the two procedures proposed in this paper are relatively simple. Each is appropriate to the quality of data and to the level of sophistication achieved to date in dealing with the relevant design problem.

DATA COLLECTION

Data needed for the decision models, regarding both the ordering of various design decisions and the weights for the evaluation criteria, were obtained via a survey. A questionnaire was distributed to workshop participants at the National Conference on the Planning and Development of Public Transportation Terminals held in Silver Spring, Maryland, on September 21-24, 1980. Of the 137 registered participants in the conference, about 100 took part in the workshops. Usable questionnaires were returned by 89 participants. Respondents were asked to rate the priority they felt each of 16 design elements should have in the overall station design process and to judge the relative importance of each of 19 criteria to the overall success of a station design. The Statistical Package for the Social Sciences (10) was used to analyze the responses.

RESULTS

Priorities in Design Specification

The workshop participants rated the relative priority of several design elements in the total design process. The instructions for this item emphasized that priority should imply temporal ordering: Higher-priority items would be emphasized in the earliest stages of the design process, and lower-priority items would be considered later.

Figure 1. Transit station design process.

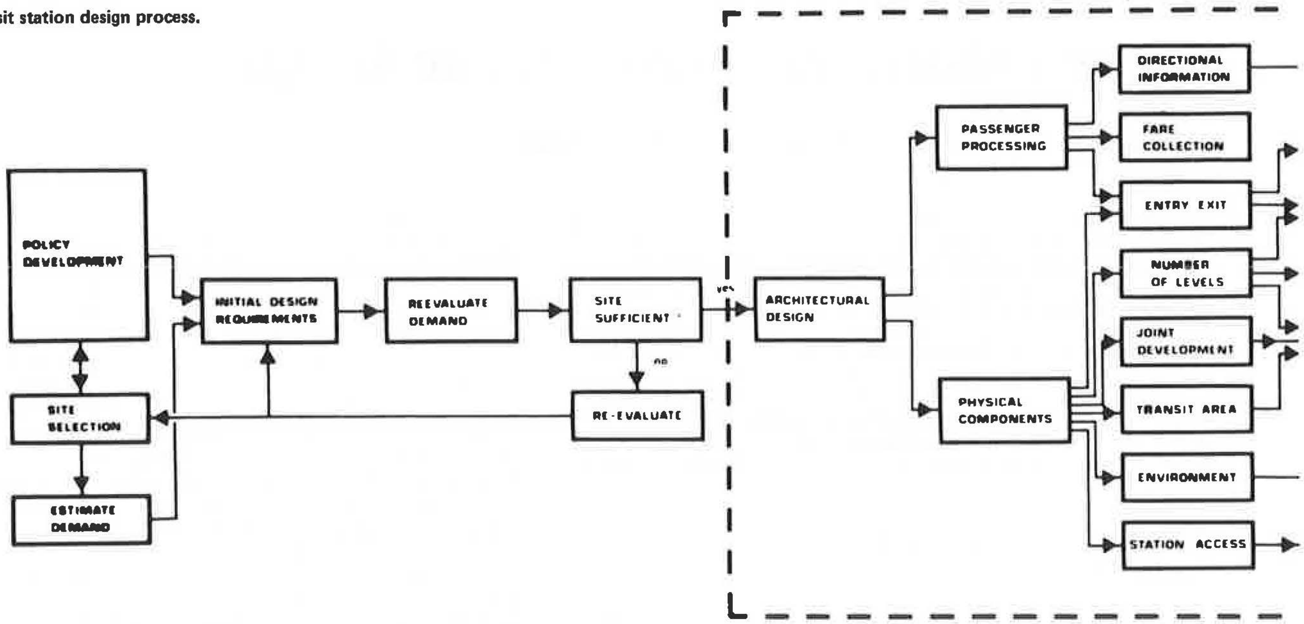
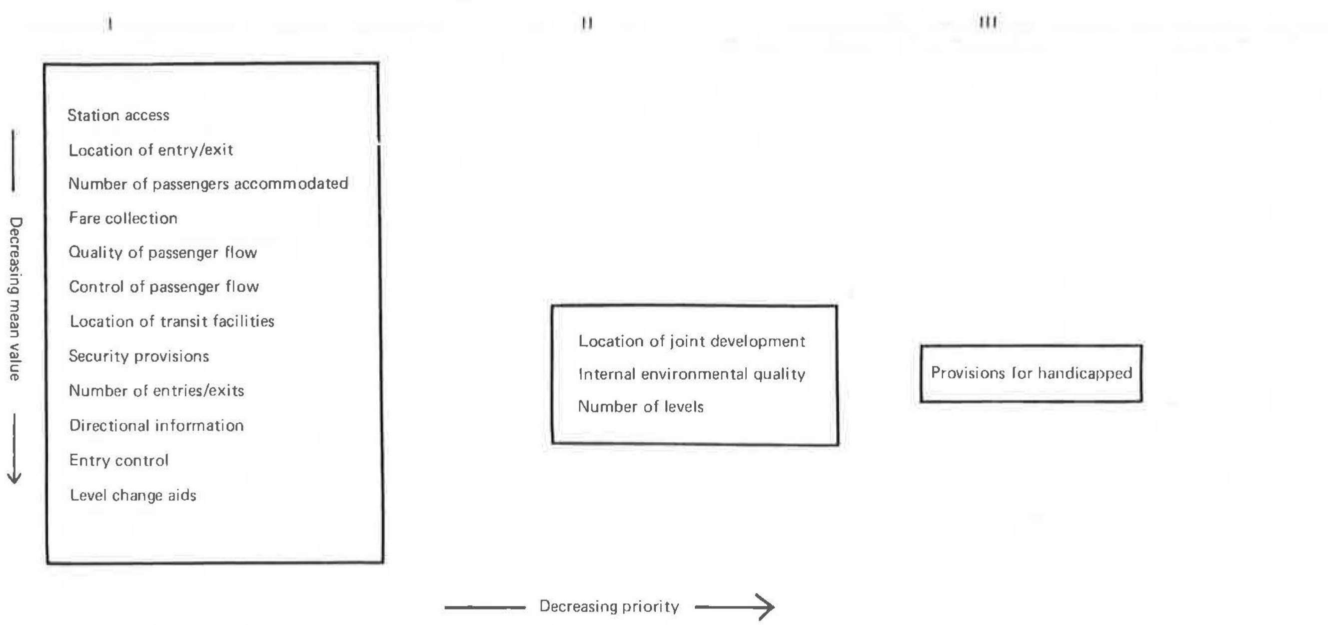


