Annotated Bibliography

1. Adams, Brock, Transportation Policy for a Changing America. Washington, D.C.: U.S. Department of Transportation, Office of the Secretary, 1978, 23 p.

This report establishes the broad directions and goals to be pursued in developing federal transportation policies and programs for the future. The overall criteria that need to be considered for transportation decision-making at the federal level are discussed. Major new directions for national transportation policy of various modes are outlined.

2. Alexander, John A. and Moavenzadeh, Fred, "Predicting maintenance cost for use in trade-off analyses." Maintenance Systems: Estimating Maintenance Costs, Solid-Waste Disposal Systems, Maintenance Station Locations, Manager Training, and Equipment Management, Highway Research Record 391, Washington, D.C.: Highway Research Board, 1972, pp. 1-10.

This study considers the trade-offs between maintenance costs and other highway costs by looking at maintenance as part of the overall system rather than independently. A method for predicting future maintenance cost for a specified environment, design, traffic volume, and maintenance policy is developed to aid the systematic analysis. The estimating method is based on simulation of the total process from design through operation and maintenance. Preliminary uses of the model on actual projects has illustrated its potential for incorporating future maintenance costs into the design process and in exploring the effect of competing maintenance policies on total transportation costs.

3. Allen, William G. and DiCesare, Frank, "Transit service evaluation: preliminary identification of variables characterizing level of service." Bus Transportation Strategies. Transportation Research Record 606, Washington, D.C.: Transportation Research Board, 1976, pp. 41-47.

This paper is an introduction to transit service evaluation and its application to medium-sized bus transit systems. The concept of transit evaluation is discussed in terms of usefulness, past work, theory, and the presentation of a set of characteristic attributes. The need for performance evaluation, its usefulness for management and government policy formulation, and its state-of-the-art is discussed. Also, a methodology of transportation system evaluation developed by the Rand Corporation is summarized.

4. Alter, Colin H., "Evaluation of public transit services: Level-of-service concept." Bus Transportation Strategies, Transportation Research Record 606, Washington, D.C.: Transportation Research Board, 1976, pp. 37-40.

   In many locales, the primary method of transportation evaluation still remains the profitability of the system. This paper recognizes the need for new evaluation methods that would measure the effectiveness of public transportation rather than its money-making ability. The author presents a level-of-service concept that can be used as an evaluation tool.

5. American Association of State Highway and Transportation Officials. A Manual on User Benefit Analysis of Highway and Bus Transit Improvements, Washington, D.C.: 1977, 189 p.

   This manual presents methodologies for the evaluation of costs and benefits from highway and bus transit improvements. It provides detailed information needed for economic analysis of most types of improvement projects.

6. "Arizona studies priority programming for highway planning." Civil Engineering, Vol. 42, No. 1, January 1972, p. 89.

   Brief news item, describing extension of the basic sufficiency system (condition, service, and safety) to include new categories (environment, economic development, traffic safety).

7. Aschman, Frederick T., "Correlation of expressway planning with city-street planning," Traffic Quarterly, Vol. 15, No. 2, April 1961, pp. 285-294.

   The article questions the big push for planning, designing and building freeway networks at the expense of neglecting other segments of a metropolitan street system. Street planning should consist of a broad approach, mapped out on the basis of comprehensive studies that identify the overlapping roles of the freeway, the arterial highway, collection-distribution streets, and local service streets.

8. Baerwald, John E., "Improvement priority ratings for local rural roads in Indiana," Proceedings, Vol. 35, Washington, D.C.: Highway Research Board, 1956, pp. 38-61.

   An examination of the use of sufficiency indices combined with economic factors and highway traffic level as a means for establishing priority ratings.

9. Baker, R. F., "Why performance evaluation of pavements," in Association of Asphalt Paving Technologists. Proceedings held February 10-12, 1979, Los Angeles, Minneapolis: Association of Asphalt Paving Technologists, 1969, Vol. 38, pp. 276-279.

   Pavement evaluation is needed for evaluating design criteria, for programming maintenance funds, and for making sure that pavements satisfy the traveling public. Criteria are discussed for evaluating pavements. It seems that a preferred objective for pavement evaluation studies is to establish the minimum performance levels that a particular highway system has the funds to support. Research goals of pavement evaluation should be accomplished by determination of (1) the basis for measuring pavement surface characteristics by each highway jurisdiction, (2) the satisfactory level of rideability for various classes of highways, and (3) use of the elastic-inelastic theories with structural analysis approach to produce realistic estimates of the change in rideability.

10. Barrell, David W. F., and Peter J. Hills, "The application of cost-benefit analysis to transport investment projects in Britain." Transportation, Vol. 1, No. 1, May 1972, pp. 29-54.

This paper explains the need for application of cost-benefit analysis to the evaluation of transportation improvement projects and outlines briefly the development of the technique. The results of a comparative survey of several cost-benefit studies which have been carried out in Britain and some conclusions as to their thoroughness and comprehensiveness are presented.

11. Barton-Aschman Associates, Inc., Statewide Transportation Plan, Phase I; Interim Report; prepared for the North Carolina Department of Transportation and Highway Safety, Raleigh, N.C.: February 1975, 34 p.

In October 1974, the North Carolina Department of Transportation initiated a new statewide transportation planning effort. The objective of Phase I of this effort (which was completed in 1976) was to identify a series of alternative statewide development patterns and the transportation services which could serve as well as generate these patterns. Additionally, a low-risk transportation program (i.e., a set of short- and mid-range transportation actions which could be taken by the state without foreclosing future development options) were to be identified. Finally, Phase I was to provide a work program to complete the remaining phases of the planning effort, i.e., the step needed to refine the alternatives and choose a particular growth pattern and corresponding transportation plan for the next 20 years. As the Phase I Interim Report, this document presents an overview of the transportation planning process that was used.

12. Baumel, C. Phillip, et al, "Procedures for developing state rail plans." Surface Transport Regulation and Railroad Planning, Transportation Research Record 687, Washington, D.C.: Transportation Research Board, 1978, pp. 2-4.

This paper reviews the problems characterizing an index method of ranking lines eligible for continued subsidization. An alternative method of ranking branch rail lines is presented. This method is the benefit-cost approach, which was used to develop the Iowa Department of Transportation rail plan.

13. Bausch, James A. and Richard R. Hoover, "Deferred maintenance: a profit maximizing approach," Transportation Journal, Vol. 17, No. 2, Winter 1977, pp. 60-64.

This paper presents a theoretical argument for defining deferred maintenance from a profitability criterion. One can then determine the optimum level of maintenance, and therefore the magnitude of deferred maintenance. Using information provided by such a criterion railroads will be able to eliminate wasteful maintenance expenditures, assign priorities to maintenance projects, and allocate funds more efficiently.

14. Bellomo, Salvatore J. et al, Evaluating Options in Statewide Transportation Planning/Programming: Issues, Techniques, and Their Relationships. Prepared for the National Cooperative Highway Research Program under NCHRP Project 8-18; by Planning Environmental International/Alan M. Voorhees and Associates, National Cooperative Highway Research Program Report No. 179, Washington, D.C.: Transportation Research Board, 1977, 91 p.

This research identifies transportation programming methodologies that are policy sensitive and that facilitate the testing and evaluation of options in a manner which produces timely results for decision-making. The focus is on reasonable cost, sketch planning-type techniques applicable to important issues in statewide transportation planning and programming.

15. Boyd, J. Hayden, et al, Evaluation of Rail Rapid Transit and Express Bus Service in the Urban Commuter Market, Arlington, VA, Institute for Defense Analyses, 1973, v.p.

This study analyzes and evaluates public transportation alternatives for serving the commuter market. The alternatives are analyzed from the standpoint of both supplier and user time costs. Quantitative data on fuel consumption and emissions are presented, and the effects of political, regulatory, and institutional constraints are discussed.

16. Building Research Advisory Board, Value Engineering in Federal Construction Agencies; Symposium/Workshop Report No. 4 from a Conference held May 27, 1969, Washington, D.C. under the sponsorship of the Federal Construction Council, Building Research Advisory Board of the National Academy of Sciences. Washington, D.C.: National Academy of Sciences 1969, 72 p.

This report contains an introduction, conclusions, and observations of basic concepts of value engineering programs. Problems in implementing programs are also discussed.

17. Burnes, Clint, "Methods of estimating improvement costs on county FAS systems in Minnesota, Highway Needs Studies 1957; A Symposium. (Paper presented at Session 2, "Economics, Finance, and Administration," of the 36th Annual Meeting of the Highway Research Board, held January 7-11, 1957, Washington, D.C.) Bulletin 158. Washington, D.C.: Highway Research Board, 1957, pp. 81-89.

The paper discusses the data needed and how to obtain it, and considers the ranges of possible cost improvements.

18. Byrd, Lloyd G., Principles of Project Scheduling and Monitoring, National Cooperative Highway Research Program Synthesis of Highway Practice 6, Washington, D.C.: Highway Research Board, 1970, 43 p.

The synthesis sets forth project scheduling and monitoring systems as management tools for highway agencies. The use of scheduling techniques, development of project schedules, and management analysis is considered. The basic input required is a long range program of priority-ordered projects.

19. Cafferty. Michael, "Urban goals and priorities: the increasing role of transportation planning," Traffic Quarterly, Vol. 25, No. 3, July 1971, pp. 309-322.

A series of proposals in reference to goals and priorities for transportation planning are presented by the Office of the Assistant Secretary for Environment and Urban Systems. U.S. Department of Transportation.

20. Cambridge Systematics, Recommendations for an Improved Statewide Programming Methodology; prepared for the Wisconsin State Department of Transportation. Madison: Wisconsin Department of Transportation, February 1977.

The paper recommends a variety of information systems, financial analysis, and project evaluation technical support tools to assist the Department in developing a long range highway improvement program. Benefit-cost analysis is suggested as one component of project evaluation and as a guide to program development.

21. Campbell, M. Earl, "Elemental versus composite ratings," Highway Sufficiency Ratings, Bulletin 53, Washington, D.C.: Highway Research Board, 1952, pp. 30-31.

The paper examines the difficulty of deriving a figure that portrays the true index of each element that went into the combination.

22. Cantilli, Edmund J. et al, Introducing Patron Opinion Into Resource Allocation for Public Transportation. Brooklyn, N.Y.: Department of Transportation and Engineering, Polytechnic Institute, 1971, 25p. (NTIS No. PB206 240).

This report develops a means of distributing transit improvement funds in which public opinion plays an integral role in the formulation of an allocation index. A model is presented which emphasizes methods of weighting various amenity factors and measuring effectiveness as a function of the gap between existing and desired conditions. A review of existing allocation techniques is included.

23. Carey, W. N. Jr., "Use of surface profile measurements," Pavement Evaluation Using Road Meters. Special Report 133. Washington, D.C.: Highway Research Board, 1973, pp. 5-7.

