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TECHNICAL WORKING PAPER

TASKS 8.5.1 and 8.5.2

EVALUATION AND ANALYSIS BY SUBAREA AND TOTAL SYSTEM OF BASIC SYSTEM CONCEPTS

Prepared for

Southern California Rapid Transit District
Study of Alternative Transit Corridors and Systems

May 1974

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INTRODUCTION

This technical memorandum describes two aspects of the evaluation work: (1) an overview of the consultant team process of evaluating the two basic alternatives developed in Task 8.1 and (2) the technical activities of Alan M. Voorhees & Associates (AMV) on specific elements of the system evaluation work. The evaluation work herein covers that analysis described as Tasks 8.5.1 and 8.5.2.

The end product of Task 8.5.1 is the definition of a final set of top-rated candidates for long-range systems and the primary data results produced for them on AMV's specific work elements.

The first part of the consultant team effort was concerned with the evaluation process to be applied, review of community comments on Phase II findings, and identification of route and system segments worthy of new analysis. This work contributed to the definition of basic system alternatives being developed in Task 8.1. The team effort then shifted to a comparison of Task 8.1 results, review of Task 8.2 and 8.3 results, searching for improved concepts in system segments and levels of service, and finally the definition of four top-rated candidate systems for final evaluation, as a basis for agreement in Task 8.5.2 upon a consultant team consensus recommendation for long-range system development.

AMV's work elements in Task 8.5.1 involved analyzing and evaluating patronage, revenue, and operating costs. These elements are involved in system and subsystem analysis generally and with traveler impact measurements needed specifically for the evaluation process.

The work in Task 8.5.2 emphasized consultant team integration of the information and conclusions developed throughout the study.

It is clear that there are advantages to developing major amounts of bus-on-freeway service with bus priority over other traffic. It is also clear that there are advantages to developing fixed-guideway rapid transit service. Results of Task 8.5.2 describe the way in which the consultants believe that these two express transit modes should be fitted together to meet long-range transit development goals. The process of analysis and evaluation that led the team to the conclusions of Task 8.5.2 has been guided by continuous attention to a number of concerns and issues facing the region. Some of those which we have been best able to articulate are the following:

Is a low-capital-cost system preferred in the long run over a high-capital cost system? If not in the long run, in the short-term, is a low-cost approach deserving of high-priority actions to defer the initial high-capital commitment or reduce the rate of spending for the high-cost system? If the answer is yes to the latter question, is an ultimate mixed system of low- and high-capital-cost facilities both technically and politically practical?

Can the use of existing freeways by buses provide the same high performance and passenger attractiveness as fixed guideway at low capital cost? Using freeways is one of the most apparent ways of using existing rights-of-way and avoiding high capital costs. It has appeared to date that the high performance which is provided by fixed-guideway rapid transit can only be provided in Los Angeles with costly underground construction in critical parts of the system. It is the high cost of guideway construction and right-of-way or tunneling which makes fixed-guideway "high cost" rather than "moderate cost." Similar questions are being asked about the performance and cost implications for greater priority use of streets by buses, the instituting of commuter rail service, and perhaps other low-cost measures.

Can general traffic and major new bus circulation needs be satisfied in major urban centers, especially the Los Angeles CBD and Wilshire, without grade-separated transit? If bus-on-freeway could be made equivalent in performance to fixed guideway, in general, it may not be feasible to bring all the buses from the freeways to the local streets for circulation and passenger distribution/collection without major transit construction in the larger urban centers. One possibility to examine, in lieu of construction, is the elimination or major reduction in the use of many streets--say, Wilshire on the Wilshire corridor--by autos and trucks in these centers.

How are local community transportation desires/needs to be met through the transit program? Jitneys, dial-a-bus, and conventional buses are one way to meet these desires; however, bicycle paths, better sidewalks, taxi subsidies for selected categories of citizens (e.g., the elderly) are examples of other ways to help. Satisfaction on this growing concern for more local mobility and less reliance on the auto may be essential to obtaining general concurrence with any large-scale regional transit program, as evidenced by recent public meetings and statements of city and other community officials. SCRTD is not legally responsible for all of these possible transportation actions nor has it had the funds to provide these costly transit services. Owing to limited funds, it has not been able to provide even conventional transit service in all of the communities that make up Los Angeles County. One approach to conceptual planning of local circulation transit services has been developed in Task 8.3 of this study.

How do we treat the energy crisis in evaluating transit policies and programs? The energy crisis and air quality problems will affect short-term actions and perhaps longer term actions as well.

Expert opinion is at odds as to the extent of the crisis in the near future and the duration of the crisis in general--some view it as serious for only a few years; others, as serious into the mid-1980's. There needs to be a transportation response to the immediate problems which are being created by the energy crisis. This response may be consistent with the control strategies of the Clean Air Act, or it may replace those strategies. In the long run, if the crisis persists, urban habits and lifestyles may have to change so much that the needs of the transit program could prove to be much different from those projected in current studies. An adaptable program appears desirable, but this does not necessarily imply avoidance of high-capital-cost projects and use of buses only. The sensitivity analysis of patronage projections that is Task 8.2 provides partial insights into the impact of air quality measures and the energy crisis on transit system decisions.

How much should we rely upon major institutional changes or altered public policies in evaluating transit options? For example, if transit could have all the priority it needed on freeways and streets, enormous short-run transit service improvement would likely result, and the high-capital cost of a rapid transit solution might well be reduced significantly. Other possible institutional, legislative, or local policy changes need to be identified which could have major consequences on long-range transit financing needs and transit performance. Transit planning to date has assumed continuation of conventional practices, but conditions may be changing rapidly. For example, up to now, planning has assumed that the relative cost for using an auto, using transit, and parking an auto would be unchanged (e.g., no increase in gasoline costs). Also, although there will be less highway construction in the future than previously planned, freeways are assumed by many planners to be operating in the future with only moderate congestion, even though capacity probably may not grow as rapidly as does demand.

If financial resources appear to limit the program, what are the consequences? In addition to considering the low-cost-system approach in its own right, there are two other solution approaches to consider. One is to take a contingency approach and design a program which is flexible regarding near-future decisions, with a low rate of expenditure in the initial years. The other is to reconsider just how "good" a new transit system ought to be provided. For example, "goodness" may be expressed in terms of the degree of traffic relief, increased mobility, or enhanced land developments that appears achievable. New transit will not eliminate freeway congestion, but will provide a degree of relief. How much relief is appropriate? Similarly, the degree of betterment of community mobility will relate generally to the level of community financial support; the degree of rationalization of development decisions will relate generally to the extent of the community commitment to transit, however "extent" is measured.

How important is it to refine the more specific system elements during Phase III? There is a large number of corridor, subarea, and community questions about the long-range development of facilities. The community meetings have produced an extensive inventory of questions and concerns; each was considered for Phase III response. However, while a number of these were addressed in Phase III, many more will have to be carried over to preliminary engineering and project implementation work. Several of the questions which are addressed in Phase III may be secondary to resolving many of the critical issues; they still must be addressed to a degree to maintain credibility with those who raised the questions originally.

How equitable will the program need to appear to each interest group to achieve general public support? Integration of short- and long-range projects and objectives, with emphasis on early service improvements, is clearly needed. However, beyond this objective there are a number of other matters. For example, to identify transportation deficiencies and to propose transit improvements to overcome them, using conventional planning approaches and objectives, will mean that different kinds of communities in the region may receive vastly different amounts of new transit service. That is, it may appear that some places need, and will use, new transit much more than will others, at least over the next decade or two under most assumptions. However, if it is decided that public policy is to create a region in which all the communities can rely much less on the automobile or to use new transit as a way to stimulate development much different from what has appeared likely, the result will be lesser geographic differences in proposed improvements. If everyone in the region is to support the program equally through, say, a sales tax, there may be pressure to move toward the latter view. At issue is how far, if at all, to move from the conventional planning approach.

How can public agencies and citizens be sufficiently informed and given more of a chance to exchange ideas? There is much more community awareness now of the need to act on transit than there was even a year ago. This new interest has evoked more concern as to the best way to respond to this need. There are many varied-interest questions which Phase I and II work seems to have generated, especially among the many newly interested persons and affected parties only now brought into the public policy debate. Basic questions of objectives, equity, community development and planning in general, which have been answered at least in part in years past, warrant renewed discussion. Can the ballot proposition discussion of the proposed transit program be conducted to provide for flexible commitments by the SCRTD, including contingency plans. Additionally, can it, at the same time, assure continuing equity between taxes and benefits and continuing dialogue between the public and the SCRTD adequate to protect the public interest as the program is implemented year by year?

Not all these issues are likely to be resolved by our technical work. Phase III has attempted to identify and describe, if not illuminate, any unresolved conflicts in terms that might permit the affected parties (citizens as well as local agencies) and the policymakers (local jurisdictions as well as SCRTD and SCAG) to reach a near-consensus, secure financial resources through ballot propositions, and accomplish other steps to implementation.

SUMMARY AND CONCLUSIONS REGARDING REGIONAL RAPID TRANSIT

The purpose of this technical analysis, upon which the consultant team has spent a major portion of its effort since last July, has been to review conclusions regarding the most appropriate system of regional rapid transit for Los Angeles.

Fixed-Guideway Rapid Transit

Despite the fact that high-capacity, exclusive right-of-way, trunk-line, or "fixed-guideway" rapid transit is expensive and time-consuming to develop, many large cities have found it to be the best option for improving public transportation. The recommendations of the consultant team last summer reaffirmed this conclusion for the Los Angeles area.

Fixed-guideway systems have high speed, high capacity, and high reliability and can be installed in the most dense areas--where the need is greatest--often by tunneling.

But Los Angeles is unusual. Its large population is extended over a larger area--with correspondingly lower average density--than a typical large city. These unique characteristics of the Los Angeles area make areawide application of fixed-guideway rapid transit especially expensive because of the extent of system required. Since the consultants' report last summer, this point has been made clear by many of the residents of Los Angeles as well as by officials of the Federal government--on which extensive fixed-guideway systems must depend for capital resources.

Yet there are several corridors in the region that connect dense concentrations of activity (both centers and strip developments) where fixed-guideway rapid transit is strongly recommended as the viable transportation improvement if sufficient capital resources can be generated for transit development. These corridors have been intensely studied, restudied, and given priorities over the years. The principal question that remains is, "At what rate can the extensive fixed-guideway system be built, in light of the continuing uncertainty regarding the availability of capital for development?"

One big cost component of fixed-guideway rapid transit is the construction of the guideway itself. This consists of the cost of right-of-way and structures, or the cost of tunneling. This cost factor leads inexorably to various approaches for placing rapid transit on existing rights-of-way, if not on existing structures as well. Among these concepts, bus rapid transit using existing freeways is emerging in the United States as a most cost-effective approach.

Bus Rapid Transit

If there is one element that makes the Los Angeles area unique, it is the vast network of freeways which dominates the existing transportation system. Consequently, the concept of bus rapid transit on existing freeways has greater potential here than perhaps anywhere else in the world.