Figure 2. Priorities for consideration of design elements.



The derived priorities of the design elements are presented in Figure 2. Sixteen design elements are divided into three categories based on the pattern of statistical significance; the elements within each category do not have significantly different mean values ($p \leq 0.05$). They are, however, arranged vertically by mean value. For example, station access has a higher observed mean value than fare collection although the two are not significantly different.

For the planner, engineer, or designer, Figure 2 provides an indication of the order in which the design features or elements should be considered. The general category of passenger-flow considerations includes access, entry-exit, fare collection, and control of the quality of passenger flow, which are considered the primary elements in designing a terminal facility. Likewise, items such as joint development, internal environment, and handicapped provisions constitute the elements to be considered late in the design process.

Criterion Weights in Design Evaluation

Given a particular transit station design, how does a designer decide how "good" it is? Evaluation measures, or criteria, must be used. When values are determined for such measures, various station designs may be compared and the "best" alternatives selected. To obtain a valid comparison of alternatives, however, it is necessary to know how important each of the criteria is to the overall evaluation. The respondents were asked to rate the relative importance of each of 19 design evaluation measures to the overall success of a design by using a scale of 1 to 10, where the higher numbers indi-

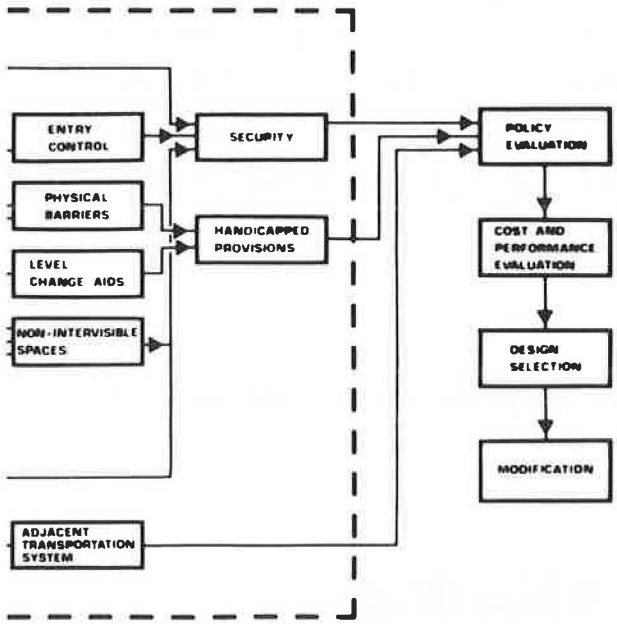


Table 1. Mean importance ratings and calculated weights for design evaluation criteria.