There are at least four fundamental uses of pavement surface profile measurements. First they can be used as a quality-control tool. Second, they can locate abnormalities along the highway. Third, they can establish a systematic statewide basis for allocation of pavement maintenance resources. Fourth and most important, they provide an objective measure for determining relations between pavement performance and pavement design factors including materials, construction practices, conditions of traffic loading and climate. This was the basis for development of the pavement serviceability and performance concept developed at the AASHO Road Test, prior to which there was no definition of pavement performance that could be used for pavement design. During the test it was determined that driver ratings of pavements exhibited excellent consistency and that some measure of longitudinal profile would provide the strongest simple predictor of the user's ratings of serviceability. Comparison of pavement ratings over the years, given the same or different designs, traffic densities, climates and soils, provides the necessary elements for a pavement structural design mechanism.

24. Carlson, H. E., "Adequacy and priority ratings for rational highway system planning," Highway Research Abstracts, Vol. 25, No. 4, April 1955, pp. 20-27.

The paper discusses the use of adequacy and priority ratings. Including road inventory and traffic analyses.

25. Carstens, Robert L. and Joseph W. Murphy, "Formulation of Iowa State Airport System," Transportation Engineering Journal of the ASCE, Vol. 103, No. TE 6, November 1977, pp. 751-762.

26. Carter, Everett C. and Joseph R. Stowers, "Model for funds allocation for urban highway systems capacity improvements," Highway Financing. Highway Research Record 20. Washington, D.C.: Highway Research Board, 1963, pp. 84-102.

This is a discussion of a method for allocation of funds for highway improvements that will yield a minimum total cost for the entire system. Consideration is given to the total cost of operating vehicles on all links of the network, plus total costs for making improvements to various links throughout the highway system.

27. Charlesworth, G. et al. "Road improvements: choosing priorities by a new formula," Engineering, Vol. 188, No. 4873, September 11, 1959, pp. 185-188.

An estimate of the economic benefits to be expected from road works showed that for eighteen schemes, four gave returns on capital outlay of under 5 percent and five gave return of over 15 percent. Allowances are made for personal accidents and the costs of congestion. The rate of return on the cost of work should be used to decide priorities between different road projects.

28. Chatterjee, Arun and Kumares C. Sinha, "Distribution of benefits of public transit projects," Transportation Engineering Journal of the ASCE, Vol. 101, No. TE 3, August 1975, pp. 505-520.

The conventional approach of evaluating public projects considers the benefits in a narrow sense and attempts to achieve technical efficiency by maximizing such benefits relative to cost. However, a new approach emphasizing the question of equity and the concept of grant efficiency is being advocated by many economists. The paper examines the basic issues related to efficiency and equity and reviews the existing techniques of including income redistributive effects of urban mass transit projects.

29. Cherwony, Walter, "Cost-centers: a new approach to transit performance," Transit Journal Vol. 3, No. 4, Fall 1977, pp. 70-80.

Typically most transit operations are faced with competing demands for service, while constrained by limited financial resources. With transit agencies faced with rising costs and increased public opposition to higher taxes to underwrite the difference between revenues and expenses, it is apparent that economic criteria will play a key role in decisions related to the cost-centers approach to transit operations in which each route and service type is treated as a separate entity. An application is also presented.

30. Cherwony, Walter and Lewis Polin, "Evaluation of long-range transit alternatives," Transportation Engineering Journal of the ASCE, Vol. 101, No. TE 2, May 1975, pp. 199-210.

A methodology was developed to measure the relative and absolute performance of alternative transit plans in a major Minneapolis travel corridor. A major element of the transit analysis was to identify the extent and location of exclusive transit facilities. One unusual feature of the analysis was that the transit mode was not specified since such a question is to be resolved at the regional level. Each of the transit facilities was evaluated in terms of population, employment, and trip ends. The alternative transit plans were evaluated not only in terms of aggregate measures of socio-economic and travel characteristics, but they were also considered in terms of efficiency measures. An ordinal ranking procedure was developed as a final step in the evaluation procedure to select the best combination of transit facilities for the corridor.

31. Cherwony, Walter and Lewis Polin, "Parametric analysis of rapid transit feasibility," Transportation Engineering Journal of the ASCE, Vol. 104, No. TE 3, May 1978, pp. 363-372.

Parametric analysis is a sketch planning technique to test the feasibility of fixed guideway systems with a variety of alternative transit technologies. This approach was used in Albuquerque, New Mexico and was found to provide a relatively low cost and efficient method of plan evaluation.

32. Collins, M. S., "Determining merit of road improvements," Traffic Engineering and Control, Vol. 4, No. 4, August 1962, pp. 208-211.

Common elements of road improvements are: Capital costs, design life, effect on maintenance, effect on traffic, effect on accidents. The method proposed here is to value and relate these factors giving the results as a total annual saving (or loss). The capital cost is related to the annual savings by dividing cost by the design life to get an arbitrary annual depreciation. No consideration of loan periods or rates is involved.

33. Cook, Kenneth E., "Application of program budgeting to transportation," Program Budgeting, Highway Research Record 288, Washington, D.C.: Highway Research Board, 1969, pp. 1-4.

Discusses the program budget process and how it can be applied to setting priorities for transportation plans. Considers basic methodology, goal structure, and analysis techniques.

34. Crain, John L. et al, Evaluation Procedures for Poverty Transportation Projects; prepared for the Urban Mass Transportation Administration, U.S. Department of Transportation, Menlo Park, California: Stanford Research Institute, 1970, 199 p. (NATIS No. PB 200 552).

An evaluation model for programs designed to provide employment-oriented transportation for the poor is developed to provide an objective tool for benefit-cost analysis for such projects. The model provides for an estimate of variables which are difficult to quantify such as benefits measured by reduced crime and welfare costs, increased labor production, and tax revenues.

35. "Criteria for highway construction scheduling," Public Works, Vol. 102, No. 7, July 1971, pp. 89-90.

The article provides a short description of priority programming and functional classification used in the Washington State Highway Department.

36. Crumlish, Joseph D., Notes on the State-of-the-Art of Benefit-Cost Analysis as Related to Transportation Systems, Technical Note No. 294, Washington, D.C.: U.S. National Bureau of Standards, 1966, 41 p.

This review of benefit-cost analysis as a tool for evaluating alternative courses of action describes the technique, discusses a number of studies, and indicates the difficulties inherent in this area of applied economics. The author concentrates on the application of the technique to large scale transport problems and indicates where the technique can be helpful and where there is little chance for its success.

37. Deen, James B., "Fiscal policies and transportation planning," Traffic Quarterly Vol. 17, No. 1, January 1963, pp. 108-123.

Fiscal policies try to allocate the cost of providing transportation to the highway users. The principles of economic self-support of a project and the delay and congestion costs associated with peak flows are also discussed.

38. Dickey, John W. and Alan W. Steiss, "Programming models in the systemic planning process," High Speed Ground Transportation Journal, Vol. 3, No. 1, January 1969, pp. 33-45.

In this article an effort is made to formulate a systems approach to urban problems. By combining the elements of operations research, system analysis, and comprehensive planning, such a formulation is made. Criteria for basic models are outlined and

a programming model meeting these criteria is presented both in theoretical terms and in application. Systematic planning is discussed in terms of its role in the public decision process.

39. Donnell, Philip M. and Lawrence S. Tuttle, "Priorities determination and programming in Tennessee," Highway Needs Studies 1957; A Symposium, (papers presented at Session 2, "Economics, finance, and administration, of the 36th Annual meeting of the Highway Research Board, held January 7-11, 1957, Washington, D.C.), Bulletin 158, Washington, D.C.: Highway Research Board, 1957, pp. 63-77.

This paper describes the development of the priority rating method and procedures found to be best adapted to the formulation of the initial 5-year short range program to remedy the state highway system's most critical deficiencies. This is the first step necessary in order to put into operation the long-range programs recommended for the system. A second step should be the formulation of criteria, techniques, and procedures necessary to establish a continuing construction program to meet future deficiencies as they accrue.

40. Epps, Jon A. Developing decision-making maintenance management tools," Public Works, Vol. 107, No. 2, February 1976, pp. 78-80.

An attempt has been made to develop a system by which all highway maintenance operations can be coded and placed into functional groups, develop maintenance quality standards and maintenance methods for the various highway classes, develop a maintenance rating system that can be used to schedule highway maintenance operations, implement the rating system on a trial basis, and assess the established quality standards and maintenance methods. A literature review identified the basic elements of a successful maintenance management program. The elements relate to maintenance methods, quality standards, inventory evaluation, priority scheduling, cost accounting, maintenance strategy, training, data bank, and implementation. The activity classification is detailed, the rating system is outlined and the computer programs developed to fit the needs of different levels of management within the highway department are briefly described.

41. Epps, Jon A. et al, Development of Maintenance Methods and Cost Codes, College Station, Texas: Texas Transportation Institute, Texas A&M University, July 1974, 42 p. (NTIS No. PB 239 534).

Funding for highway maintenance operations in Texas comprises a significant part of the total highway budget. Because of the great number and variety of maintenance functions and the different acceptable maintenance levels for different road types, it is critical that a comprehensive decision system be developed to assure that maintenance funds be used in an optimum manner. The objectives are to develop a system in which all highway maintenance operations can be placed into functional groups, develop levels of acceptability for maintenance operations for various highway classes, develop a maintenance rating system that can be used as a basis for the determination of a priority schedule for highway maintenance operations, and implement on a trial basis a maintenance rating system and assess the established level of acceptability for maintenance operations.

42. Evans, Eugene G. and Theodore B. Treadway, "Economic analysis of truck climbing lanes on two-lane highways," Economic Factors Influencing Engineering Decisions, Highway Research Record 245, Washington, D.C.: Highway Research Board, 1968, pp. 1-16.

Determination of the economic feasibility of adding truck climbing lanes on two-lane highway grades. Analysis based on the increase in travel time (delay) experienced by road users in passenger cars and small trucks, which was converted into a monetary value. Vehicle operating costs and accident costs were not included. Simulation analysis for traffic generation was used.

43. Evans, Henry K., "Economic studies for highways," Traffic Quarterly, Vol. 22, No. 4, October 1968, pp. 479-495.

The study concerns three types of investigations: those dealing with analyzing the comparative worth or feasibility, those dealing with the economic base and land use of an area, and those designed to reveal the impact of routes on an area.

44. Fielding, Gordon J. et al, Development of Performance Indicators for Transit; Final Report. Irvine, California: Institute of Transportation Studies and School of Social Sciences, University of California, 1977, 131 p. (NTIS No. PB 278 678).

This research provides the rationale and developmental structure for the evaluation of transit performance through quantitative performance criteria. It specifies efficient and effective transit service as appropriate goals to be encouraged by federal and state governments and identifies those criteria which focus on significant aspects of performance.

45. Fielding, Gordon J. and Roy E. Glauthier, Distribution and Allocation of Transit Susbsidies in California, Irvine, California: Institute of Transportation Studies, University of California, 1976, 44 p.