Varying degrees of operating efficiency can be achieved with bus rapid transit, depending principally on the extent to which priority treatment is provided to increase the speed and ease of travel by bus. This concession can range from no priority (e.g., buses operating in mixed traffic on a metered freeway) to completely separate and exclusive bus lanes within the freeway right-of-way. The El Monte-Los Angeles busway, an example of the latter kind of bus rapid transit facility, has experienced a notable increase in usage since service began.

Between these extremes are many variations in priority treatment which allow buses and carpools to achieve higher operating speeds than low-occupancy vehicles, over which buses and carpools may receive preference in ramp entry or lane usage. Physical constraints on realization of any of these intermediate priority treatments are few; any of the intermediate priority treatments can be designed and implemented quickly. In fact, the California Department of Transportation has indicated it will undertake in Los Angeles experimentation with a variety of priority treatments to assess the relative attractiveness, safety, and community impact of each.

The consultant team has concluded that bus rapid transit, when appropriate, should be applied within the Los Angeles area for several reasons. If the region is to respond rapidly to the increasing level of urgency of rapid transit development, bus rapid transit is an appropriate response. It can be implemented in the near future and within the scope of foreseeable financial resources.

An "All-Bus" Rapid Transit System?

Large areas of Los Angeles lie too far from freeways for immediate-length trips to benefit from the kind of high-speed service which only a grade-separated facility such as a freeway can provide. Many of the areas exhibit high transit dependency rates. Regional mobility and accessibility for these areas would not be appreciably improved if an "all-bus" system were the goal of the region.

Some of these areas that are not, and cannot be, well served by bus rapid transit are also major concentrations of land activity, with a high density of population and employment. The regional core contains several of these activity concentrations. It is the planning policy of the City of Los Angeles, as well as the entire region, to increase accessibility to and among these areas of concentrated activity. In many of these areas, activity concentration is already so great that, even if buses could achieve much greater speeds on surface streets, the areas could not be penetrated by a high level of bus rapid transit service.

There are other unanswerable questions concerning high-volume priority bus operations; most notably, how the public may react to reserving lanes. Execution of high-volume transfers between bus rapid transit lines appears difficult. Furthermore, potential problems have been recognized in the development of high-bus capacity on surface streets.

In summary, the conclusion of the consultants' studies is that a bus rapid transit system, although deserving of a major role, will not suffice as an exclusive regional solution. The all-bus approach simply breaks down in many of the critical areas of the region where rapid transit needs are greatest.

"All Fixed Guideway"?

On the other hand, in order to fulfill anywhere near all the rapid transit requirements of the Los Angeles area, any fixed-guideway system would have to be developed over considerable time. Because fixed-guideway facilities are costly, lines must necessarily be widely spaced. But with such fixed-guideway spacing, large areas would also be poorly served for some years by rapid transit. These areas would include not only extensive residential developments, but also a number of significant outlying centers of activity.

Personal Rapid Transit (PRT) is one form of transit that has received considerable interest in Los Angeles and elsewhere. PRT is a radically different concept that could provide a high-quality form of transportation. While there are many versions of the concept, basically it involves providing nonstop or nearly nonstop service from a passenger's origin station to his destination station through the use of small vehicles operating on a fixed guideway. A network of guideways could be constructed, with stations spaced close to one another.

The engineering and environmental consultants conducted a careful review of PRT and some advanced versions of it designed for completely nonstop, single-party travel service. This review included independent studies and discussions with organizations that have undertaken substantial research and development.

The review confirmed that PRT, as conceptualized, would provide a highly attractive transportation service that offers the prospect of attracting large numbers of patrons. However, many problems were uncovered which could not be fully resolved.

The principal technical problem concerns the difficulty of handling large numbers of travelers in areas of dense activity such as in the regional core. It was concluded that substantial congestion would be caused on the guideways and in the stations, much as congestion is now experienced on downtown streets. Additionally, vehicles would have to be very closely spaced to achieve the required carrying capacity. Close spacing would require an advanced control system to solve a number of potentially serious safety problems. Such control systems are only in the concept stage at present.

Most PRT proposals suggest the use of elevated structures because of the need to separate the dense network from surface streets. Although careful design can minimize the adverse visual impact in many areas, it is believed that an intolerable situation would be created downtown, where one or two guideways would be needed on every block, along with closely spaced elevated stations. Psychological problems that might be faced by PRT riders have also been suggested, but not proven. In terms of economics, it is difficult to forecast the capital cost of the PRT systems, since none have been developed with the capability that appears to be required in the Los Angeles region. Almost all experts agree that a considerable amount of research and development will be required before the more desirable versions can be considered to be "on the shelf." As a result, limited use of PRT in Los Angeles is visualized as part of the first-stage system, and only in feeder and distribution, rather than line-haul service.

In all areas, fixed-guideway design and construction will take time--probably a longer time than any part of the region is willing to wait for significant rapid transit development. Most areas do now warrant and deserve at least the high level of service affordable by bus rapid transit.

A Balanced Rapid Transit System

Unfortunately, there is no simplistic answer to the transportation problems facing Los Angeles. After long and hard study, the consultant team has reached the conclusion that neither an "all-bus" nor an "all fixed-guideway" system is the solution to this area's needs for rapid transit. On the other hand, each of these basic approaches--where applied in a balanced manner--can provide greatly improved transit service for the region.

Therefore, the consultant team has concluded that the region should undertake a balanced rapid transit system development process. Such an approach will make the best utilization of both bus rapid transit and fixed-guideway rapid transit. The approach recommended here will provide the flexibility to maximize public transportation services

- immediately, by committing large amounts of resources and energy to near-term improvements including the introduction of bus priority rapid transit, and
- over time, since the fixed-guideway transit system corridors will be implemented using a flexible contingency approach which makes the most effective use of any available future flow of funds.

Because of the uncertainty concerning the available amount of Federal financial resources required to assist with the high-capital costs, the fixed-guideway elements on any balanced public transportation goal for the region must be discussed and planned for, using a building block approach based upon the corridor priorities of the region. The consultant team has developed an incremental approach by which SCRTD may implement a comprehensive improvement of public transportation in conjunction with continual development of a regional rapid transit system.

The first step is a transit improvement program incorporating immediate-action projects to satisfy many important local circulation needs and opportunities as well as to begin the process of developing a balanced rapid transit system. Together with the County of Los Angeles and individual cities, SCRTD has set up a continuing process for identifying and implementing near-term improvements as rapidly as financial resources can be obtained. It is anticipated that a majority of the projects in the latest inventory (described in the Task 8.7 Technical Working Paper) will be implemented, with buses in operation within the next three-year period.

Consideration by the consultants of the need for local circulation within communities has produced a document entitled <u>Conceptual Planning of Local Circulation and Feeder Transit Systems</u> (the Technical Report of Task 8.3). Rather than attempting to solve specific community problems, the document proposes one possible methodology for application at the local level throughout the District. It also served to direct consultant formulation of specific circulation and feeder components of our Phase III recommendations.

The second step recommended toward balanced rapid transit involves major surface and freeway bus improvements built upon the establishment of bus priority measures. The RTD Board has received a report from Wilbur Smith and Associates concerning implementation of priority measures for high-occupancy vehicles. Both Caltrans and the City of Los Angeles are proposing experimentation with various types of traffic priority measures on facilities within their jurisdictions. The extent to which bus priority operation is included in the first one-to-three years' transit improvements program depends upon the implementation of requisite traffic improvements by these agencies. Furthermore, SCRTD should continue expanding its bus fleet to capitalize on continuing expansion by Caltrans, the County, and the various municipalities of successful bus priority measures.

In this manner, bus priority should be fully exploited to further improve service levels and to build up patronage for intermediate-length trips (between five and ten miles) as the foundation of a balanced rapid transit system.

The high-capital-cost, fixed-guideway elements of the public transportation goal must be developed through the concept of incremental building blocks, which may be combined into various levels of system development to correspond to available levels of Federal financial assistance.

As an approach to matching system development levels and Federal assistance levels, the consultant team has developed a series of four "Rapid Transit Building Block" levels. Each level provides a complete picture of the level of system development achievable with a given level of Federal funding, including a continuing process for bus priority implementation and bus system expansion to fully exploit the potential of bus rapid transit.

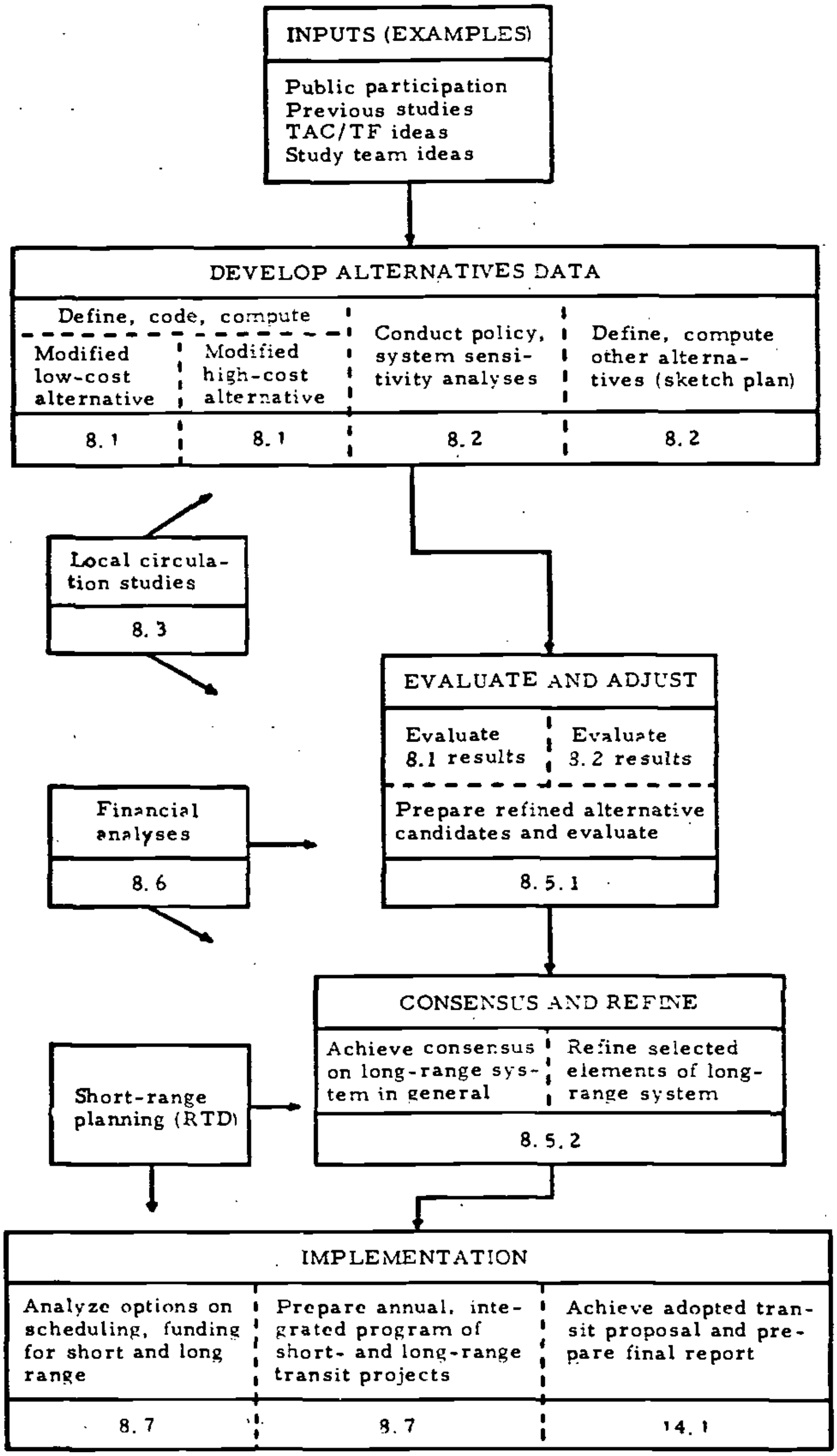
OVERVIEW OF THE PHASE III PROJECT METHODOLOGY

The basic flow of the primary work tasks of the Phase III Work Program is charted in general form in Figure 1. It can be noted that this project

Figure 1

PRIMARY WORK TASKS:
SIMPLIFIED FLOW

AMV



has relied heavily upon sensitivity and sketch plan techniques; it is, therefore, worthwhile to develop an understanding of this process.