Design Element	Mean	Group Mean	Weight
Passenger safety	9.307		6.8
Passenger security	9.207	9.205	6.8
Efficiency of passenger movement	9.102		6.8
Level of crowding	8.575	8.575	6.3
Design flexibility	7.864		5.4
Level change aids	7.773		5.4
Weather protection	7.761		5.4
Lighting	7.568		5.4
Developmental impacts	7.545		5.4
Environmental impacts	7.295		5.4
Aesthetics	7.091		5.4
Joint development	7.059		5.4
Energy use	6.955		5.4
Mechanical backup facilities	6.849		5.4
Air quality	6.830		5.4
Number of levels	5.593	5.593	4.1
Personal care facilities	4.920	4.920	3.6
Concessions	4.080		3.0
Advertising	3.977	4.029	3.0

cate greater importance. These responses can be incorporated into an evaluation model. The basic requirements for such a model include measures of performance and utilities for each of the design elements and the relative importance of each. Because of its simplicity and relative ease of use, the aggregation rule and weighting procedure incorporated in this paper take the form of a simple weighted linear average:

$$U_i = \sum_j w_j u_{ij} \qquad (1)$$

where

U_i = total utility of alternative i,
w_j = weight attached to design element j, and
u_{ij} = performance of design element j in alternative i.

The particular measurements (u_{ij}) need to be generated anew for each unique design application.

General estimates of the weights can, however, be developed from the mean importance ratings. Table 1 illustrates the separation of the design elements into statistically significant groups and the aggregate means associated with each group. These aggregate means are simply the averages of the individual means within each group. The evaluation weights are then obtained for each combination as follows:

$$\hat{w}_j = X_j / \sum_k X_k \qquad (2)$$

where

$\hat{w}_j$ = estimated weight for each element in the combination j,
X_j = mean for combination j, and
$\sum_k X_k$ = sum of all combination means.

The calculated weights are presented in the last column of Table 1. The sum of the weights taken over all the design elements is constrained to be 100.

The weights can be incorporated into the model as follows, along with the performance measures, to arrive at a utility for each alternative design:

$$\hat{U}_i = \sum_j \hat{w}_j u_{ij} \qquad (3)$$

Once the performance utility is established, tradeoffs can be made with costs to arrive at a final design.

CONCLUSIONS

The illustration of the general transit station design process as a formally ordered sequence of steps provided a framework for developing candidate designs for a transit station. Responses to a survey indicated the relative priority in the overall design process of important design elements. Station access, entry and exit locations, numbers of passenger accommodated, fare collection, and the characteristics of passenger flow were assigned the highest priorities. The importance of the various design criteria to the success or evaluation of a station design was also established by using survey results. Passenger safety and security, efficiency of passenger movement, and level of crowding were rated the most important factors; concessions and advertising were considered least important.

ACKNOWLEDGMENT

This research study was sponsored by the Office of University Research, U.S. Department of Transportation, under contract with the University of Virginia, Charlottesville. We wish to thank the technical monitor, Norman G. Paulhus, Jr., Office of Technology Sharing, U.S. Department of Transportation, for providing valuable suggestions and reviews of this project.

REFERENCES

1. M.J. Demetsky and L.A. Hoel. Design Criteria and Evaluation of Transportation Interface Facilities. High-Speed Ground Transportation, Vol. 11, No. 1, Spring 1977, pp. 75-92.
2. M.J. Demetsky, L.A. Hoel, and M.R. Virkler. Methodology for the Design of Urban Transportation Interface Facilities. U.S. Department of Transportation, Rept. DOT-TST-77-46, Final Rept., Dec. 1976.
3. M.J. Demetsky, L.A. Hoel, and M.R. Virkler. A Procedural Guide for the Design of Transit Stations and Terminals. U.S. Department of Transportation, Rept. DOT-TST-77-53, Final Rept., June 1977.