This paper discusses transit performance measures as a tool for evaluation of transit operation. Such a methodology is discussed as a possible means of allocating transit subsidies in California.

46. Fritts, C. E., "Relation of sufficiency ratings, tolerable standards, and priorities," Highway Sufficiency Ratings, Bulletin 53, Washington, D.C.: Highway Research Board, 1952, pp. 36-40.

This paper is concerned with the economic establishment of cut off points in allowable sufficiency ratings. It presents the necessity of identifying tolerable standards for various variables under differing conditions, and it considers benefit-cost ratios.

47. Frye, Frederick F., Alternative Multimodal Passenger Transportation Systems, Comparative Economic Analysis. National Cooperative Highway Research Program Report 146, Washington D.C.: Highway Research Board, 1973, 68p.

The objective of this research is to develop improvements and expansion of existing processes that evaluate alternative multimodal transportation system plans. These improvements were sought on the basis of increasing the number of relevant criteria used in the evaluation framework and ensuring that the measuring techniques (economic evaluation criteria) developed represented accurately the impacts of alternative transportation plans.

48. Gardner, Evan H., "Basic information requirements for priority programming," in American Association of State Highway Officials. Proceedings of a convention held October 5-7, 1965, New York, New York. Washington, D.C.: American Association of State Highway Officials, 1966, pp. 206-214.

This is a synopsis of information requirements, which includes structural and functional aspects of the roads and considers annual user cost and rate of return.

49. Gardner, Evan H., "The congestion approach to rational programming," Highway Needs and Programming Priorities. Bulletin 249, Washington, D.C.: Highway Research Board, 1960, pp. 1-22.

Conventional sufficiency ratings are subjective and arbitrary in the assigning of point values and fail in the comparison of rural with urban facilities. A proposed priorities rating formula for the Commonwealth of Pennsylvania that resolves most of these difficulties is discussed. The formula does not use safety as an independent factor, believing its containment in the structural and functional elements of rating to be a proper evaluation of and to be duplicated within a rating system. "Structural" and "functional" factors are evaluated in dates of refinement rather than points.

50. Gardner, Evan H. and James B. Chiles, "Sufficiency ratings by investment opportunity," Programming and Needs: 1963 and 1964, Highway Research Record 87, Washington, D.C.: Highway Research Board, 1965, pp. 1-28.

Multiple alternatives are available for improvement of any highway; each investment yields its own particular rate of return in congestion dollars saved to the user. The alternative that yields the greatest rate of return is the best investment opportunity for that particular road section, and the rate of return for this optimum improvement is the measure of insufficiency in the highway.

51. General Analytics, Inc. and COMSIS Corporation, Objective Priority Programming Procedures: Narrative and User's Documentation; prepared for the U.S. Federal Highway Administration, Report No. DOT-FH-11-7882, Washington, D.C.: U.S. Department Of Transportation, Federal Highway Administration, 1973, 151p. (NTIS No. PB 225 001).

The procedures and computer program presented in this report provide a framework for the states to use in developing priority programs of projects. The procedures include the sufficiency rating factors and other factors felt to be important by society today. The report discusses the inventory of priority programming methods, the survey and evaluation of current and proposed procedures, the development of a methodology, the specification of factors and variables, the procedures for application of the method, and the test of the computer program.

52. Gilbert, Dennis and Alan Jessop, "Taxonometric evaluation," Transportation, Vol. 7, No. 2, June 1978, pp. 137-166.

This paper considers the formation of a coherent and useful link between the design and evaluation stages and suggests a method of dealing with probabilistic forecasts.

53. Gilbert, Gorman and Jarir S. Dajoni, Measuring the Performance of Transit Services, Durham, North Carolina: Institute of Policy Sciences and Public Affairs, Center for Policy Analysis, Duke University, 1975, 27 p.

This paper presents an evaluation framework defining various governmental inter-relationships and specifies the types of performance indicators and measures to be used in evaluating transit. It provides a basis for determining how to use these indicators and measures once they have been computed. It discusses the use of performance as a criteria for the allocation of funds among systems.

54. Godwin, H. F. and L. L. Smith, Development of Present Serviceability Index Equations for evaluation Florida Pavements, Research Report No. 158, Gainesville: Office of Materials and Research, Florida Department of Transportation, 1972, 23p.

This report covers the development of pavement serviceability index (PSI) equations for evaluating flexible and rigid pavement systems in Florida. The procedures used in the selection of the pavement sections and the methods of rating by a panel are discussed. The subjective and objective data are statistically summarized in tabular and graphical form. The manipulation of such data and the development of present serviceability equations for each pavement type (system) are included.

55. Gomez, Juan F. and Clarkson H. Oglesby, "A proposed approach to setting road maintenance levels for forest service roads," Low Volume Roads; Proceeeding of a Workshop held June 16-19, 1975, Boise, Idaho, Special Report 160, Washington, D.C.: Transportation Research Board, 1975, pp. 378-384.

This paper reports on a simple rational approach for setting road maintenance levels for all forest roads. The criteria used in this approach are based on knowledge of the land and its uses and the roads that serve it, within the limitations on resources for maintenance. The report presents an orderly means of reducing maintenance levels while minimizing total negative impact. Maintenance level needs are evaluated by resource functions such as timber, recreation, fire control, watershed protection, and wildlife. The procedure requires that a single-paged form be computed for each road or group of roads. The process is completed in three steps: advance information, appraisal, and budget review. Advance information is existing data about roads such as type, length, width and volume. Analysis is a form of land use planning in which inventory data, objectives, and available resources are assessed by an inter-disciplinary team. The team develops the negative impact rating as suggested on the form. Each person subjectively weighs the relative impact of the road maintenance levels on the various functions. In the budget review step, maintenance levels are adjusted so that they are compatible with funding level.

56. Granum, James O. and Clinton H. Burnes, "Advance programming methods for state highway systems," Highway Needs and Programming Priorities, Bulletin 249, Washington, D.C.: Highway Research Board, 1960, pp. 23-51.

An examination of the decision-making processes involved in selecting highway improvement projects in several states and a Canadian Province is reported in this paper. It is concluded that eight major factors must be present for most effective programming of work. These are: (a) legislative support, (b) executive action, (c) factual survey, (d) budget decision, (e) systematic priority analysis, (f) systematic coordination, (g) scheduling and control and (h) administrative organization. These are briefly described and illustrated by examples.

57. Granum, James O. and Ronald M. Gordon, "Flexible analysis of highway needs in Manitoba," Programming and Needs: 1963 and 1964, Highway Research Record 87, Washington, D.C.: Highway Research Board, 1965, pp. 78-97.

This paper sets forth a computer program to determine physical road needs and costs.

58. Granum, James O., "Perspective on highway programming -- report on workshop meetings" American Association of State Highway Officials, Proceedings of the 1970 Convention held November 9-13, 1970, Houston, Texas, Washington, D.C.: 1971 pp. 114-124.

The paper summarizes the proceedings of a series of workshops held in 1969 concerning the programming of projects in state highway departments. Besides providing a perspective on highway programming, the paper discusses the factors for consideration, ranging from highway finance to maintenance and operation; from citizen and user concern to the legislatures, and the Congress. An outline is provided of the criteria for decision making combining engineering economy studies as well as socio-economic aspects.

59. Gronberg, Gordon D., "Use of pavement condition data in highway planning and road life studies," Pavement Condition Evaluation, Highway Research Record 40, Washington, D.C.: Highway Research Board, 1963, pp. 37-40.

This paper examines the use of current and projected pavement condition in the various stages of highway planning. It points out the need for cost data for future planning.

60. Grunow, Robert N., "PERT and its application to highway management," Construction Programming and Scheduling, Highway Research Record 32, Washington, D.C.: Highway Research Board, 1963, pp. 38-54.

The paper outlines the possible applications of several management tools, particularly the program evaluation review technique (PERT) to highway project programming. It is argued that an approach based on management techniques would allow best utilization of all resources in the implementation of a highway project.

61. Grunow, Robert N., "Vehicle delay at signalized intersections as a factor in determining urban priorities," Highway Needs Studies 1958, Bulletin 194, Washington D.C.: Highway Research Board, 1958, pp. 42-48.

The paper addresses vehicle delays occasioned by traffic signals. The objective is to compare one urban section with another using the average total delay occasioned by the signals in 24 hours.

62. Gruver, James E. et al, "Highway investment analysis package," Transportation Programming, Economic Analysis, and Evaluation of Energy Constraints, Transportation Research Record 599, Washington, D.C.: Transportation Research Board, 1976, pp. 13-18.

The highway investment analysis package (HIAP), a computerized evaluation and investment programming model, has been developed for the FHWA to aid state, regional, and local organizations in making the best use of limited highway funds. HIAP uses microeconomic theory to analyze individual roadway sections and limited networks of sections specified by their physical, traffic and operational characteristics. Estimates of both highway user and non-user impacts are produced. HIAP develops multiperiod investment programs by selecting those improvements that maximize either user benefits or one of several accident reduction measures. The selection process permits consideration of a broad

range of funding constraints, which may be tailored to the specific needs of individual organizations. Based on marginal analysis, the process allows consideration of multiple alternatives and staged improvements at each analysis site.

63. Gulbrandsen, Odd, "Optimal priority rating of resources--allocation by dynamic programming," Transportation Science, Vol. 1, No. 4, November 1967, pp. 251-260.

The paper describes how to find the "best" sequence of allocation of resources to projects by a combination of the dynamic programming method and Lagrange's multiplier method. The optimization is done within the limits of the total resources available.

64. Haddon, William Jr., and David Klein, "Assessing the efficacy of accident countermeasures," Traffic Quarterly, Vol. 19, No. 3, July 1965, pp. 321-332.

A study of two widely used countermeasures is presented.

65. Haley, Charles E. et al, "Travel time--a measure of service and a criterion for improvement priorities," Travel Time and Vehicle Speed, Highway Research Record 35, Washington, D.C.: Highway Research Board, 1963, pp. 1-17.

Travel time is an indication of traffic congestion. A simple priority formula is developed to aid in determining major street construction priorities in urban areas. The formula includes delay, rate, collisions, traffic volume and structural conditions of the pavements.

66. Hall, Edward M. and C. Dwight Hixon, "The use of a priority formula in urban street programming," Programming and Needs: 1963 and 1964, Highway Research Record 87, Washington, D.C.: Highway Research Board, 1965, pp. 57-77.

This paper develops a simple method that aids in developing major arterial street improvement programs in urban areas. Research from three cities covering a span of six years is presented. Three basic test formulas are developed and evaluated. The results indicate that an urban street construction priority formula should not be too complex and should minimize the judgement elements that go into it. The formula makes possible the presentation of various projects in a relative priority list.

67. Harral, Clell G. et al, "Evaluating the economic priority of highway maintenance: some exploratory analyses," presented at the Pan American Conference on Highway Maintenance held November 22-29, 1977, Accra, Ghana, Washington, D.C.: Transportation Department, World Bank, 1977.