In the transportation planning process, it is possible to analyze alternative transit and highway configurations either in very fine or coarse detail. Constraints on the level of detail are usually imposed by cost and time considerations since detailed analysis is both time consuming and expensive. Often, the transportation planner is faced with the choice of analyzing many alternatives at a coarse-grained scale or a few alternatives at a fine-grained scale. In recent years the issues in transportation planning have become increasingly complex, while the variety of possible alternatives has expanded at a rapid pace. Contemporary planning efforts are, therefore, more inclined to performance of systems analysis at coarser detail so that all important issues are addressed. Sketch planning is a relatively new process which allows the planner to perform coarse-grained analysis in a systematic and efficient manner. Acceptance of the notion that there is, in fact, a wide range of alternatives is essential to the whole design of the work to be accomplished.

The Major Steps

All previous studies have provided a foundation for development of the Phase III recommendations. Citizens' feedback from previous phases and Governmental agency reviews of these studies have constituted sources of community input. In addition, regular, frequent work sessions and coordination meetings were held jointly with the team and interested agency staffs to provide a continuous interflow of ideas and review. This is shown at the top of Figure 1.

The first major thrust of the work effort was concerned with developing procedures and tools for generation and evaluation of alternative concepts. One important tool was tabulation of those policies and strategies which could serve as system building blocks. During the study, the sensitivity of a number of individual policy matters and combinations of policies were assessed; those which produced significant, favorable impact were incorporated into the recommended plan. An evaluation process was developed to guide the generation of alternative plans and to provide a guage for impact assessment. Also developed were two detailed transit computer network concepts at a full 1300-zone scale. Detailed patronage estimates were produced from these two network concepts. One of these networks represents a relatively high-capital-cost system similar to the Phase II recommended plan. The Task 8.1 Technical Working Paper, 1990 Patronage, Revenue and Cost Estimates for Two Transit Concepts, documents the development and analysis of these networks. The networks provide standards around which and between which other alternative concepts, systems, and capital-cost programs were tested, using what is referred to as "sketch plan" techniques.

After these evaluation and analysis tools were developed, it was possible to hypothesize and quantify impacts of modifications to the two detailed "base" alternative systems. During this part of the study, many alternatives were generated and analyzed. Some alternatives were route location concepts; others related to specific technology concepts; still others focused on implementation strategies. These alternatives produce various concepts of line-haul, feeder, and circulation systems for sketch plan testing. Patronage, revenue, cost, and other impacts pertinent to the evaluation criteria were quantified and evaluated to determine many logical combinations of alternatives. This process of generating alternatives and testing them allowed systematic piecing together of different regional transit system plans, which resulted in input for review and selection of a recommended consensus plan. The piecing together of "good" system ideas is noted in the basic Work Plan as one of the last steps of Task 8.5.1--the development of "top-rated candidate" alternatives. The achieving of a consensus plan from among the top-rated candidates took place at the outset of Task 8.5.2 after a final evaluation process.

Evaluation

The most rigorous evaluation work in the overall Phase III project occurred at the end of Task 8.5.1. Evaluations were developed for each top-rated candidate plan, with impacts quantified or described in relation to the previously defined evaluation criteria. This evaluation process allowed the plans to be ranked in various ways.

The following section does not describe the entire evaluation process. Two facets of the Phase III work, which is different from Phase I/II and studies elsewhere in general, and which required different approaches to an effective evaluation of the various analysis results, are these:

- There is a wide divergence in many characteristics, and a major difference in weighing of criteria, between extremely low-capital-cost and high-capital-cost systems, and

- The sensitivity analysis and the sketch planning analysis of many alternatives produce information not previously available. For example, decisions on the preferred long-range system plan and, say, the first major development stage of that system depend greatly on (1) evaluation of the degree of probability of institutional flexibility and change (i. e., what portion of a freeway can be assigned to buses, priority use of a single lane, exclusive use of a lane, exclusive use of several lanes, many ramps, etc.); (2) prospects for Federal grants for constructing high-capital-cost facilities or establishment of major operating subsidy programs; and (3) impact of energy/gasoline shortages or air pollution control programs.

One further issue that had to be dealt with was that many of the alternatives to be compared did not easily lend themselves to conventional alternative comparison methods. In many cases, the consultant team was comparing policy/system options in which the significant differences are measured in terms of the degree of probability of obtaining Federal operating or capital costs, of institutional flexibility and change, of energy or air pollution crises, etc. The manner in which these issues were addressed by the team will be described on an individual basis as each issue is encountered in documenting the Phase III evaluation.

PHASE III EVALUATION PROCEDURES

Introduction

The purpose of this section is to describe the basic procedural framework utilized by the consultant team in evaluating alternative public transportation options. The procedure was developed around the recommendations of Gruen Associates prepared for SCAG.[1] A modification of the Gruen procedure was developed and applied last year to Phases I and II of the SCRTD Study.[2] Certain further modifications of the latter approach have been made; the most significant of these are

- Costs were separated from other factors, and tradeoffs between costs and impacts were emphasized.
- Rating of alternatives avoided numeric aspects, although some numerical scoring was useful in focusing team thinking.
- Use was not made of the four "affected groups" method to summarize results; summarizing by functional categories was slightly different from Phase I/II. Evaluation of individual criteria in each category by the arbitrary numerical approach of Phase I/II was replaced by individual rater's judgments (which have been documented).
- Individual criteria were revised (changed, deleted, added) based on study team experience in Phase I/II, citizen meetings, etc.

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[1] Gruen Associates, Transportation Plan Evaluation Process, prepared for Southern California Association of Governments, July 1973.

[2] Peat, Marwick, Mitchell & Co., "The Long-Term Transit Solution: Choices of Corridors, Modes, Route Extent, Alignments and Station Spacing," Chapter III, July 30, 1973.

The reason for using a systematic evaluation process was to assure rigorous consideration of a set of decision criteria. The results of such an analysis will then be useful for describing the rationale behind a certain decision. Systematic consideration of the criteria was most important because from it the decision must follow. As evaluators consider each criterion, patterns will usually emerge whereby certain alternatives are distinctly better than others. In some cases alternatives will not be distinctly different, in which case other decision criteria such as political expediency may become the deciding factors.

The evaluation of various criteria requires consideration of certain impinging factors, both quantifiable and qualitative. The consultant has attempted to document the manner in which these factors were weighed in arriving at the evaluation for each criterion. Hopefully, this will provide an explanation for all decisions so that review and revision by others will be facilitated.

It is also important to understand the basis for evaluating criteria. Many issues emerge during consideration of transportation improvement programs. For each of these issues the region must define goals toward which it desires to move. For the various goals objectives must be defined as more definite achievement targets. Only then can evaluation criteria be established to ascertain how well the objectives can be met by the various candidates. The evaluation, therefore, indicates how well the candidates respond to the issues of concern to the region.

Previous Evaluation Processes

The Gruen and Phase I programs differed slightly in certain respects. The Phase III program is based upon both of those programs, taking good aspects of each and adding or modifying where necessary. These changes do not, however, alter the intent of either previous program.

To describe the manner in which the Phase III program derives from and modifies those methodologies, pertinent important aspects of both programs will be discussed. This discussion will not be comprehensive since both proposals can be reviewed in readily available reports. The discussion will deal mainly with major program characteristics to be changed in order to point up variations.

The Gruen report[1] developed a general approach for evaluating transportation system alternatives. That program called for organizing individual evaluation criteria in major categories and summarizing results by category for presentation to various interest groups. The individual evaluations should be well documented to serve as backup for the group results.

The proposal also calls for initial technical evaluations by technical staff and consultants. These would be tentative (subject to revision), using information obtained in reviews with decisionmakers and lay groups. The program would be a continuously iterative process of reviews and revisions until a consensus is reached.

The Gruen program calls for ranking of possible alternatives according to how well they satisfy various criteria. Thus, the best plan is ranked first; the worst is ranked last. This approach does not permit reflecting nearly identical evaluations for two or more alternatives. It also suggests use of numerical ranking, which could be summed to obtain a grand score. Some means of avoiding these two situations is desirable.

The Gruen program proposed assigning different value systems to the criteria and then having the staff evaluate each value system. However, it would be quite difficult for an individual to objectively evaluate any

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[1] Gruen, op. cit.

value system other than his own. Also the extensive exposure and iteration proposed for the evaluation should effect the same results if external inputs are properly integrated into the analysis. It appears that proper care to reflect reactions expressed by external groups would better achieve the desired effects than use of alternative value systems, particularly if the base evaluation is executed by professionals from consultant staffs experienced in reactions from various community strata. Reactions must be documented, in much the same manner as public participation meetings are being documented.

The evaluation process developed in Phase I of the current study is built from the Gruen plan. More specific details and procedures are defined for use within the context of the Gruen procedure. Several important new considerations were proposed however. Considerations of the impact on four affected groups was suggested. This was an extension of alternative value systems proposed by Gruen. The groups considered were: travelers, community, transit operators, and government. These groups may well be affected differently, but probably not independently. It was stated in the report that impacts on government really were effects on other programs, which could be carried further to mean community and traveler impacts. Also, impact on the transit operator should probably not be separated from impact on the traveler and the community if the operator is a public agency.

The Phase I/II report also included evaluation criteria defined by members of the consultant team. These criteria were prepared for the major responsibility areas of the team: engineering, traveler, socioeconomic, environmental, and financial. Although not used as such, these groupings present an appropriate means of summarizing individual criteria in the manner suggested by the Gruen report. These five categories correspond with the three Gruen categories: Performance (benefit) criteria, Impact criteria, and Implementation criteria. It was therefore decided that the five categories used in Phase I/II be adopted to facilitate evaluation of the consultant disciplines involved.