4. L.A. Hoel, M.J. Demetsky, and M.R. Virkler. Criteria for Evaluating Alternative Transit Station Design. U.S. Department of Transportation, Rept. DOT-TST-76-78, Final Rept., Feb. 1976.
5. M.R. Virkler, M.J. Demetsky, and L.A. Hoel. Transit Station Design: Case Studies of Planning and Design Method. U.S. Department of Transportation, Rept. DOT-RSPA-DPB-50-79-14, Final Rept., Feb. 1980.
6. J. Griffiths, L.A. Hoel, and M.J. Demetsky. Transit Station Renovation: A Case Study of Planning and Design Procedures. U.S. Department of Transportation, Rept. DOT-RSPA-DPB-50-79-14, Final Rept., June 1979.
7. L.G. Richards and L.A. Hoel. Planning Procedures for Improving Transit Station Security. U.S. Department of Transportation, Rept. DOT-RSPA-DPB-50-80-14, Final Rept., Feb. 1980.
8. D.M. McCants. Decision Weights for Transit Station Design. Univ. of Virginia, Charlottesville, thesis, 1981.
9. D.M. McCants, M.J. Demetsky, and L.G. Richards. Decision Procedures in Transit Station Design. Univ. of Virginia, Charlottesville, Final Rept., May 1981.
10. N.H. Nie, C.H. Hull, J.G. Jenkins, K. Steinbrenner, and D.H. Bent. Statistical Package for the Social Sciences, 2nd ed. McGraw-Hill, New York, 1975.

Publication of this paper sponsored by Committee on Intermodal Transfer Facilities.

Planning and Preliminary Design of White Plains, New York, Transportation Center

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A consolidated transportation center in downtown White Plains, New York, was initially proposed in 1967 as part of the Urban Renewal Agency's revitalization plans. Subsequent studies led to site selection and basic planning concepts. The planning and preliminary design study for the White Plains Transportation Center is described. Its purpose was to advance the Transportation Center from a planning concept to working preliminary engineering and architectural plans and to establish planning standards and design criteria, passenger demand estimates, and preliminary cost estimates. A four-phase study was conducted in which maximum participation of project sponsors and local planning agencies was fostered through a series of workshops. To supplement existing information, passenger travel surveys were conducted to determine bus and rail passenger origin-destination patterns, peak-period pedestrian volumes, and parking, taxi, and bus operating characteristics. Projections of passenger demand were made to the design year based on local and regional population, labor force, and employment forecasts. The final design concept recommended for implementation includes a ground-level bus facility located on two parcels of land adjacent to the relocated White Plains railroad station. The second level provides for loading and unloading of kiss-and-ride, taxi, rail, and corporate minibus passengers. Four parking levels are provided above the kiss-and-ride level. Provisions have also been included for direct pedestrian connection to future downtown developments, including a proposed convention center, offices, and a hotel complex. Implementation of the project is being advanced by the City of White Plains through a combination of joint development (private and local) and federal funding.

The City of White Plains, New York, the seat of Westchester County government, is the major regional retail shopping center for Westchester and Putnam Counties of New York and Fairfield County of Connecticut and is the headquarters of numerous major international corporations. White Plains is located in the south-central portion of Westchester County. Three Interstate highways--I-684, I-87, and I-95--connect the city and the region with New England, New York City, and coastal Connecticut. The Consolidated Rail Corporation (Conrail) provides both freight and passenger service. Located about 22 miles north of Grand Central Station, White Plains is an express stop for commuter trains to and from New York City.

The city, which had a 1980 population estimated at 47 000 people, provides employment for 40 000 people. White Plains is the home of 11 corporate headquarters or major office complexes. As a retailing center, it has an annual sales volume of more than $600 million generated from approximately 900 establishments. Eight leading retailers are located within the city, in addition to the new $100 million enclosed shopping mall known as the Galleria, which houses more than 150 stores and 20 restaurants. Currently, there are plans for an additional 200 000 ft^2 of retail space, 800 hotel rooms, 1 million ft^2 of office space, 900 dwelling units, and 600 000 ft^2 of public facilities to be added to the inventory of downtown White Plains. The study area and location of the proposed Transportation Center are shown in Figure 1.

TRANSPORTATION SYSTEMS

Efficient transportation is a necessity for White Plains to accommodate its anticipated growth. The internal highway network has been completed, and additional roadways are under construction and in the planning and design stages. The intracounty bus system, coordinated by the Westchester County Department of Transportation, has been improving its existing service through route additions, schedule improvements, and modernization of the bus fleet.

These existing public transit facilities, including the commuter rail station and bus terminal, are poorly located and improperly coordinated. Both public transportation modes must be improved and better used in order to ensure continued urban vitality and growth.

Rail

The present White Plains railroad station was built in 1914 by the New York Central Railroad. The station building was constructed near the northerly end of a sharply curved section of tracks. Low-level passenger platforms were built between the tracks with passenger access via two sets of stairways served by a tunnel or "subway" through embankment.