This research report describes a decision-making framework for evaluating alternative design and maintenance strategies for low-volume roads. The highway design and maintenance standards model (HDM) is described and application is made to estimate the benefits of different maintenance activities. The model is also used to arrive at an "optimal" allocation of resources among different road types and traffic volumes.

68. Heathington, Kenneth W., "Evaluation of urban public transportion," a paper presented at the 43rd Annual ORSA meeting held May 9-11, 1973, Milwaukee, Wisconsin, Knoxville: Transportation Research Center, University of Tennessee, 1973.

This paper explores alternative approaches that one may take in evaluating public transportation and identifies the criteria which should have application to various urban areas.

69. Herendeen, James H., "Role of economic analysis in plan selection," Transportation Engineering Journal of the ASCE, Vol. 104, No. TE 1, January 1978, pp. 55-68.

The planning and programming requirements for major transportation projects have undergone significant changes. The need to consider environmental, social, and land-use impact in addition to economic issues and the necessity of incorporating citizen inputs has resulted in the development of new methodologies capable of accomodating these concerns. There is still a need for sound economic analysis of alternatives. This paper reviews the evolution of economic analysis in the

planning process, describes available techniques and examines the function of economic analysis in the plan selection process.

70. Hibbard, Thomas H. and Fred Miller, "Applications of benefit-cost analysis: the selection of 'non-construction projects,'" Cost-Benefit and Other Economic Analyses of Transportation, Transportation Research Record 490, Washington, D.C.: Transportation Research Board, 1974, pp. 31-39.

The traditional benefit-cost framework, frequently used to evaluate construction projects, is used to analyze non-construction activities of highway agencies for the purpose of improving resource allocation within and between programs. Drawing from three examples of maintenance projects from the parks and bicycle trails programs, the authors demonstrate that difficult-to-value variables such as safety, recreational experiences, and benefits to bicycle riders can be evaluated with benefit-cost analysis. In hypothetical cases of safety benefits from pothole patching, construction of parks for campus and day users, bicycle route construction for commuters and the values of benefits required to justify the investments are calculated. The optimum frequency for maintenance projects is also examined. The conclusions are that techniques exist to improve project selection within many programs and that a better understanding of the versatility of benefit-cost analysis will lead to its more frequent use.

71. Highway Research Board, Committee on Highway Programming, "A review of scheduling procedures for state highway construction programs," Construction Programming and Scheduling, Highway Research Record 32, Washington, D.C.: Highway Research Board, 1963, pp. 1-37.

This report emphasizes the execution or administration phase of the programming process by reporting available details of scheduling and control methods and procedures, with only incidental attention to the basis for making decisions on the priority of projects.

72. Hoch, Irving, "Benefit-cost methods for evaluating expressway construction," Traffic Quarterly, Vol. 15, No. 2, April 1961, pp. 208-225.

The article outlines some general procedures for calculating benefits and costs of expressway construction based on research done for the Chicago Area Transportation Study (CATS). The procedures discussed should have general applicability to problems of metropolitan area expressway construction.

73. Hooper, Curtis J., "Considerations in rating urban streets," Highway Sufficiency Rating, Bulletin 53, Washington, D.C.: Highway Research Board, 1952, pp. 14-16.

The differences between the characteristics of rural highways and urban streets points out the need to consider different elements for the sufficiency ratings of the two areas.

74. Hummel, Charles M., "A criterion designed to aid highway expenditure programming," Highway Needs and Programming Priorities, Bulletin 249, Washington, D.C.: Highway Research Board, 1960, pp. 52-60.

The paper outlines the logic behind the choice of travel time as the one criterion that can be used for programming the expenditure of funds available for construction of highways. A detailed demonstration of how this criterion might be employed in programming is given. In conclusion, some comments relative to the benefits claimed for this criterion are offered.

75. Hunter, William W. et al, Methodology for Ranking Roadside Hazard Correction Programs, Chapel Hill: Highway Safety Research Center, University of North Carolina, July 1977, 45 p.

This study describes the development and use of a computerized system to facilitate the prioritizing of roadside fixed-object treatments.

76. Hurley, Jamie Woodrow, Jr., Feasibility of Transportation Projects--An Energy-Based Methodology, Ph.D. dissertation, University of Florida. Ann Arbor, Michigan: University Microfilms International, 1975, (UMI order No. 75- 23896).

A benefit-cost analysis method for evaluating transportation projects, where the basic standard of value is net energy rather than the traditional monetary units, is described. Mathematical models and tables are constructed to estimate energy requirements for construction and equipment investments, operations maintenance requirements, and road user requirements at the project level. The technique, as applied to a bus and car-pool demonstration project in Miami, Florida, showed considerable differences between the values obtained by the energy-based method and those obtained by economic analysis.

77. Hutchinson, Bruce G., "Programming of regional highway investments," Transportation Engineering Journal of the ASCE, Vol. 98, No. TE 3, August 1972, pp. 493-508.

A procedure is advanced for programming capital investments in a large primary highway network. Four classes of benefits are identified and these are: link addition benefits; capacity benefits; geometric benefits; and pavement benefits. Information is introduced from Ontario to demonstrate how the marginal benefits associated with any of these decisions may be calculated.

78. Johanson, J. Charles, "Efficiency in the making--Indiana adopts factual programming," Traffic Quarterly, Vol. 16, No. 3, July 1962, pp. 357-380.

The Indiana State Highway Commission has developed a flexible rational rating program for rural state highways using electronic computers to store and retrieve the collected data.

79. Johnson, Marvin M. et al, "Dynamic programming of highway safety projects," Transportation Engineering Journal of the ASCE, Vol. 97, No. TE 4, November 1971, pp. 667-679.

Although there may be several feasible highway safety improvement projects which are candidates for implementation, funds are seldom sufficient to implement all projects. This paper examines the application of dynamic programming to this problem. An example demonstrates the manner in which this technique leads directly to the optimum safety project.

80. Jorgensen, Roy E., "Use of sufficiency ratings in long-range planning," Highway Sufficiency Ratings, Bulletin 53, Washington, D.C.: Highway Research Board, 1952, pp. 32-35.

The development of a long range program using sufficiency ratings is a relatively simple process assuming that cost estimates for construction projects are available.

81. Juster, Richard D. and Wayne M. Pecknold, "Improving the process of programming transportation investments," Transportation Programming, Economic Analysis, and Evaluation of Energy Constraints, Transportation Research Record 599, Washington, D.C.: Transportation Research Board, 1976, pp. 19-24.

This paper presents a methodology that integrates regional equity, funding constraints, public acceptance, and uncertainty into a technical programming procedure. Developed for the Massachusetts Department of Public Works, it can be used to generate tentative multiple-period investment programs that are reasonably efficient in an economic sense and complex with a variety of funding, legislative, and community constraints. The program generation procedure is a heuristic one, based on marginal analysis. It handles independent and mutually exclusive investments, project benefit interdependencies, multiple funding sources, regional and other expenditure minimums, and functional classification constraints. It uses a measure of benefits, capital costs, and an estimate of the political acceptability of each project and compares alternative projects.

82. Juster, Richard D., A Methodology for Statewide Programming of Transportation Investments. Master's thesis, Cambridge: Department of Civil Engineering, Massachusetts Institute of Technology, 1974.

The thesis presents a heuristic benefit-cost procedure for evaluating highway projects. The procedure utilizes an incremental benefit-cost ratio approach and proceeds myopically from period to period. Within a period the approach handles both minimum and maximum fund constraints as well as alternative project design scales.

83. Kashuba, E. and R. Osborne, An Introduction to the Program, Management Information System. Program Management Information System Synopsis No. 1, Washington, D.C.: Program Management Division, Office of Highway Planning, U.S. Federal Highway Administration 1977, 14 p.

The program management information system (PMIS) is an automated data storage and retrieval service which contains information relating to highway planning, programming, budgeting, and scheduling on a state-by-state basis. The system is a reference tool for management, a device whereby the decisions which confront the manager of a state's highway program may be placed in a nationwide context. This allows a manager dealing with specific questions to recognize them to be either unique and therefore necessitating individualized treatment or particular instances of a more general problem which may have been dealt with in other states. The program information system can lend confidence to state transportation managers in their decision-making process by expanding the data base upon which these decisions must stand.

84. Kashuba, E., Long-and-Short range Programs, Program Management Information System Synopsis No. 2, Washington, D.C.: Program Management Division, Office of Highway Planning U.S. Federal Highway Administration, September 1977, 7 p.

This report addresses long and short-range programs and is based on data that was developed by the states, the FHWA field offices, and the FHWA headquarters.

85. Kerttula, W. J., "Systematic approach to project development and computer-aided design," Development of Wisconsin's Integrated Operation System. Highway Research Record 326. Washington, D.C.: Highway Research Board, 1970, pp. 27-32.

This paper describes the decision-making process as a series of steps including the development of goals, the selection of improvement projects, and the investigative and design activities required to realize the goals. It also describes a four-step process involved in project development

86. Knox, Ronald R. et al, "Programming highway improvements in new funding environment," in Transportation Programming, Economic Analysis, and Evaluation of Energy Constraints. Transportation Research Record 599. Washington, D.C.: Transportation Research Board, 1976, pp. 7-12.

This paper describes the highway programming process and techniques developed in Illinois to set priorities and develop resource allocation methodologies to carry them out. Fundamental to the process is an inventory of transport service problems on the entire Illinois highway system. This requires matching short-range priorities and existing service problems to longer range goals. Included in the paper are discussions of deficiencies and problems of existing programming techniques, the philosophies behind the development of the Illinois process, and the development of TIP information.

87. Lago, Armando M., "Cost functions and optimum technology for intercity highway transportation systems in developing countries," Traffic Quarterly, Vol. 22, No. 4, October 1968, pp. 521-553.

The paper addresses traffic volume, trip distance, terrains, and factor costs for each technology. A highway transportation cost model is presented which traces the manner in which decision makers, by selecting appropriate values for variables, will be able to select technology that minimizes total transportation costs.

88. Lamm, Lester P., "Applying programming budgeting to highways: an illustrative example," Program Budgeting. Highway Research Record 288. Washington, D.C.: Highway Research Board, 1969, pp. 10-19.

This paper includes a summary of the process and its application to transportation. It considers cost-effectiveness, alternative programs, TOPICS, and accidents.

89. Leclerc, R. V. and T. R. Marshall, "A pavement condition rating system and its use," in Association of Asphalt Paving Technologist. Proceedings of conference held February 10-12, 1969, Los Angeles. Minneapolis: Association of Asphalt Paving Technologists, 1969, Vol. 38, pp. 280-295.

This study calls for a method of rating pavements that would provide accurate, uniform results. It involves a combined rating of ride quality and degree of structural distress in a particular section of pavement. Application of this rating system to Washington state's priority programming study calls for a critical rating level to be established for each class of highway. Through an analysis of pavement ages and present condition ratings, annual point loss rates are determined. Critical rating levels are established from these results.