The Phase I/II procedures called for scoring the alternatives according to their ranking. The scores were then manipulated mathematically to obtain a total score for each alternative. Although such an approach appears to make the decision effort easier, it has many inherent difficulties. The main problem has to do with importance or value ratings of individual criteria. Different people attach different levels of importance to various criteria. Any numerical sum of scores implies some importance valuation of individual criteria. That valuation may differ from those of decisionmakers or citizens. The Phase III evaluation indicates how each alternative compares with the others for a given criterion, but does not assign relative values to the criteria. The decisionmakers (or citizens) can weigh the individual criteria as they wish to reach their own decisions.

Cost Separation

The Phase I/II evaluation criteria have been modified to separate cost from other factors because of the extreme importance of cost in selecting a system. Because it is so important, cost might tend to overshadow all other criteria and therefore bias the evaluation. Most of the other criteria may be of approximately the same order of magnitude of importance, thus they can be treated simultaneously in the evaluation. Once that evaluation is complete, the significance of one system's evaluation with respect to others should be weighed to determine whether the marginal benefits are worth the extra cost (assuming the better system costs more). If not, the cost of the second-best system in the evaluation should be compared to that of the system next best to it to ascertain whether the marginal benefits justify the additional cost. This procedure implicitly amounts to tradeoff studies between costs and impacts and probably can be effectively used by decisionmakers and understood by the community in making tradeoffs.

Ranking Score

The score assignment should be modified to avoid numeric aspects of ranking. Such a modification would use graphic symbols where the size of symbols or, in some cases, bands, indicates the relative satisfaction of criteria. By using variable-size graphical presentation, numerical summing of scores is almost precluded--using different types of symbols probably still permits numerical scoring but makes it more difficult than using numbers.

The consultant team's numerical scoring approach may yet be the best way to represent the relative attractiveness of various alternatives. Use of numerical scores for team evaluations could be better controlled to preclude summing than for use in review and presentation. When using numeric scoring, the direct summing of individual scores has been avoided even at the team level. Decisions in all cases were based upon the sense of relative attractiveness developed by the rater during the process of individual evaluations. The numerical ratings by the team were translated to graphic display for review and presentation.

Group Evaluations

Evaluating alternatives from the viewpoint of four affected groups has been avoided. Impacts on the operator and government are really more properly considered as impacts on the community and travelers. In addition, certain criteria are directed principally at either the traveler or community, and so would be almost meaningless if directed at the other group. To attempt a complete evaluation for four separate impact groups therefore seems to unnecessarily complicate the process.

It should be emphasized that two subgroups are included in the traveler group. These are facility users and non-users. Transportation improvements affect each differently--directly or indirectly depending on the nature of improvements.

Category Summaries

Evaluations of the individual criteria can be summarized according to categories for presentation to decisionmakers and elsewhere. The major categories defined in the Gruen and Phase I programs can be rearranged according to the following stratification:

Gruen Categories	Phase III Categories	Phase I Categories
Performance	COST	Engineering
	ENGINEERING	
	HARDWARE	Traveler (System)
	USER	Traveler (Trip)
	NON-USER	
Impact	SOCIOECONOMIC	Socioeconomic
	ENVIRONMENTAL	Environmental
Implementation	FINANCIAL	Financial

(Individual criteria in each category have been prepared by consultant team members responsible for respective functional areas. These are revisions of criteria described in a Phase I technical memorandum.)

The evaluations for individual criteria were generalized (not summed) for their category by the raters, surmising the sense of relative acceptability of each system alternative. The resultant category evaluations and costs are being documented and presented to decisionmakers and the community. Individual criteria evaluations serve only to explain or back up the category results.

Corridor Analysis

The evaluations of line location alternatives were first conducted for individual line segments and then summarized systemwide. (The mode technology aspects were evaluated separately in Phase I.) The location alternatives in each corridor were compared separately. In some situations hardware implications required consideration of hardware/location combinations. Decisions regarding location were made for each corridor; these decisions were then considered and revised as necessary to yield a recommendation for the total system.

Individual Criteria

Provision was made in Phase III for revision of the individual criteria proposed for each of the functional areas in the Gruen and Phase I reports. Revisions included additions or changes in application. These modifications resulted primarily from observations in community meetings and application of the criteria in Phase II.

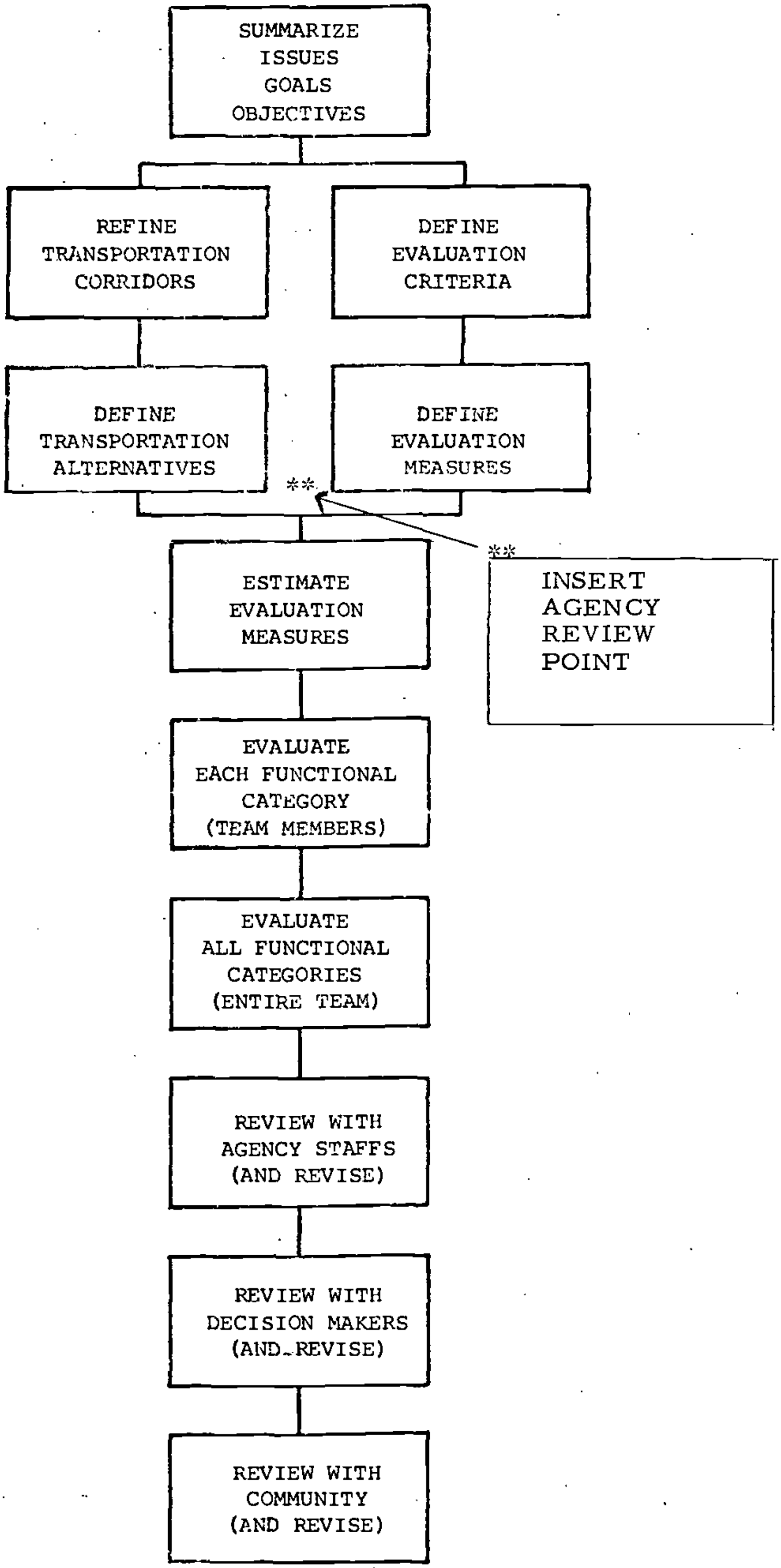
The Evaluation Process

The evaluation process is shown in Figure 2. The process was initiated with a definition of the issues to be considered and followed by a definition/redefinition of the objectives already a matter of record in current reports. Individual evaluation criteria were then redefined, based on the objectives.

There were two streams of evaluation work in Phase III: (1) comparing the low-capital-cost concept for the region with the high-capital-cost concept and (2) identifying a preferred element in each subarea or corridor.

Here is described only the subarea/corridor process. The first step was to define the corridors of interest and the alternatives to be evaluated within each corridor. While this process is normally straightforward, overlap problems did occur, especially when comparing express bus with fixed guideway. For example, one guideway location may serve parts of corridors served by two locations in a competing bus alternative. Where a fairly clear definition of corridors could not be resolved, corridor combinations were considered. Given the criteria and alternatives, the next step was to prepare materials required to evaluate each

Figure 2 EVALUATION PROCESS



criterion. This included cost estimates, patronage estimates, and impact studies. As part of defining the evaluation criteria, a means by which to measure or judge their satisfaction also had to be established. Various studies were then designed to concentrate on preparation of such measures. The cost and patronage estimates were the most obvious of such measures. Impact measures are generally more difficult to conceive and define but easier to prepare. Considerable effort was devoted to defining these details in the Gruen report. It is important that the criteria and appropriate measures be defined a priori to assure a meaningful, effective, and efficient analysis. In cases where neither cost nor other quantifiable measures could be defined, a qualitative, analytical procedure had to be defined to evaluate alternatives. Review of the criteria and the measures proposed in the Gruen report was performed by each consultant to assure sufficiency and applicability of the criteria and measures to the effort at hand.

Once all measures had been prepared, the consultant team members prepared displays which summarized measures of criteria in their respective functional areas.

All rationale during the evaluation process was documented both for reference in team review and for description and justification at later stages. This documentation is particularly important for nonquantifiable factors since judgment on them is most likely to be questioned.

The resultant category evaluations and cost-impact tradeoffs are now being presented to and discussed with technical advisory groups and the RTD board. Modifications based on judgment variations will most certainly occur, particularly those due to criteria weighing variations. Questions and suggestions will be reconsidered by the team to determine whether revision of individual evaluations would be appropriate. This entire evaluation process will continue iteratively, even after plan adoption, in the manner described in the Gruen report.

EXTENDING THE SEARCH FOR ALTERNATIVES

To obtain a broad range of community input and reaction to the consultants' Phase II preliminary recommendations, eighteen formal community meetings were held throughout the County between August 23 and October 29, 1973. In addition, several hundred direct contacts and presentations have been made in all municipalities within the District as well as to County, State, and Federal officials. Working papers prepared by the socioeconomic/environmental consultant will document the public's response to the preliminary plan at the community meetings and other presentations.

During those hearings, 925 responses were received from citizens and public officials. The communities' concerns as of last summer are shown below in five summary categories. The percentages shown indicate the percentage of the total 925 responses associated with each topic.

35% Stations, Alignments, Hardware, and Technology--New alignments, station location, alternative hardware, air-conditioned vehicles, etc.

29% Service and Safety--Questions concerning how the system would work, timing, feeder service, and safety.

15% Funding, Financial and Costs, and Benefits--How much the community will have to pay, for how long, and for what benefit; what funding alternatives there are, etc.

8% Environment--Visual aspects, secondary impacts of stations such as congestion and pollution, energy questions, etc.

13% Political/Public Participation--How the individual communities can be involved with plan refinement, jurisdictional questions, etc.

Moreover, the consultants held a continuing series of working sessions and both formal and informal reviews with agency members of the Technical Advisory Committee to critique the Phase II recommendations.

Each staff documented for the consultant team the conclusions of their appraisals and their own planning processes. The consultants responded to these community and technical reactions via new patronage studies of additional and relocated rapid transit lines, review of environmental and community factors, and reassessment of potential rights-of-way and associated capital costs.

The most significant effect resulting from this community and technical interaction was the extension of the search for alternatives to improve transit in the region. In parallel with the team's response, which was a refinement and modification of the Phase II recommendations, the evaluation acquired a renewed emphasis on low- and medium-cost system concepts. In order to focus toward the development of data to establish a new set of evaluations and to determine priorities for rapid transit implementation, the study team held general discussions which attempted to lay out a large number of conceptual options along the spectrum of possible alternative solutions. Through this exercise the consultants attempted to span a range of possibilities for transit system improvement. Approximately two dozen scenarios were discussed as reasonably different approaches to system development. Specifically intended to represent differing levels of service and cost (both capital and operating costs), the scenarios were considered either alternative end-states or incremental stages in the development of a system.

The kinds of approaches resultant from this search for alternatives included

- Improvement of existing SCRTD system
- All-bus system with priority measures for buses moderately successful
- All-bus system with priorities generally successful
- All-bus system with priorities extremely successful
- Limited commuter rail services with an all-bus system

- Limited fixed-guideway (10-40 miles) construction with an all-bus system
- Moderate amount of fixed-guideway (40-80 miles) construction with improved existing SCRTD system
- Moderate amount of fixed guideway with an all-bus system
- Large amount of fixed-guideway (80-120 miles) construction with improved existing SCRTD system
- Large amount of fixed guideway with an all-bus system supplementing
- Progressively larger amounts of fixed-guideway construction with an all-bus system supplementing
- Extensive fixed-guideway construction in most areas with small all-bus system supplementing

It was clear to the study team that to fairly assess the potential of this wide range of alternatives some common basis for analysis needed to be developed. The team decided to combine the most salient input from community/technical interactions with recent thinking about possible alternative solutions to form an extensive set of "segments" which could be assessed individually and conjointly. This collection of possible system components thus became a common denominator in study team evaluation. Each segment was assessed--evaluated in a general way--by the study team. This assessment resulted in evaluations at the category level by the consultant responsible for each functional area:

- Capital costs and engineering issues
- System usage potential
- Physical impacts
- Social impacts and planning policy

The assessments were progressively refined over the course of the study effort, especially during the testing phase when as many optional concepts as possible were considered.

Documentation of the segment evaluations takes the form of a file maintained by the study team. The file consists of the individual assessments plus the sensitivity ratings of the evaluation of each segment to changes in individual category assessments. The maps presented in the consultants' working papers reflect this voluminous file.

Development of Data Base

Recognition and initial assessment of the range of alternatives indicated that certain kinds of information would be necessary in order to select from among the alternatives. These needs for detailed information were used to define new systems for computer testing in Task 8.1.

The Simplified Representation of Alternatives (Figure 3) indicates one dimension for differentiation of possible approaches--capital cost (or investment). Operating cost and level of service are other dimensions. The approach proposed by the study team was to develop sufficient detailed information to responsibly evaluate optional concepts at any point along the spectrum of possibilities. The Phase II recommendation--built upon earlier computerized transit system testing--had already provided detailed information on a moderately-high-capital-cost approach. SCAG had nearly completed similar testing (network T2D) of the Phase II recommendation for about 120 miles of fixed guideway. The set of information thus developed might represent a "large amount of fixed-guideway construction with improved existing SCRTD system." As documented in the Task 8.1 Technical Working Paper, it was decided that a test was required of a somewhat "larger amount of fixed guideway together with a supplementing all-bus system." Hence, the study team prepared networks R2A and R2B--with about 150 miles of fixed guideway and an all-bus system supplementing--to represent a high-capital-cost system.

Also regarded as involving high capital costs was an all-bus system network prepared and analyzed in detail by SCAG and designated T1D

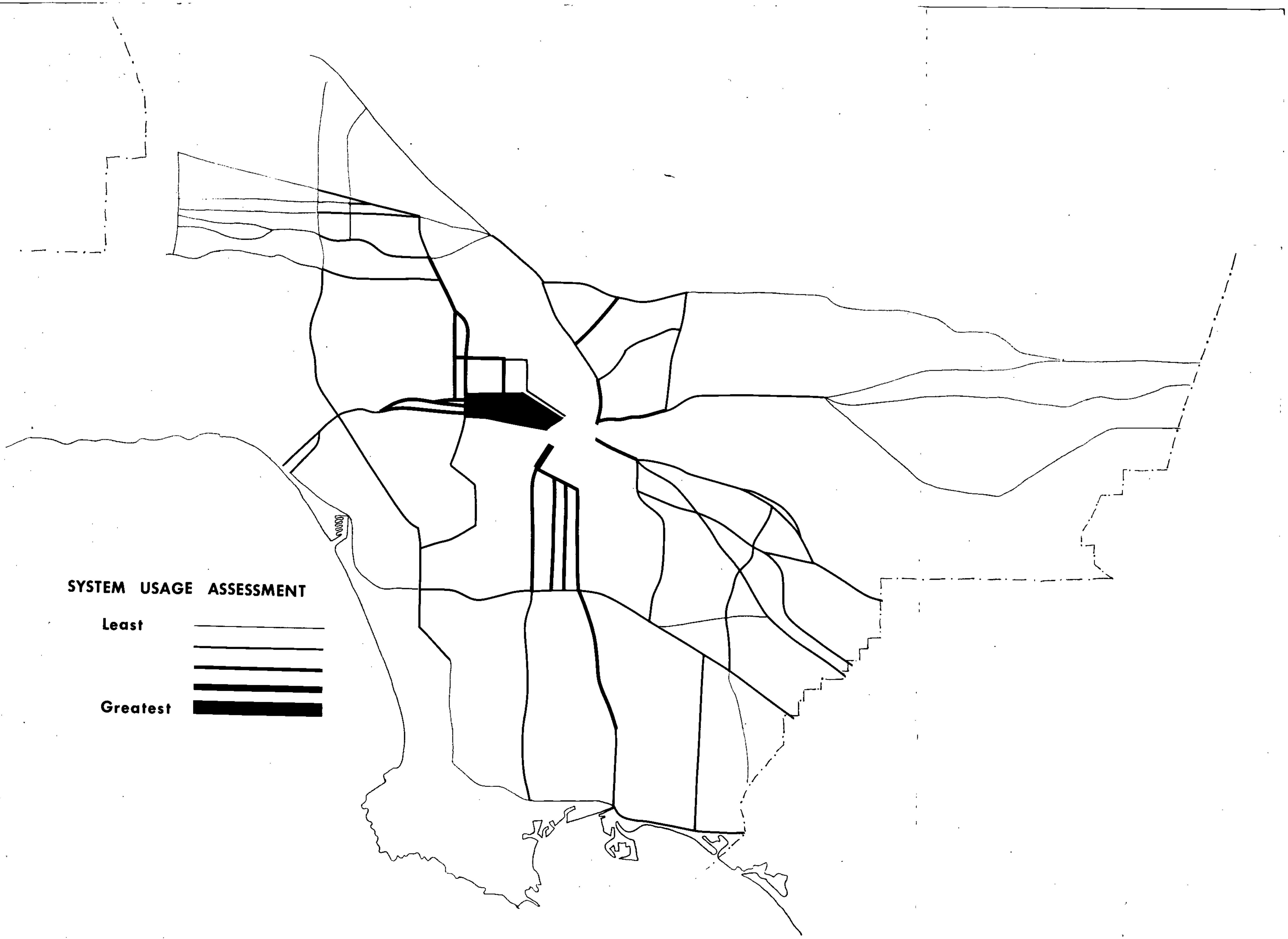
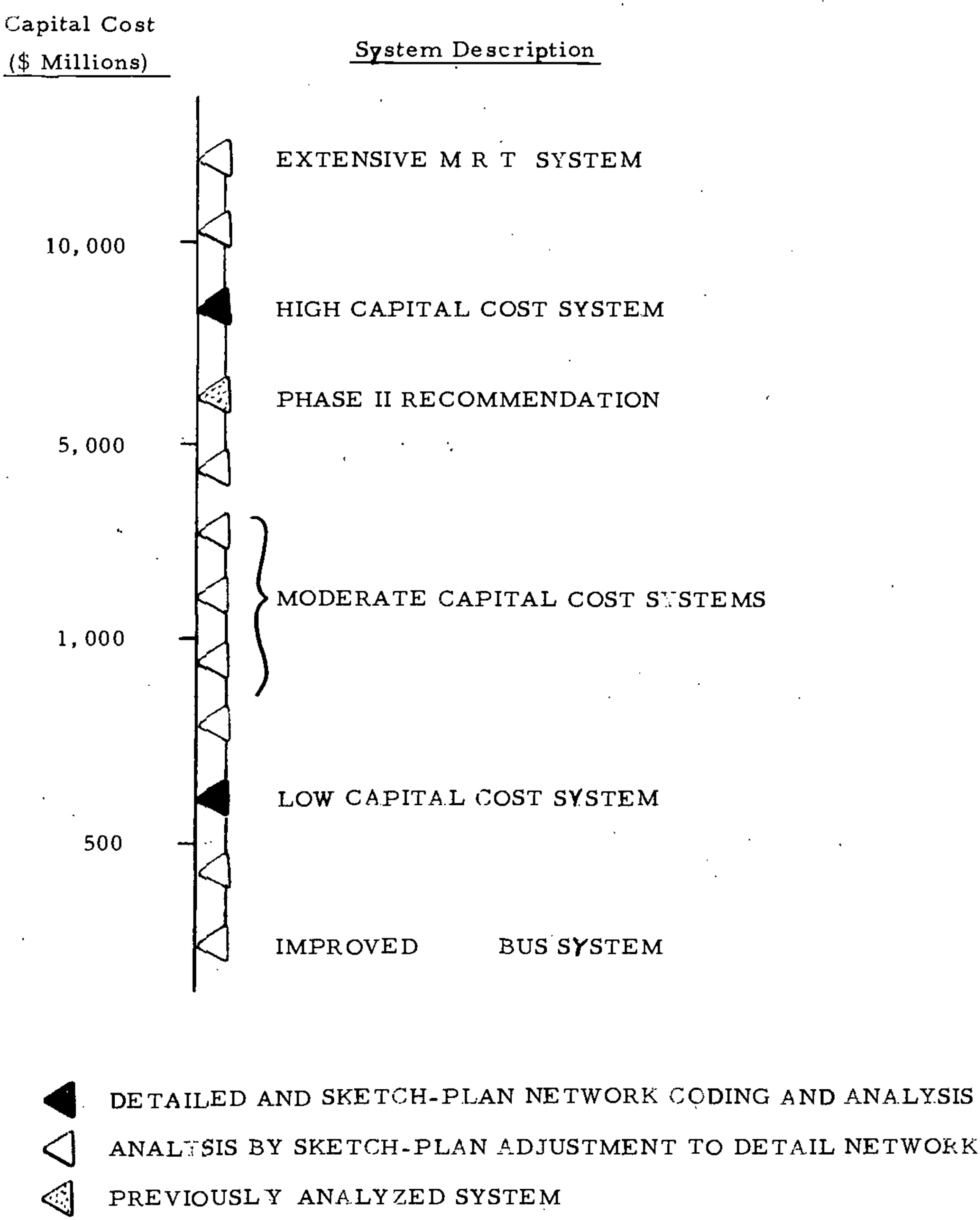