90. Leclerc, R. V. and T. R. Marshall," Washington pavement rating system: Procedures and application," Improving Pavement and Bridge Deck Performance; proceedings of the Western Summer Meeting held August 17-19, 1970, Sacramento, California, under the sponsorship of the Highway Research Board and the California Division of Highways, Special Report 116, Washington, D.C.: Highway Research Board, 1971, pp. 112-121.

This paper presents a method of pavement evaluation utilizing a combined rating of ride quality and degree of structural distress observed for a particular section of pavement. For application to the priority programming system as used in Washington state for legislative budgeting of highway maintenance and construction, critical rating levels for the various classes of highways were developed along with predictive formulas estimating when any given roadway will reach this critical level. Application of this method to other geographic areas is also briefly discussed.

91. Lemer, A. C. and Fred Moavenzadeh, "The analysis of highway pavement systems," Theory of Pavement Design. Highway Research Record 337. Washington, D.C.: Highway Research Board, 1970, pp. 78-85.

The paper suggests that performance criteria may be described in terms of serviceability, reliability, and maintainability. Serviceability is the quality of providing satisfactory service to the user and is evaluated through applications of utility theory. Reliability is the probability that adequate serviceability will be maintained throughout the facility's design life; it may be predicted by use of a semi-Markov process approach. Maintainability is a measure of the effort required during a facility's life to maintain adequate serviceability. Methods for analysis are suggested and applied to existing data to show how the model may be used in practice to yield facilities having good performance characteristics.

92. Lin, Feng-Bor and Lester A. Hoel, "Structure of utility-based evaluation approaches," Transportation Engineering Journal of the ASCE, Vol. 103, No. TE 2, March 1977, pp. 307-320.

Existing utility-based transportation planning approaches are proven to be fallacious for providing information for decision-making. To provide a valid basis for further improvement of such approaches, an evaluation structure in the context of additive utilities is developed. Guidelines for the evaluation structure are provided and are illustrated with a multi-dimensional evaluation problem.

93. Lipinski, Martin E., "Evaluating multimodal transportation alternatives," Transportation Engineering Journal of the ASCE, Vol. 104, No. TE 3, May 1978, pp. 253-265.

A method for developing an evaluation methodology for multimodal intercity freight transportation in a specific corridor is presented. A sequential decision process is used in developing the evaluation framework. An interactive computer system to assist in the analysis of individual evaluations is presented.

94. Lockwood, Stephen L., "Transportation planning in a changing environment," Traffic Quarterly. Vol. 28, No. 4, October 1974, pp. 521-536.

The article discusses a new planning process which is sensitive to new problem definitions that can include changing community values and technology changes.

95. Lu, Danny Y. et al, Forecasting Serviceability Loss of Flexible Pavement, College Station, Texas: Texas Transportation Institute, Texas A&M University, November 1974 (NTIS No. PB 244 603).

The purpose of this project was to improve the reliability of the performance estimating method used in the Texas Highway Department for forecasting rehabilitation requirements for flexible pavements.

96. Lu, Weiming, "Thoroughfare planning and goal definition," Traffic Quarterly, Vol. 17, No. 2, April 1963, pp. 219-235.

The article discusses the importance of goal definition as related to the prediction of land use and travel patterns in a metropolitan area and how it affects the final transportation plan.

97. Mahoney, Joe P. et al, "Optimization of pavement rehabilitation and maintenance by use of integer programming," Maintenance, Decision Making and Energy Use, Roadside and Pavement Management, and Preferential Bridge Icing. Transportation Research Record 674, Washington, D.C.: Transportation Research Board, 1979, pp. 15-22.

An interger programming technique is used to develop a computer program (RAMS) which determines optimal maintenance strategies for pavements. The purpose of this paper is to describe how optimal maintenance solutions for highway segments are obtained using the RAMS program and to show the results of an actual problem with a group of highway segments located in Texas.

98. Mak, King K. and Paul S. Jones, "Priority analysis procedure for ranking highway improvement projects," Transportation Programming and Management. Transportation Research Record 585, Washington, D.C.: Transportation Research Board, 1976, p. 35-48.

This paper presents a priority analysis scheme for ranking highway improvement projects. The procedure is based on a scoring model approach that evaluates highway projects in terms of as many as 26 parameters that are divided into eight groups: need, deficiency, continuity, benefit-cost, local opinion, and economic, social and environmental consequences. For each project, the individual parameters are evaluated and combined through a set of weighting factors into one or two indexes that can then be used to rank the projects. The selection of a parameter and a set of weighting factors were determined from responses to questionnaires distributed to state transportation board members, departments of transportation officials, and regional and local planners within the state of Georgia. The improvement projects are categorized according to 10 functional classes and nine improvement types. The projects are ranked within each category.

99. Marye, Burton, "The establishment of priorities for highway improvement programs," in Highway Research Board, Proceeding of the 20th Annual Meeting, held December 3-6, 1940, Washington, D.C., Washington, D.C.: Highway Research Board, 1941, Vol. 20, pp. 115-120.

Methods of determining mathematical ratings to guide in the selection of priorities of improvements are given and their limitations discussed. Consideration is given to structural conditions, safety factors, traffic volume, etc.

100. McBride, G. A., "Policy matters in investment decision-making," Regional Studies, Vol. 4, No. 2, August 1970, pp. 241-253.

The importance of policy determination in investment decision-making is illustrated. A methodology for formulating investment plans is discussed using the Appalachian Development Highway System as an example. Multiple objectives are involved and treated in a benefit-cost framework. The report claims that outcomes depend largely on policy-maker's statement of objectives, interest rate, and economic life of the project.

101. Melinyshyn, Walter et al, "Transportation planning improvement priorities: Development of a methodology," Transportation Planning Improvement Priorities, Highway Research Record 458, Washington, D.C.: Highway Research Board, 1973, pp. 1-12.

The selection and timing of large-scale transportation investments should be undertaken by using a cost-effectiveness technique within a framework of clearly

stated objectives and assumptions. The priority planning methodology discussed in this paper identifies and assesses transportation improvement impacts on both transportation users and the community at large. Impacts, beneficial or not, are evaluated and used to develop time streams of present worth of benefits as functions of the year of implementation. The functional benefit and cost time streams are combined with future budget estimates and subjected to linear programming analysis. The linear program selects and stages a mix of transportation improvements that maximizes the total present worth of benefits capable of being realized, given the assumed budgets.

102. Millard, R. S. and N. W. Lister, "The assessment of maintenance needs for road pavements," Paper No. 7371 in Institution of Civil Engineers, Proceedings, Vol. 48, February 1971, pp. 223-244.

Apparatus and methods developed for routine evaluation of road pavement strength, riding quality, and resistance to skidding are described. They are intended for use in operating a rating system in which the condition of roads is measured quantitatively, so that maintenance programs can be defined objectively.

103. Miller, Edward, "Scheduling of highway improvements," Transportation Systems Planning Process, Highway Research Record 394, Washington, D.C.: Highway Research Board, 1972, pp. 11-18.

Although showing that benefits exceed costs indicates that a project should be constructed, it does not necessarily indicate that the optimum time for construction is now. Likewise, the highest priority projects are not necessarily those with the highest benefit-cost ratios or the highest internal rates of return. Instead, for most highway projects the optimum time of construction is when annual benefits minus maintenance costs first exceed the product of the discount rate and the capital cost of the project. If funds are not available to build all projects now, the projects to be built first should be selected in order of their priority ratio. In the simplest case the priority ratio is the first year benefits minus maintenance and operating costs, divided by the capital cost of the project.

104. Million, L. N. et al, Suggested Action Program for the Relief of Airfield Congestion at Selected Airports, Washington, D.C.: U.S. Federal Aviation Administration, April 1969, 213 p. (NTIS No. AD 689 107).

This report identifies and analyzes the possible improvements leading to reduced aircraft delays. The report is primarily concerned with construction projects which will enhance airport capacity. It also examines certain procedural improvements. Each improvement has been evaluated from a cost versus delay viewpoint.

105. Mobarak, Hamed and Adib Kanafani, "Use of value of time in project evaluation," Transportation Engineering Journal of the ASCE, Vol. 104, No. TE 2, March 1978, pp. 123-130.

A method of combining the technique of equilibrium traffic assignment and the analysis of value of time is proposed. The method is used to determine cost-effectiveness functions for proposed transportation facilities. The implications of different value of time on the levels of investment are examined.

106. Mongan, Thomas R. et al, "Measuring transportation system performance;" Transportation Engineering Journal of the ASCE, Vol. 101, No. TE 3, August 1975, pp. 437-454.

Quantitative measures of several aspects of urban transportation system performance which are difficult to incorporate in a benefit-cost analysis are presented. Two major types of evaluation methodologies are also presented. Problems of presenting evaluation data in an effective manner are considered.

107. Morris, Mark, "A sufficiency rating system for secondary roads," Highway Research News, No. 5, May 1963, pp. 43-60.

Emphasis is placed on the evaluation of physical characteristics of a highway and on the condition of various structural features. Significance of the service of the highway to the community is also examined.

108. Moskowitz, Karl, "Numerical ratings for highway sections as a basis for construction programs," Highway Planning, Bulletin 17, Washington, D.C.: Highway Research Board, 1948, pp. 28-39.

A method of assigning numerical ratings to highway sections, taking cognizance of structural adequacy, safeness, and service, as a basis for construction priorities is offered.

109. Mundt, Barry M., "Multiproject scheduling for transportation construction programs," Transportation Programming and Management, Transportation Research Record 585, Washington D.C.: Transportation Research Board, 1976, pp. 17-24.

Federal funding has a significant effect on the structuring of state transportation programs because of the controls on the use of such funds. The total amount of federal, state, and local funds available for transportation programs have not kept pace with the needs for new or upgraded transportation facilities. Thus, pressure is being placed on transportation program managers to maximize the use of available resources. The key to efficient use of resources--work force, money, and time--is control of production. Such control can be exercised by applying multi-project scheduling principles during the preconstruction and construction phases of a project. This paper discusses the elements and operation of a multi-project scheduling system that has been implemented successfully by three state departments of transportation. It points out how multiproject scheduling can be used to anticipate resource problems likely to occur in the future and to provide the basis for determining appropriate courses of corrective action.

110. Mundy, Ray A., "Mass transit guidelines versus a consumer orientation in public transportation systems," Transit Planning and Operations, Transportation Research Record 625, Washington, D.C.: Transportation Research Board, 1977, pp. 33-36.

This paper evaluates present and proposed mass transit guidelines that contain level-of-service criteria for public transportation. The rationale presented supports the need for expansion of these guidelines to include the total range of public transportation alternatives and a consumer orientation.

111. Nakamura, Vilma F. and Harold L. Michael, "Serviceability ratings of highway pavement," Pavement Condition Evaluation, Highway Research Record 40, Washington, D.C.: Highway Research Board, 1963, pp. 21-36.

This paper examines the question of how comfort and convenience can be measured for use as a parameter to determine optimum construction and maintenance programs.

112. Nash, Christopher et al, "Criteria for evaluating project evaluation techniques," American Institute of Planners Journal, Vol. 41, No. 2, March 1975, pp. 83-89.

This article stresses the underlying values implicit in any project evaluation technique. Value bases of conventional benefit-cost and matrix evaluation techniques are considered and their underlying similarity is noted. The article offers four criteria considered vital in choosing a suitable evaluation technique.

113. Nelson, LaVerne M., "A practical road improvement program," Public Works, Vol. 102, No. 9, September 1971, pp. 98-99, 134.

The sufficiency rating system for Del Norte, California is based on a 1000 point system. The study includes a listing of the costs of making the survey to gather needed data.

114. Neufville, Richard D. (de) and Yosuo Mori, "Optimal highway staging by dynamic programming," Transportation Engineering Journal of the ASCE, Vol. 96, No. TE 1, February 1970, pp. 11-24.

A procedure for defining an optimal sequence of highway improvements over time by the use of dynamic programming is described. Use of a variable increment, alternative oriented approach achieves computative efficiency.

115. Neumann, Lance et al, "Integrating system and project planning for effective statewide programming of investments," Travel Demand, Mode Choice and System Analysis, Transportation Research Record 499, Washington, D.C.: Transportation Research Board, 1974, pp. 83-93.

The paper argues that the traditional sequential view of system planning and programming must be revised in order for planning to be a more effective guide to program decisions.

116. New Mexico, State Highway Commission, Planning and Programming Division, Ratings for Highway Improvement, Santa Fe, New Mexico: 1971.

This report maintains that rating procedures have proven to be the most satisfactory, realistic, and factual means of evaluating highway need and programming improvements. As a basis for priority decision, the ratings should indicate the relative urgency of need and should define the conditions of critical defficiency. The items selected for appraisal are assigned points based on factors such as structural adequacy, safety, and capacity.

117. Northwestern University, Transportation Center, Development of Experimental Design Methodology for Evaluating Mass Transit Demonstrations: An Application to the Seattle Express Bus Service Demonstration, 2 volumes, Washington, D.C.: U.S. Urban Mass Transportation Administration, September 1972. (NTIS Nos. PB 235 509 (Vol. 1) and PB 235 510 (Vol. 2).

This report develops a systematic means of evaluation for determining not only the effectiveness of specific projects, but also the extent of its application to other areas of the country.

118. Oglesby, C. H., "Cost effectiveness as a measure for setting maintenance levels and priorities," Maintenance Management; Proceedings of a Workshop held July 22-24, 1968, Ohio State University, Columbus, Ohio, Special Report 100, Washington, D.C.: Highway Research Board, 1968, pp. 37-42.

This paper has attempted to take a preliminary look at how cost effectiveness can be applied to decisions about setting highway maintenance levels and priorities. It explores the forms that analyses used to measure cost effectiveness will take and the problems that will be encountered in carrying them through. It also examines the question of giving decisions regarding highway maintenance greater sensitivity to the wishes of the public. It suggests that cost effectiveness can be a valuable aid to decision-making.

119. O'Leary, Jeremiah D., "Evaluating the environmental impact of an urban expressway," Traffic Quarterly, Vol. 23, No. 3, July 1969, pp. 341-351.

To arrive at a solution to environmental impact disputes, it is necessary to first identify the facts involved in the controversy thereby enabling a faster and more accurate evaluation of the issues at hand.

120. Organisation for Economic Co-operation and Development, Road Research Group Maintenance of Rural Roads: Principles of a Road Maintenance Management System, Paris: Organisation for Economic Co-operation and Development, August 1973, 171 p.

This report outlines possible approaches for defining maintenance strategies. The data collection and analysis needed for this purpose are discussed. A system of standards for programming maintenance expenditures is developed, and a possible method for the choice of priorities are presented. In order to provide for the best utilization of available resources on the basis of road user needs, it is recommended that a total system of maintenance management be implemented without delay and that the choice of priorities be based on a coherent set of standards.

121. Pennsylvania Department of Transportation, Review of United States Railway Association Preliminary System Plan, Harrisburg: 1975, 141 leaves.

The report outlines a railroad system plan based primarily on financial viability and community impact. The analysis indicated that the Pennsylvania proposal would have higher revenues, lower costs, and larger net income than the USRA preliminary system plan proposal. The report also indicates how a rail trust fund could contribute to the financial betterment of reorganized railroads. The report contained a detailed analysis of branchline viability and a community impact analysis for each line designated by USRA as potentially excess. Because the Erie-Lackawanna R. R. entered reorganization early in 1975, the USRA issued a supplemental preliminary system plan report on Erie-Lackawanna lines in April, 1975. Thereupon PennDOT completed and submitted to USRA an additional in-depth report on these branch lines in late June.

122. Pennsylvania State Transportation Advisory Committee, Fiscal Review Task Force, New Directions for PennDOT, Harrisburg: April 1976, 20 p.

At the direction of the State Transportation Advisory Committee, an ad hoc Fiscal Review Task Force conducted a study of PennDOT's fiscal and operational policies with respect to the current financial dilemma and its impact on PennDOT efforts to effectively develop and maintain the state highway system. Recognizing the need for additional revenue and public acceptance of an increased level of highway financing, the task force recommended that the following priorities be applied to future funding: (1) preservation of the existing highway plant, (2) a capital program viewed as enhancing the maintenance function.

123. Peterson, Dale E., "A system for planning roadway improvement, "Improving Pavement and Bridge Deck Performance; Proceedings of the Western Summer Meeting: August 17-19, 1970, Sacramento, California, Special Report 116, Washington, D.C.: Highway Research Board, 1971, pp. 122-130.

A system for planning roadway improvements is being used to inventory and evaluate pavements throughout the state. The main elements affecting pavement performance are discussed. The present condition of each road section is evaluated according to each element. The system uses prediction equations to determine when improvements will be required, along with the type of improvement and amount of correction necessary for the roadway to maintain a satisfactory level of performance.

124. Pigman, J. G., Optimal highway safety improvement investments by dynamic programming, Research Report 398, Lexington: Division of Research, Bureau of Highways, Kentucky Department of Transportation, 1974, 48 p.

The objective of this study was to develop dynamic programming methods that will optimize annual priorities for highway safety improvement projects. The task of deciding which projects to implement under a given budget and which to defer until later is central to the management and planning of highway systems. Dynamic programming transforms a multistage decision problem into a series of one-stage decisions.

125. Positer, Theodore H. and Thomas D. Larson, "Administering state mass transportation programs in Pennsylvania," Management of Transportation and Environmental Review Functions. Transportation Research Record 603, Washington, D.C.: Transportation Research Board, 1976, pp. 1-7.

This paper presents the findings of a review of the transit related activities carried on by the Pennsylvania DOT, looking at both institutional arrangements and administrative processes. It points out a number of policy issues concerning the range of functional responsibilities, planning and programming processes, intermodal considerations, funding sources, and intergovernmental relations that may be facing other states in the development of transit programs.

126. Public Technology, Inc., Improving Transit System Performance: Proceeding of the First"National Conference on Transit Performance; held September 18-21, 1977, Norfolk, Virginia, under the sponsorship of the American Public Transit Association, and the Urban Consortium for Technology Initiatives. Washington, D.C.: U.S. Urban Mass Transportation Administration, January 1978, (NTIS no. PB 291 032/1SL).

The purpose of this conference was to improve the understanding of various ways to evaluate and improve transit operations. Discussed were the needs for better management of resources, since transit must compete with other public services for funds.

127. Purnell, J. Stanley, "Planning transportation facilities to guide urban development," Traffic Quarterly, Vol. 20, No. 2, April 1966, pp. 277-287.

This article discusses some alternatives for regional development patterns which can be guided by transportation planning.

128. Rao, Srikanth et al, "Future of highways--fiscal constraints," Transportation Engineering Journal of the ASCE, Vol. 103, No. TE 3, May 1977, pp. 385-398.

Highways face an uncertain future with respect to fiscal resources. New investment strategies are appropriate to this climate of austerity with emphasis on optimal allocation of scarce resources rather than on needs identification. A fiscal

planning process is described that facilitates program tradeoffs within various income scenarios. Application of the process in Pennsylvania is described.

129. Rayer, J. Paul, "Virginia's program of urban highway planning," Traffic Quarterly, Vol. 21, No. 2, April 1967, pp. 185-195.

This is a practical approach to provide plan updating within the realm of funds available based upon the cooperation of the local and state governments.

130. Read, Voorhees, and Associates, Ltd., Development of a Methodology for Planning Improvement Priorities, Phase 1 and 2; Summary Report, Downsview, Ontario: Ontario Ministry of Transportation and communications, August 1972, 52 p.

131. Reynolds, D. J., The Assessment of Priority for Road Improvements, London: Her Majesty's Stationery Office, 1960, 30 p. (Great Britain, Road Research Laboratory, Road Research Technical Paper, No. 48).

This paper describes the method, developed as part of the program of the Road Research Laboratory, for enabling highway authorities to assess the relative priority to give to alternate road improvement projects on the basis of their relative value to the community. The method involves estimating the monetary value of the net annual benefits arising from the improvement and comparing it with the capital cost of the improvement.

132. Rihani, Fuad et al, "Statewide transportation planning: The North Carolina experience," Management of Transportation and Environmental Review Functions, Transportation Research Record 603, Washington, D.C.: Transportation Research Board, 1976, pp. 42-48.

North Carolina's experience in statewide transportation planning is an attempt to deal with comprehensive multimodal transportation planning at the statewide level through the use of sketch-planning techniques. The characteristics and relationships of the social, economic, political, and environmental systems that affect the state are described and analyzed. Four projected futures for the state are identified with corresponding development patterns. All feasible modes of transportation are considered, and transportation requirements are defined for each projection. The elements common to all or most of these requirements are screened and formulated into low-risk, short-range (5-year) action programs, grouped into four major classes: capital improvements, operating, regulatory, and promotional programs. Similar classes are used to identify mid-range (10- to 15-year) conceptual programs. These, however, provide policy direction rather than deal with specific projects and are addressed to each of the different projections separately. The effort indicates that sketch-planning can be effective and economical as a planning approach. As a decision-making tool, it seems that more time and better reconciliation of conflicts in the public and private sectors are needed before it is fully useful.

133. Rothrock, C. A., "Urban congestion index principles," Urban Traffic Congestion, Bulletin 86, Washington, D.C.: Highway Research Board, 1954, pp. 26-39.

This paper examines the characteristics of congestion and proposes the use of a congestion index as a companion to the sufficiency rating system.

134. Rykken, Kermit B., "A rural highway congestion index and its application," Proceedings of the 29th Annual Meeting, held December 13-16, 1949, Washington, D.C., Washington D.C.: Highway Research Board, 1950, Vol. 29, pp. 367-374.