SYSTEM USAGE ASSESSMENT
Least
Greatest

FIGURE 3

SIMPLIFIED REPRESENTATION OF ALTERNATIVES



(see the Task 8.1 Technical Working Paper). This system might represent an "all-bus system with priorities extremely successful." To provide an information base for all-bus systems with priorities only moderately to generally successful, the study team prepared networks R1A and R1B--all-bus systems with maximum bus-on-freeway speeds of 55 mph and 40 mph, respectively. See the Task 8.1 Technical Working Paper for documentation of this network development. The R1 tests were intended to represent a low-capital-cost system; an all-bus approach, to represent a moderate-capital-cost system.

Combined bus and fixed-guideway approaches to moderate-capital-cost systems could be evaluated by adjusting and modifying through sketch plan analysis the results of detailed testing of a low-capital-cost system and the array of higher-capital-cost systems. System development concepts approaching an "extensive mass rapid transit system" could be evaluated by extrapolation of the results of the testing of high-capital-cost systems. Very-low-capital-cost approaches, such as an improved existing SCRTD system, could be assessed based on earlier LARTS transit system testing.

In this manner the study team assembled a set of detailed tests of optional concepts that either had been conducted or would be conducted within the study itself. The procedures used for conducting new tests are documented by AMV in the Task 8.1 Technical Working Paper. Also documented in that paper are parametric descriptions of the R1 and R2 system networks and the results of respective testing.

For comparative purposes, relevant information concerning transit system tests to date (performed by LARTS/SCAG or the study team) is given in Figure 4, Los Angeles Regional Transit System Tests.

Revenue Estimates

Estimates of revenue for each of the detailed-analysis systems was calculated by multiplying the transit trip table (zone-to-zone trips) by the

FIGURE 4. LOS ANGELES REGIONAL TRANSIT SYSTEM TESTS[1]

	Transit Network Used	Highway Network Used	Approximate Date of Test	SCAG Region Population (millions)	Total Person-Trips (millions)	Intra-zonal Person-Trips (millions)	LARTS Area Transit Trips (millions)	Express Trunk-Line Transit Trips (millions)
1967 Observations			1967 Survey	9.0	22.2	n/a[2]	0.49	None
Buses Only--Improved and Integrated	T1A	H2B/H3A	Aug 72	15.7	54.3	n/a	0.84	None
LARTS Seven-Corridor Rapid Transit	T2B	H3I	Apr 73	13.9	48.5	12.2	1.66	1.46
	T2B	H3I	Apr 73	15.7	54.3	n/a	1.82	n/a
SCAG Version of Phase II System	T2D	H3N	Nov 73	13.9	48.5	14.5	1.45	1.01
SCAG All-Bus System	T1D	H3N	Dec 73	13.9	48.5	14.5	1.84	1.30
AMV Low-Capital-Cost Systems	R1A	H3N	Jan 74	13.9	48.5	14.5	1.23	0.81
	R1B	H3N	Jan 74	13.9	48.5	14.5	1.20	0.76
AMV High-Capital-Cost Systems	R2A	H3N	Jan 74	13.9	48.5	14.5	1.32	0.61
	R2B	H3N	Jan 74	13.9	48.5	14.5	1.32	0.63

Notes: (1) These tests are discussed in detail in the Task 8.1 Technical Working Paper.
(2) n.a. = Data not available or not obtained by AMV.

zone-to-zone fare matrix. The fare was assessed based solely upon the corresponding highway distance between zonal pairs. Fare was calculated using the current SCRTD base amount (35¢) for an initial travel distance plus the current incremental fare (8¢) for a prescribed length of fare zone. The 1990 average daily revenue for each of the primary test systems is

Alternative System	Average Daily Revenue
R2A	$667,800
R2B	668,500
R1A	607,600
R1B	591,800

These estimates reflect patronage forecast assuming an auto operating cost of 5.76¢ per mile; see the Task 8.1 Technical Working Paper for forther discussion of this subject.

Tests were conducted under Task 8.1 to determine the impact of (1) a flat fare of 25¢ per trip and (2) increases in the base fare to 40¢ and the zone fare to 10¢. In the former test, 1990 ridership increased appreciably, but average daily revenue for R2A dropped to $371,500. With higher base and zone fares, decrease in ridership did not offset the increase in average daily revenue to $709,800 for R2A. The results of this one test seem to indicate that for travel on a high-quality rapid transit system SCRTD might be able to increase fares beyond the present base/zone rate with a net increase in operating revenue. Such an indication is significant in designing a program to meet operating expenses of any rapid transit system. Further discussion of patronage sensitivity to fares is included in the Task 8.2 Technical Working Paper.

Orange County Travel Generation

The test networks analyzed in Task 8.1 quite possibly may have resulted in underestimation of the amount of travel that might accrue to an SCRTD rapid transit system because of possible transit improvements in Orange County. The Orange County Transit District developed test networks of their own for the OCTD Corridor Study. These networks represented greatly expanded feeder and circulation transit services--including extensive demand-responsive service--in all areas of Orange County. OCTD also utilized a subregional modal choice model which forecasts transit usages in Orange County as a response developed over time to high-quality trunk-line, as well as local, transit.

OCTD designed test networks primarily for comparing alternative concepts for transit within Orange County and to connect Orange County with Los Angeles and Riverside Counties. Whether these tests are valid for other purposes (e.g., input to SCRTD tests) or as absolute estimates of usage given 1990 conditions remains to be investigated. For the sake of conservative estimating, the SCRTD and SCAG test networks have utilized (1) the LARTS regional modal choice model in all areas and (2) the network representation of local transit selected by the SCAG Systems Task Force. This approach may have understated the impact of possible OCTD services on SCRTD lines.

The study team has recognized the range of possible travel generation attributable to OCTD actions both in developing trunk-line profiles for system sizing purposes and in considering the importance of and possibilities for system staging.

Consideration of Special Generators

Another category of travel that is very probably underestimated in the network analysis includes trips attributable to "special generators" (or attractors)--those land uses for which LARTS is unable to forecast accurate travel demand on the basis of population/employment factors alone. This category includes colleges (student trips), airports (air traveler trips) and other transportation interface points, and entertainment/recreation facilities such as parks, beaches, stadiums, arenas, race tracks, amusement parks, tourist attractions, and cultural (music/theatre) centers.

To be compatible with the study's planning horizon and the basis of all other travel forecasts, one would need a projection of the relative usage and significance of these special generators/entities. Undoubtedly, there exists today a usable data base covering usage or attendance relative to many of these entities--there are several that are significant generators of traffic (mostly auto). However, there has been no substantive research conducted that might provide the basis by which to estimate the relative share of travel attributable to these facilities and for which purposes public transportation might accrue.

The study team has, however, attempted to include consideration of significant special generators in developing trunk-line profiles for system sizing. It must be remembered that many of these activities occur during off-peak times so that their contribution to the sizing of a transit system is negligible. Other activities are seasonal, or infrequently attract the average tripmaker. The question must be raised as to whether an objective is to design a transit system with the capacity to handle any and all irregular peak loads.

The study team has not factored special generators into the forecasting of operating revenue or considered them the basis for major system decisions.

OPERATING COST ANALYSIS

Operating and maintenance cost estimates were prepared by AMV for several preliminary and final alternatives to a complete local and rapid transit system. The results of the preliminary analyses contributed to defining a final top-rated set of candidates, from which resulted the definition of the consensus system recommendation.

Two methodology items are worth noting. First, in the Task 8.1 Technical Working Paper the basic approach to cost estimating as applied in Phase III was described. The point was made that a three-factor cost model was used in order to recognize the cost implications of the unusually high speed of freeway buses compared with the average fleet bus today. It was found that it costs less to operate a bus at a higher speed because a driver (a major cost element) can be more productive; i.e., more passengers can be served with the same amount of effort and time expended. Secondly, the basic cost estimates were subjected to additional analysis in which the values for selected operational factors were varied. Some of this sensitivity work was noted in the Task 8.1 Working Paper, where it was used to check the validity of the estimating method; however, additional calculations were made, and the results are described below.

The same genre of comment which AMV has made for its patronage work pertains to the operating cost estimates: (1) a systematic analytical approach was applied; the comparison among alternatives was sound; and the difference in operating costs between alternatives can be evaluated with confidence; and (2) the approach is based on approximations of future operating conditions. These applications are a sound guide to the probable 1990 operating costs, albeit a number of refinements can, and probably will, be made as system definition work proceeds to preliminary and design engineering and on to the development of actual operating plans and refined patronage estimates.

The most useful and reliable data resulting from these estimates are the total operating costs, cost per passenger, bus and rail fleet size, vehicle-miles of use per vehicle by type of service, and average bus operating cost per vehicle-mile by type of service. While the calculations for the express services were made on a trunk-line-by-trunk-line basis, the results for each line should not be used for analysis of alternative lines except in the most general way. For example, the total system results are sound, but individual lines have a number of assumptions pertinent to them that are related to how buses on lines interact, where peak-load points are located, etc.

Factors and Assumptions

All alternatives were analyzed using a standard set of assumptions as to levels of service, demand variations during the day, hours of operation, etc. Factors on express system speed and data on patronage for express, feeder, and local service were tailored to individual alternatives. For each alternative a base test was calculated by uniformly and consistently applying the factors and assumptions. In the preliminary alternative testing, variations of certain factors were also tested.