The paper describes a congestion index technique for rating a rural trunk highway system using data involving ADT, continuously restricted sight distance, geometric design features, and their relationship to accident rates.

135. Schimpeler, Charles C. et al, "Optimum staging of projects in a highway plan," Transportation Programming and Management, Transportation Research Record 585, Washington, D.C.: Transportation Research Board, 1976, pp. 25-34.

Many transportation studies recommend improvements for some future design year and stage construction of these improvements by five-year increments. Numerous methods have been used to stage recommended improvements, but only limited work has been done on developing procedures that optimize a special objective function for

priority selection. One previous approach to staging was to examine current capacity deficient corridors and the target year volumes on the proposed facilities. Priorities were then set so that the facilities needed to relieve existing congestion congestion were first, the facilities most heavily used in the future were next, and the less used future facilities were last. Another approach was to develop intermediate year travel forecasts from land-use or traffic assignment models for intermediate years. The staging determination was similar to the fuel system evaluation process except that the intermediate year alternatives considered were combinations of projects composing the design year plan.

136. Schulz, D. F. and P. C. Evenson, Transportation Improvement Program for the Kenosha, Milwaukee and Racine Urbanized Areas in the Southeastern Wisconsin Region, Waukesha, Wisconsin: Southeastern Wisconsin Regional Planning Commission, December 1978, 231 p.

Three approaches for preparing a Transportation Improvement Program (TIP) are examined. The first involves ratification by the MPO of programming decisions made by state and local transportation agencies. The second relies on collective judgement of a committee to choose projects for implementation. The third also utilizes such a forum, but provides the committee with a formalized decision-making structure whereby programming decisions are based on an expressed enunciation of priorities. Such a structure is presented in detail.

137. Shahin, Mohammed Y. et al, Development of an Installation Surfaced Area Maintenance and Repair Management System, Champaign, Illinois: U.S. Army Construction Engineering Research Laboratory, September 1975, 92 p. (NTIS no. AD A017 328).

A newly developed pavement maintenance and repair management system, designed to help maintenance personnel achieve the greatest benefit from funds expended, is described. Procedures for the following six basic activities are detailed: dividing the pavement network into sections; inspecting pavement sections; recording pavement information; determining maintenance and repair needs; determining maintenance priorities; and developing work plans. Although designed for paved systems, the system can be adapted for unpaved surfaces. Cards for recording pavement information are provided along with written forms and maps suggested for use in repair planning. Examples of the system usefulness are presented.

138. Shortreed, John H. and Richard F. Crowther, "Programming transport investment: a priority planning-procedure," Planning and Programming for Transportation, Transportation Research Record 574, Washington, D.C.: Transportation Research Board, 1976, pp. 48-57.

A priority programming procedure was developed and is being implemented by the Ontario Ministry of Transportation and Communications. The procedure initially deals with rural highway investment but can be extended to transit and urban areas. This paper shows how the linear programming formulation is a valuable extension of current methods of cost-benefit analysis. The basis of the extension is the explicit consideration of trade-offs concerning the time of investment for improvements. The method also provides for different interest rates for discounting benefits and costs. The paper describes the linear-programming formulation including the treatment of alternatives, regional budgets, and commitments. The paper also discusses the treatment of interrelated or joint benefits of improvements. Finally, the paper presents the calculation procedure for the key benefits: user time and vehicle operating cost. This procedure accounts for variations in hourly volumes over the year and uses existing information as input.

139. Smith, David G., A Methodology for Airport Investment Planning With Application to the Large Air Transportation Hubs of the United States, Ph.D. dissertation, University of Maryland, Ann Arbor, Michigan: University Microfilms International, 1976, (UMI order No. 77-26568).

Airport investments are a critical area of transportation planning where new and better methods are needed. This dissertation develops new methods of capacity planning and cost allocation for airport investment problems.

140. Spencer, James W., "An approach to planning and programming local road improvements based on a network wide assessment of economic consequences," Engineering Economy. Highway Research Record 224, Washington, D.C.: Highway Research Board, 1968, pp. 1-32.

This paper suggests that an optimum approach should be based on a network wide assessment of economic consequences, including consequences of the induced trips. The evolution of an optimum set of improvements is not presently feasible by this method but an approach is outlined by which alternative sets of improvements may be compared.

141. Spicher, Robert E., Perspective on Highway Programming, Washington, D.C.: Highway Users Federation for Safety and Mobility, 1970, 22 p.

This report provides a general discussion of the status of highway programming and considers the use of programming methods as basis for decision-making.

142. Stuart, Darwin G. and Warren D. Weber, "Accommodating multiple alternatives in transportation planning," Transportation System Evaluation Techniques, Transportation Research Record 639, Washington, D.C.: Transportation Research Board, 1977, pp. 7-13.

This paper examines several methodological improvements that enable a wider range of multimodal alternatives to be included in the transportation planning process. 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 judgemental assessment, as well as several areas for additional methodological improvement, is also discussed.

143. Swanson, Elwood B., "Priorities are key to advance road programming," Rural and Urban Roads, Vol. 2, No. 8, August 1964, pp. 22-24.

The article describes priority program in use in Hennepin County, Minnesota based on functional highway classifications, sufficiency rating cost, and available funds to arrive at priority and develop 3-year and 15-year plans.

144. Swanson, John A., "General comments on sufficiency-rating procedures," Highway Sufficiency Ratings, Bulletin 53, Washington, D.C.: Highway Research Board, 1952, pp. 7-10.

This paper sets forth a general summary of sufficiency rating procedures used in various states. Formulas are tailored to fit the conditions existing in a particular state.

145. Thiers, Gerald R. et al, "Developing priorities for street improvement program in urban areas," Planning and Evaluation of Transportation Systems. Highway Research Record 348, Washington, D.C.: Highway Research Board, 1971, pp. 109-118.

This paper describes the development and application of a rational method for evaluating alternative street-improvement programs in urban renewal areas. The methodology was developed in response to a need for a program of street reconstruction that would result in the assignment of priorities but would be based on a careful evaluation of all the relevant factors involved. A numerical rating of each street, curb, and sidewalk element is produced, which permits all components to be listed in order of importance. The rating that is obtained for each street section is compared to a desired level of improvement. The difference between actual and desired conditions is a numerical measure of the improvement that can be achieved. The value is weighted to reflect the relative importance of each street section, and priorities for improvements are established by determining the improvement-cost ratio for each street section.

146. Thomas, Edwin N. and Joseph L. Schofer, Strategies for the Evaluation of Alternative Transportation Plans, National Cooperative Highway Research Program, Report 96, Washington, D.C.: Highway Research Board, 1970, 111 p.

This project was intended to identify and evaluate the broad array of factors which should be considered in making an intelligent choice among alternate transportation plans. Application of cost-effectiveness analysis to transportation plan evaluation was prepared to demonstrate the use of evaluation methodology.

147. Tomazinis, Anthony R., Productivity, Efficiency, and Quality in Urban Transportation Systems, Lexington, Massachusetts: Lexington Books, 1975, 237 p.

The author suggests a new approach in urban transportation planning and a new type of urban transportation plan, based on studies of efficiency, productivity, and quality of service.

148. Transportation Research Board, Issues in Statewide Transportation Planning; Report of a conference held February 21-24, 1974, Williamsburg, Virginia, Special Report 146, Washington, D.C.: Transportation Research Board, 1974, 263p.

This report contains a summary of findings of the conference. Issues involved in and the reasons for statewide planning and programming were addressed. Focus was placed on the available methodologies that are useful for statewide transportation programming and the desirable characteristics of those methodologies. A strong consensus was reached about the research needs for the methodological improvements required to make the statewide transportation systems planning and programming process more effective.

149. Transportation Research Board, Priority Programming and Project Selection, National Cooperative Highway Research Program, Synthesis of Highway Practice 48, Washington, D.C.: Transportation Research Board, 1978, 31 p.

This report describes the state-of-the-art in priority programming. It includes a synthesis of definitions and elements, of how programming is managed, how decisions are made regarding why, when, where, and at what level improvements should be implemented, how decisions are modified, technical prioritizing and its effect on the allocation of natural resources, and how the allocation of resources affects priorities.

150. Transportation Research Board, Research Needs for Evaluating Urban Public Transportation; Proceedings of a Conference held April 3-5, 1974, Special Report 155, Washington, D.C.: Transportation Research Board, 1975, 123 p.

Fifty-seven (57) research project statements were developed by the six workshops at the Conference.

151. Transportation Research Board, Transportation Programming Process; Proceedings of a Conference held March 23-26, 1975, Orlando, Florida, Special Report 157, Washington, D.C.: 1975, 75 p.

Traditionally, programming has been accomplished independently for each mode of transportation and the processes in use have varied significantly among modes. Intermodal planning has recently received greater emphasis, challenging conventional programming techniques to be responsive to new requirements resulting from a broader more comprehensive approach to transportation planning. These proceedings have identified and discussed several key issues related to the programming process. The issues can be divided into six (6) areas: (1) programming should be based on goals and objectives and not on fund structures; (2) governmental roles in programming should be clearly delineated; (3) programming should continue to emphasize the trend toward decentralization of decision-making to the lowest feasible level of government; (4) fiscal philosophy for transportation programs is moving away from modal trust funding and categorical grants; (5) diverseness and disparateness are characteristics of the present time; and (6) there should be a continuum in the planning, programming, and selection process.

152. Twin Cities Area Metropolitan Transit Commission, Evaluation of Alternative Service Improvements; Interim Report No. 6; by ... and Simpson and Curtin Transportation Engineers, St. Paul, Minnesota: July 1969, (NTIS no. PB 195 843).

The effect of implementing various transit capital and operating strategies on network patronage, revenue, and operating cost is discussed along with projected results of a suggested alternative fare plan. Benefits and costs for alternative improvement packages are also examined.

153. Twin Cities Area Metropolitan Transit Commission and Alan M. Voorhees and Associates, Screening and Evaluation of Public Transit Vehicle Systems. St. Paul: February 1970, 158 p. (NTIS No. PB 195 808).

An important early thrust of the long-range study for transit in the Twin City area was the development of a series of transit evaluation criteria. The purpose of this report is to review the broad range of possible hardware systems and to select from among them those which appear to offer potential for solving the long-

range transit problem in the Twin City area. The transit evaluation criteria form the principal basis for both accomplishing this initial selection of possible systems and developing and selecting the recommended transit plan.

154. Tyson, W. J., "The role of evaluation indicators in transport planning," Transportation Planning and Technology, Vol. 4, No. 1, 1977, pp. 37-45.

This paper summarizes recent changes in responsibilities for transport planning in the United Kingdom and analyzes their implications for evaluation techniques. It is argued that evaluation of projects will be replaced by evaluation of policies. As a result, evaluation indicators which give a reliable guide to the overall ranking and performance of policies are needed. Characteristics which these indicators should possess are discussed and advantages and limitations of different evaluation methods for selecting indicators are analyzed. Since detailed benefit cost studies save severe limitations in this respect, a new approach--a corridor model--is described.

155. Underwood, William C., "Procedures for financial analysis of transit operating assistance grant requests," Urban Transportation Finance, Transportation Research Record 589, Washington, D.C.: Transportation Research Board, 1976, pp. 36-40.

The increasing reliance of transit operations on public financial support has caused funding agencies to begin to employ mechanisms for evaluating the operating expense performance of transit operators seeking financial assistance. One such mechanism involves the comparison of the aggregate expense estimates of individual properties with industry-wide performance. This paper reports on the development of such an evaluation framework designed for Pennsylvania by Peat, Marwick, Mitchell & Co. The evaluation technique is discussed, and specific administrative actions are illustrated in response to the operating expense performance of individual operators.

156. Wachs, Martin et al, "Integrating localized and systemwide objectives in transportation planning," Traffic Quarterly, Vol. 28, No. 2, April 1974, pp. 159-184.

Theories, methodologies, and evaluation criteria developed in urban transportation planning are reviewed. A process has been outlined that recognizes both the monetary criteria for evaluating transportation project alternatives and the individualistic values of particular communities of interest that would benefit by or be disadvantaged by transportation system changes.

157. Walton, Ned E. and Neilon Rowan, Warrants for Highway Lighting, National Cooperative Research Program Report 152, Washington, D.C.: Transp. Research Board, 1974, 117p.

The number of warranting conditions is used as the design criteria determinant and the basis for cost-effective priorities. A priority model is presented based on lighting effectiveness (the reduction of warranting conditions through the use of roadway lighting), vehicles or people served, lighting intensity, roadway mileage over which the people are served, and total annual lighting costs. The priority model favors those facilities with high warranting conditions that can be lighted most economically. It is concluded that the total design process is a rational approach through which current practices can be revised.

158. Wegmann, Frederick J. and Everett C. Carter, "The emerging statewide transportation planning process," Traffic Quarterly, Vol. 25, No. 3, July 1971, pp. 365-390.

This article emphasizes the need for the establishment of goals for long-term planning programs and the importance of the socio-economic role of transportation alternatives and new technology to increase the efficiency of the movement of people and goods.

159. Wigle, W. G., Highway Programming in Ontario, Downsview, Ontario, Canada: Program Office, Ontario Department of Highways, November 1969, 11 p.

Discussion of the problems of highway programming in Ontario. Includes inventory sheets of data taken to determine priorities. A new system to be implemented will assess the social and economic benefits.

160. Willey, William E., "Arizona experience with sufficiency ratings," Highway Sufficiency Ratings, Bulletin 53, Washington, D.C.: Highway Research Board, 1952, pp. 3-6.

Arizona was one of the first states to utilize sufficiency ratings on their highways. Their experience shows sufficiency to be a useful tool in determining highway priorities.

161. Willey, William E., "Priority programming for Arizona Highways," Traffic Quarterly, Vol. 26, No. 3., July 1972, pp. 425-434.

A rating system for highway sections competing for improvement funds is described in this paper. For each section of roadway, a score which is the combination of two ratings is developed. The first of these is a sufficiency rating system which assigns points to the physical condition of the roadway, its safety and the adequacy of service it provides. The second is a project rating of socio-economic factors whereby points are assigned for various such factors (environment, economic development, etc.). Sections are then compared on an equitable statewide basis in order to determine the most beneficial allocation of funds.

162. Wilson, David I. and Joseph L. Schofer, "A decision-maker defined cost-effectiveness framework for highway programming," Transportation System Analysis, Transportation Research Record 677, Washington, D.C.: Transportation Research Board, 1979, pp. 1-6.

This paper describes an effort on the part of the Chicago Area Transportation Study to develop a simple, linear weighting scheme for use in ranking Federal Aid Urban Systems highway projects for inclusion in the TIP for DuPage County, Illinois.

163. Winnitoy, W. E., "Rating flexible pavement surface condition," Design of Overlays and Pavement Rehabilitation, Highway Research Record 300, Washington, D.C.: Highway Research Board, 1969, pp. 16-26.

After a study of existing methods of rating or evaluating surface condition of flexible highway pavements, the Saskatchewan Department of Highways concluded that none were suitable for its requirements. Therefore a more applicable method was developed and put into routine use. Definitions for surface condition defects are given, the principles behind the rating method are discussed, and the procedures for using the rating form are outlined. In three years of use, the method has proven to be satisfactory for comparative condition studies and for providing quantitative bases for capital maintenance budgetary and action requirements.

164, Wisconsin Dept of Transportation, Division of Planning, A Long Range Priority Planning Study of Rural Arterial Highways in Wisconsin, Madison: 1971.

165. Wisconsin Dept. of Transportation, Division of Planning, Highway Improvement Priority Planning Analysis, 1972-1985, Madison: 1972.

Description of the development procedure for the priority plan, links which were or were not included, and improvement type codes. Some service volume charts.

166. Wolfe, Harry P., "Multi-year programming of airport grant funds," Paper presented at the 57th Annual Meeting of the Transportation Research Board, held January 1978, Washington, D.C., Phoenix: Transportation Planning Division, Arizona Department of Transportation, 1978.

167. Zakaria, Thabet, "Analysis of urban transportation criteria," Transportation Engineering Journal of the ASCE, Vol. 101, No. TE3, August 1975, pp. 521-536.

Describes various criteria that account for the quality of the transportation service, accessibility to various land-use opportunities, economic efficiency, system and traffic characteristics, community disruption, pollution of the environment, adaptability to changes in technology and travel behavior, and aesthetic quality of transportation facilities.

168. Yu, Juan C. and Richard C. Hawthorne, "Goal-programming approach to assessing urban transit systems," Planning and Programming for Transportation, Transportation Research Record 574, Washington, D.C.: Transportation Research Board, 1976, pp. 35-47.

This paper discusses the development of a procedure for using the goal-programming technique to evaluate urban transit systems for meeting transportation goals of a community. A set of sample community goals are assumed to illustrate how the technique is practical in actual application.

SOURCES OF PUBLICATIONS

Addresses below are for the corporate authors, issuing agencies, and commercial publishers from whom the publications listed in this circular may be obtained.

Only in-print publications of the Transportation Research Board are available from the Transportation Research Board. Out-of-print publications of the TRB (Bulletins 1-362, Records 1-399, and Special Reports 1-60) are available from the University Microfilms International.

American Association of State Highway and Transportation Officials, 444 North Capitol Street, Suite 225, Washington, D.C. 20001

American Association of State Highway Officials see American Association of State Highway and Transportation Officials

American Institute of Planners, see American Planning Association

American Planning Association, 1776 Massachusetts Avenue, NW, Washington, D.C. 20036

Arizona Department of Transportation, Transportation Planning Division, 206 S. 17th Street, Phoenix, Arizona 85007

Association of Asphalt Paving Technologists, 155 Experimental Engineering Building Minneapolis, MN 55455

Barton-Aschman Associates, see North Carolina Department of Transportation and Highway Safety

Civil Engineering, Morgan-Grampian Construction Press Ltd., 30 Calderwood Street, London, SE18 6QH England

Engineering, Design Council, 28 Haymarket, London SW 1Y 4SU England

Florida Department of Transportation, Office of Materials and Research, Haydon Burns Building, 605 Suwannee Street, Tallahassee, FL 32304

Her Majesty's Stationery Office, Atlantic House, Holborn Viaduct, London EC1P 1BN, England

High Speed Ground Transportation Journal, see Journal of Advanced Transportation

Highway Research Abstracts, see Transportation Research Board

Highway Research Board, see Transportation Research Board

Highway Users Federation for Safety and Mobility, 1776 Massachusetts Avenue, NW, Washington, D.C. 20036

Institute for Defense Analyses, Program Analysis Division, 400 Army-Navy Drive, Arlington, VA 22202

Institute of Policy Sciences and Public Affairs, Center for Policy Analysis Duke University, Box 4875 Duke Station, Durham, NC 27706

Institution of Civil Engineers, Thomas Telford, Ltd., Publications Division, 26-34 Old Street, London EC1V 9AD England

Journal of Advanced Transportation, Institute for Transportation, Inc., 1410 Duke University Road, Durham, NC 27705

Kentucky Department of Transportation, Bureau of Highways, Division of Research, State Office Building, Frankfort, KY 40601

Lexington Books, 125 Spring Street, Lexington, MA 02173

National Academy of Sciences, Publications Office, 2101 Constitution Avenue, NW, Washington, D.C. 20418

National Bureau of Standards, Office of Technical Publications, U.S. Department of Commerce, Washington, D.C. 20234

NTIS: National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161

New Mexico State Highway Department Planning and Programming Division, P.O. Box 1149, Santa Fe, NM 87503

North Carolina Department of Transportation and Highway Safety, P.O. Box 25201, Raleigh, NC 27611

Ontario Department of Highways Program Office, see Ontario Highway Transport Board

Ontario Highway Transport Board, 151 Bloor Street West, 10th Floor, Toronto, Ontario, Canada

Ontario Ministry of Transportation and Communications, 1201 Wilson Avenue, West Tower, Downsview, Ontario M3M 1J8 Canada

Organisation for Economic Co-Operation and Development, 2 rue André Pascal, 75775 Paris, France

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Public Technology, Inc., 1140 Connecticut Avenue, NW, Washington, D.C. 20036

Public Works, Public Works Journal Corporation, 200 S. Broad Street, Ridgewood, NJ 07451

Regional Studies, Pergamon Press, Maxwell House, Fairview Park, Elmsford, NY 10523

Rural and Urban Roads, Scranton Gillette Communications, Inc. 380 Northwest Highway, Des Plaines, IL 60016

Southeastern Wisconsin, Regional Planning Commission, 916 North East Avenue, P.O. Box 769, Wakesha, WI 53186

SRI International, 333 Ravenswood Avenue, Menlo Park, CA 94025

Stanford Research Institute, see SRI International

Texas A&M University, Texas Transportation Institute, College Station, TX 77843

Traffic Engineering and Control, Printerhall Limited, 29 Newman Street, London W1P 3PE England

Traffic Quarterly, Eno Foundation for Transportation, P.O. Box 55, Saugatuck Station, Westport, CT 06880

Transit Journal, American Public Transit Association, 1225 Connecticut Avenue, NW Washington, D.C. 20036

Transportation, Elsevier Scientific Publishing Co., P.O. Box 211, 1000 AE Amsterdam, The Netherlands

Transportation Engineering Journal of the ASCE, American Society of Civil Engineers 345 East 47th Street, New York, NY 10017

Transportation Journal, American Society of Traffic and Transportation, 547 West Jackson Boulevard, Chicago, IL 60606
Transportation Planning and Technology Gordon and Breach Science Publishers, Ltd. 42 William IV Street, London, W.C. 2, England
Transportation Science, Operations Research Society of America, 428 E. Preston Street, Baltimore, MD 21202
Transportation Research Board, Publications Office, 2101 Constitution Avenue, NW, Washington, D.C. 20418
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