The major factors or assumptions and the values used for them in the base tests are

• Average number of equivalent weekdays per year	315 w/d - costs 300 w/d - revenue
• Vehicle speeds in peak	
Fixed guideway, typical	40 mph
Fixed guideway, short runs	35 mph
Bus on freeway	Varies by alternative
Busways	35 mph
Surface bus, typical	13 mph average
Feeder bus	13.5 mph daily average
• Passengers per vehicle in peak	
Fixed guideway, typical	120 passengers
Fixed guideway, short runs	150 passengers
Bus on freeway	36 passengers
Busway	36 passengers
Surface bus, typical	45 passengers
Feeder bus	45 passengers
• Spare vehicles over peak demand	
Fixed guideway	10 percent
Bus on freeway	12 percent
Busway	12 percent
All other buses	8 percent

- Passenger demands in peak hour (one-way as a percentage of daily two-way)

Express service, very long runs	16
Express service, long runs	15
Express service, medium runs	14
Express service, short runs	13
Surface bus, typical	14
Feeder bus	15

Results for Preliminary Test Systems

Estimates were made of base tests for T1D and T2D, and then for R1A, R1B, R2A, and R2B. A summary of the results for selected key items is provided in Figure 5, followed by the actual worksheets for each test system. The costs are given in 1973 dollars. Certain refinements in the operating cost estimates which were considered later in the final evaluation are not reflected in this preliminary analysis. For example, the costs of operating freeway bus priority measures, such as metered-ramp by-passes, and operating bus stations on the freeways, were not included.

The T1 and T2 data were of limited interest inasmuch as the alternative system concepts were of limited value; i.e., they were used only to better define the R1 and R2 concepts. The T1 concept would require, for example, about 7,900 buses with over one-half to be assigned to freeway operations--if, in fact, the concept had been possible to implement. The operation cost per passenger (excluding the major stations and transfer operating problems and costs) would not be out of line with the costs per passenger for other more realistic concepts--approximately 65¢ per passenger.

The R1 bus-on-freeway concepts, defined as R1A and R1B, developed per passenger costs similar to T1. R1A had operating speeds on the freeway similar to T1 and faster than R1B. The operating costs per passenger reflect this R1 concept difference. R1B is about 5 percent

FIGURE 5. 1990 OPERATING RESULTS FOR PRELIMINARY ALTERNATIVE CONCEPTS(1)

	Annual Cost ($ million)		Cost per Pass ($)		Number of Vehicles (including spares)	
Network	Total	Express(2)	Total	Express(2)	Total	Express(2)
T1D	358	187	0.65	0.48	7,909 (B)	4,224 (B)
T2D	242	120	0.56	0.40	882 (FG)	882 (FG)(3)
					3,404 (B)	471 (B)
R1A	243	119	0.66	0.49	5,291 (B)	2,702 (B)
R1B	224	107	0.68	0.54	5,044 (B)	2,615 (B)
R2A	223	101	0.56	0.48	735 (FG)	735 (FG)
					3,358 (B)	
R2B	232	98	0.59	0.52	728 (FG)	728 (FG)
					3,589 (B)	

Notes: (1) These are "base test" results, with comparable assumptions for all; costs are expressed in 1973 dollars.

(2) Express = fixed guideway, bus-on-freeway portion of trip, and busway; it does not include the feeder bus and non-freeway portion of bus-on-freeway services.

(3) FG = Fixed-guideway car; B = Bus

THIS IS THE R-16 BASE TEST
THIS IS NOT A VARIATION

CBD PRODUCTIONS = 270000.0
SUPPORT COST / CBD PRODUCTION = $ 0.20
SUPPORT VEHICLE SPARES = 0.08

PEAK ONE-WAY/24-HOUR TWO-WAY PASSENGER RATIO (SURFACE) = 0.14
PEAK ONE-WAY/24-HOUR TWO-WAY PASSENGER RATIO (FEEDER) = 0.15
PEAK 2-HR/24-HR VEHICLE MILE RATIO = 4.5
NUMBER OF TRUNK MODES = 3
OPERATING DAYS PER YEAR = 31[illegible].0
TOTAL DAILY TRANSIT PASSENGERS = 1100000.0
TOTAL DAILY FEEDER (TRANSIT) PASSENGERS = 33029б.0
TOTAL DAILY SURFACE (NON-TRUNK) PASSENGERS = 439408.0
FEEDER VEHICLE MILE GENERATION RATE PER FEEDER PASSENGER = 0.350
SURFACE VEHICLE MILE GENERATION RATE PER SURFACE PASSENGER = 0.400
AVERAGE DAILY SPEED PER FEEDER VEHICLE = 13.5
AVERAGE DAILY SPEED PER SURFACE VEHICLE = 13.0
SEATS PER NON-TRUNK VEHICLE = 45.0
NON-TRUNK VEHICLE PEAK LOAD FACTOR = 1.0
NON-TRUNK VEHICLE ANNUAL ADMINISTRATIVE COST = $ 12500.0
NON-TRUNK VEHICLE HOURLY CHARGE PER HOUR = $ 7.60
NON-TRUNK VEHICLE MAINTENANCE COST PER MILE = $ 0.19
PEAK HOUR TRIPS PER SURFACE VEHICLE = 1.00
PEAK HOUR TRIPS PER FEEDER VEHICLE = 1.25
REVENUE DAYS PER YEAR = 300.0

MODE	VEHICULAR SEATS	PEAK FACTOR	FRACT SPARE VEH	ADM COST PER VEH	COST PER VEH HR	COST PER VEH MILE	AVG DAILY SPEED	MODAL DESCRIPTION
1	60.0	0.9	0.12	13000.0	7.60	0.19	25.0	BUS ON FREEWAY
2	45.0	0.9	0.12	13000.0	7.60	0.19	35.0	BUS ON BUSWAY
3	60.0	0.9	0.12	13000.0	7.60	0.19	37.0	FREEWAY BUS ON BUSWAY (VEHS INC IN MODE 1)

LINE	24-HR MAX LD PT VOLUME	PK-HR PK-DIR VOLUME	PK-HR VEHS AT MAX LD PT	PK-2HR VEHICLE MILES	DAILY VEHICLE MILES	ROUND TRIP TIME	VEHICLES REQUIRED + SPARES	MODE TYPE	LINE LENGTH	NET PK LINE SPEED	LINE PEAK O-W/24-HR PASS RATIO	TOTAL OP COST PER DAY
1A	25740.0	3348.2	93.0	3253.2	14639.6	50.0	86.8	1	10.0	24.0	0.13	$ 10947.7
1B	26160.0	3225.6	89.6	4390.4	19755.8	70.0	117.1	1	14.0	24.0	0.16	$ 14641.9
2A	29530.0	3825.9	106.3	4835.5	21759.8	65.0	124.9	1	13.0	24.0	0.13	$ 16346.6
2B	19530.0	3124.8	86.8	6076.0	27342.0	92.3	149.5	1	20.0	26.0	0.16	$ 19359.7
3A	31550.0	5112.0	142.0	5964.0	26838.0	60.0	159.0	1	12.0	24.0	0.15	$ 20161.4
3B	12780.0	2044.8	56.8	7952.0	35784.0	184.6	195.7	1	40.0	26.0	0.16	$ 25337.1
4A	4540.0	596.7	16.6	667.1	3002.1	57.5	17.9	1	11.5	24.0	0.13	$ 2255.3
4B	1080.0	172.8	4.8	420.0	1890.0	115.4	10.3	1	25.0	26.0	0.16	$ 1335.2
5A	20940.0	2714.4	75.4	3430.7	15438.1	44.6	62.7	2	13.0	35.0	0.13	$ 8874.5
5B	8370.0	1339.2	37.2	1822.8	8202.6	64.6	44.9	1	14.0	26.0	0.16	$ 5807.9
5C	17190.6	2234.7	62.1	2824.6	12709.9	42.2	48.9	3	13.0	37.0	0.13	$ 7041.6
6	37520.0	4880.8	135.6	4517.0	20326.5	47.5	120.5	1	9.5	24.0	0.13	$ 15269.9
7A	5760.0	748.8	20.8	327.6	1474.2	22.5	6.7	1	4.5	24.0	0.13	$ 1107.5
7B	9900.0	1584.0	44.0	2772.0	12474.0	83.1	68.2	1	18.0	26.0	0.16	$ 8832.3
8A	32760.0	4258.8	118.3	4968.6	22358.7	60.0	132.5	1	12.0	24.0	0.13	$ 16796.5
8B	15660.0	2505.6	69.6	5724.6	25760.7	108.5	140.9	1	23.5	26.0	0.16	$ 18240.0
8C	14560.0	1872.0	52.0	546.0	2457.0	15.0	14.6	1	3.0	24.0	0.13	$ 1845.8
9A	19260.0	3081.6	85.6	6291.6	28312.2	96.9	154.9	1	21.0	26.0	0.16	$ 20046.6
9B	7650.0	1224.0	34.0	3927.0	17671.5	152.3	96.7	1	33.0	26.0	0.16	$ 12512.4
10A	1710.0	273.6	7.6	505.4	2274.3	87.7	12.4	1	19.0	26.0	0.16	$ 1610.3
10B	19410.0	5003.[illegible]	83.6	8132.5	36597.6	129.2	201.7	1	28.0	26.0	0.16	$ 26104.3
11A	4140.0	662.4	18.4	644.0	2898.0	46.2	15.9	1	10.0	26.0	0.16	$ 2051.9
11B	9720.0	1555.2	43.2	3780.0	17010.0	115.4	93.0	1	25.0	26.0	0.16	$ 12044.0
12	15300.0	2448.0	68.0	4046.0	18207.0	76.5	99.6	1	17.0	26.0	0.16	$ 12891.6
13	7020.0	1123.2	31.2	2839.2	12776.4	120.0	69.9	1	26.0	26.0	0.16	$ 9046.4
14	4500.0	720.0	20.0	770.0	3465.0	50.8	19.0	1	11.0	26.0	0.16	$ 2453.4
15A	8550.0	1368.0	38.0	2194.5	9875.3	76.2	54.0	1	16.5	26.0	0.16	$ 6992.2
15B	11340.0	1814.4	50.4	1058.4	4762.8	27.7	26.1	1	6.0	26.0	0.16	$ 3372.3
15C	10710.0	1713.6	47.6	5914.3	26614.3	163.8	145.6	1	35.5	26.0	0.16	$ 16844.5
16	19170.0	3067.2	85.2	3220.6	14492.5	54.0	85.9	1	10.8	24.0	0.16	$ 10867.2
17	900.0	144.0	4.0	266.0	1197.0	87.7	6.5	1	19.0	26.0	0.16	$ 847.5
18	1350.0	216.0	6.0	700.0	3150.0	115.4	17.2	1	25.0	26.0	0.16	$ 2230.4
19	[illegible]	1170.0	32.5	341.3	1535.6	15.0	9.1	1	3.0	24.0	0.13	$ 1153.6

MODE	DAILY VEHICLE MILES	ANNUAL VEHICLE MILES	TOTAL VEHICLES REQUIRED	TOTAL ADMINIST COSTS	TOTAL HOURLY COSTS	TOTAL VEHICLE MILE COSTS
1	[illegible]	[illegible]	2502.9	[illegible]	[illegible]	20943696.0
2	[illegible]	[illegible]	62.7	515526.2	1055968.0	923972.6
3	[illegible]	[illegible]	43.9	636110.9	822361.5	760684.8

LINE-HAUL TRUNK SYSTEM ANNUAL OPERATING COST = $[illegible]
(NOTE: EXTRA COST OF TRUNK LINE VEHICLES DUE TO HIGH VEHICLE MILEAGE NOT INCLUDED)

SURFACE BUS ESTIMATES -- (ALL NON-TRUNK, NON-FEEDER, NON-CAD DISTRIBUTION)

DAILY SURFACE VEHICLE MILES = [illegible]
DAILY SURFACE VEHICLE HOURS = 13520.2
SURFACE VEHICLES REQUIRED = 1476.4
SURFACE MAINTENANCE OPERATING COST = $ 10519424.0
SURFACE HOURLY OPERATING COST = $ [illegible]
SURFACE ADMINISTRATIVE COST = $ 18455120.0
SURFACE SYSTEM OPERATING COST = $ [illegible]

FEEDER BUS ESTIMATES

DAILY FEEDER VEHICLE MILES = [illegible]
DAILY FEEDER VEHICLE HOURS = [illegible]
FEEDER VEHICLES REQUIRED = [illegible]
FEEDER MAINTENANCE OPERATING COST = $ [illegible]
FEEDER HOURLY OPERATING COST = $ [illegible]
FEEDER ADMINISTRATIVE COST = $ [illegible]
FEEDER SYSTEM OPERATING COST = $ [illegible]

CAD TRUNK LINE DISTRIBUTION COST = $ [illegible]

GRAND ANNUAL OPERATING COST = $ [illegible]
OPERATING COST PER PASSENGER = $ [illegible]

MODE	PASS PER VEH MILE	COST PER PASSENGER	AVERAGE SPEED	MAINT COST PER MILE	HOURLY COST PER MILE	ADMIN COSTS PER MILE	TOTAL COST PER MILE	VEHICLE MILES	VEH MILES PER VEH
TRUNK	[illegible]	[illegible]	25.46	0.190	0.299	0.228	0.716	149096672.0	57027.1
SURFACE	[illegible]	[illegible]	13.06	0.190	0.585	0.333	1.108	55365392.0	37500.0
FEEDER	[illegible]	[illegible]	13.50	0.190	0.563	0.327	1.075	36415120.0	36281.3
SYSTEM	1.44	[illegible]	[illegible]	0.190	0.404	0.267	0.932	240877184.0	47772.7

THIS IS THE R-1A BASE TEST
THIS IS NOT A VARIATION

CBD PRODUCTIONS = 274740.0
SUPPORT COST / CBD PRODUCTION = $ 0.20
SUPPORT VEHICLE SPARES = 0.08

PEAK ONE-WAY/24-HOUR TWO-WAY PASSENGER RATIO (SURFACE) = 0.14
PEAK ONE-WAY/24-HOUR TWO-WAY PASSENGER RATIO (FEEDER) = 0.15
PEAK 2-HR/24-HR VEHICLE MILE RATIO = 4.5
NUMBER OF TRUNK MODES = 3
OPERATING DAYS PER YEAR = 315.0
TOTAL DAILY TRANSIT PASSENGERS = 1231749.0
TOTAL DAILY FEEDER TRANSIT PASSENGERS = 403793.0
TOTAL DAILY SURFACE (NON-TRUNK) PASSENGERS = 424162.0
FEEDER VEHICLE MILE GENERATION RATE PER FEEDER PASSENGER = 0.350
SURFACE VEHICLE MILE GENERATION RATE PER SURFACE PASSENGER = 0.400
AVERAGE DAILY SPEED PER FEEDER VEHICLE = 13.5
AVERAGE DAILY SPEED PER SURFACE VEHICLE = 13.0
SEATS PER NON-TRUNK VEHICLE = 45.0
NON-TRUNK VEHICLE PEAK LOAD FACTOR = 1.0
NON-TRUNK VEHICLE ANNUAL ADMINISTRATIVE COST = $ 12500.0
NON-TRUNK VEHICLE HOURLY CHARGE PER HOUR = $ 7.60
NON-TRUNK VEHICLE MAINTENANCE COST PER MILE = $ 0.19
PEAK HOUR TRIPS PER SURFACE VEHICLE = 1.00
PEAK HOUR TRIPS PER FEEDER VEHICLE = 1.25
REVENUE DAYS PER YEAR = 300.0

MODE	VEHICULAR SEATS	PEAK FACTOR	FRACT SPARE VEH	ADM COST PER VEH	COST PER VEH HR	COST PER VEH MILE	AVG DAILY SPEED	MODAL DESCRIPTION
1	40.0	0.9	0.12	13000.0	7.60	0.19	32.0	BUS ON FREEWAY
2	45.0	0.8	0.12	13000.0	7.60	0.19	35.0	BUS ON BUSWAY
3	40.0	0.9	0.12	13000.0	7.60	0.19	37.0	FREEWAY BUS ON BUSWAY (VEHS INC IN MODE 1)

LINE	24-HR MAX LD PT VOLUME	PK-HR PK-DIR VOLUME	PK-HR VEHS AT MAX LD PT	PK-2HR VEHICLE MILES	DAILY VEHICLE MILES	ROUND TRIP TIME	VEHICLES REQUIRED + SPARES	MODE TYPE	LINE LENGTH	NET PK LINE SPEED	LINE PEAK O-W/24-HR PASS RATIO	TOTAL OP COST PER DAY
1A	30000.0	3900.0	108.3	3791.7	17062.5	40.0	80.9	1	10.0	30.0	0.13	$ 10902.6
1B	23190.0	3710.4	103.1	5050.3	22726.2	56.0	107.7	1	14.0	30.0	0.16	$ 14521.6
2A	38000.0	4940.0	137.2	6243.6	28096.2	52.0	133.2	1	13.0	30.0	0.13	$ 17953.3
2B	26160.0	4185.6	116.3	6138.7	30624.0	70.6	153.2	1	20.0	34.0	0.16	$ 21467.5
3A	45403.0	7264.5	201.8	8475.2	38138.5	48.0	180.8	1	12.0	30.0	0.16	$ 24309.8
3B	18279.0	2924.6	81.2	11373.6	51181.2	141.2	214.1	1	40.0	34.0	0.16	$ 30000.4
4A	6000.0	780.0	21.7	872.1	3924.4	46.0	18.6	1	11.5	30.0	0.13	$ 2507.6
4B	1461.0	233.6	6.5	566.2	2556.7	68.2	10.7	1	25.0	34.0	0.16	$ 1498.7
5A	25676.0	3337.9	92.7	4218.7	18984.2	44.6	77.1	2	13.0	35.0	0.13	$ 10912.9
5B	10000.0	1600.0	44.4	2177.8	9800.0	49.4	41.0	1	14.0	34.0	0.16	$ 5744.4
5C	20000.0	2600.0	72.2	3286.1	14787.5	42.2	56.8	3	13.0	37.0	0.13	$ 8192.9
6	40000.0	5200.0	144.4	4802.8	21612.5	38.0	102.5	1	9.5	30.0	0.13	$ 13810.0
7A	8000.0	1040.0	28.9	455.0	2047.5	18.0	9.7	1	4.5	30.0	0.13	$ 1308.3
7B	13425.0	2147.7	59.7	3758.4	16913.0	63.5	70.7	1	18.0	34.0	0.16	$ 9913.7
8A	45000.0	5850.0	162.5	6825.0	30712.5	48.0	145.6	1	12.0	30.0	0.13	$ 19624.7
8B	22437.0	3589.9	99.7	8202.0	36908.9	62.9	154.4	1	23.5	34.0	0.16	$ 21034.5
8C	20000.0	2600.0	72.2	758.3	3412.5	12.0	16.2	1	3.0	30.0	0.13	$ 2180.5
9A	27000.0	4320.0	120.0	8820.0	39690.0	74.1	166.0	1	21.0	34.0	0.16	$ 23264.7
9B	9584.0	1533.4	42.6	4919.8	22139.0	116.5	92.6	1	33.0	34.0	0.16	$ 12977.0
10A	3000.0	460.0	13.3	886.7	3990.0	67.1	16.7	1	19.0	34.0	0.16	$ 2338.8
10B	28000.0	4480.0	124.4	12195.5	54879.9	98.8	229.6	1	28.0	34.0	0.16	$ 32168.5
11A	3000.0	480.0	13.3	466.7	2100.0	35.3	8.8	1	10.0	34.0	0.16	$ 1230.9
11B	6997.0	1119.5	31.1	2721.1	12244.7	88.2	51.2	1	25.0	34.0	0.16	$ 7177.4
12	19746.0	3159.4	87.8	5221.7	23497.7	60.0	98.3	1	17.0	34.0	0.16	$ 13775.4
13	10000.0	1600.0	44.4	4044.4	18200.0	91.8	76.1	1	26.0	34.0	0.16	$ 10668.1
14	5000.0	800.0	22.2	855.6	3850.0	38.8	16.1	1	11.0	34.0	0.16	$ 2256.7
15A	12000.0	1920.0	53.3	3080.0	13860.0	58.2	56.0	1	16.5	34.0	0.16	$ 8124.2
15B	16000.0	2560.0	71.1	1493.3	6720.0	21.2	28.1	1	6.0	34.0	0.16	$ 3939.0
15C	15054.0	2408.6	66.9	8313.2	37409.2	125.3	156.5	1	35.5	34.0	0.16	$ 21927.8
16	22000.0	3520.0	97.8	3696.0	16632.0	43.2	78.8	1	10.8	30.0	0.16	$ 10627.6
17	1106.0	177.0	4.9	326.9	1471.0	67.1	6.2	1	19.0	34.0	0.16	$ 862.2
18	5000.0	800.0	22.2	1944.4	8750.0	88.2	36.6	1	25.0	34.0	0.16	$ 5128.9
19	10000.0	1300.0	36.1	379.2	1706.2	12.0	8.1	1	3.0	30.0	0.13	$ 1090.3

MODE	DAILY VEHICLE MILES	ANNUAL VEHICLE MILES	TOTAL VEHICLES REQUIRED	TOTAL ADMINIST COSTS	TOTAL HOURLY COSTS	TOTAL VEHICLE MILE COSTS
1	588654.9	185489296.0	2567.0	33370528.0	44053696.0	35242960.0
2	18984.2	5980016.0	77.1	1002846.6	1298517.0	1136203.0
3	14787.5	4658062.0	56.8	738930.8	956790.9	885031.8

LINE-HAUL TRUNK SYSTEM ANNUAL OPERATING COST = $118685456.0
(NOTE: EXTRA COST OF TRUNK LINE VEHICLES DUE TO HIGH VEHICLE MILEAGE NOT INCLUDED)

SURFACE BUS ESTIMATES -- (ALL NON-TRUNK, NON-FEEDER, NON-CBD DISTRIBUTION)

DAILY SURFACE VEHICLE MILES = 169664.8
DAILY SURFACE VEHICLE HOURS = 13051.1
SURFACE VEHICLES REQUIRED = 1425.2
SURFACE MAINTENANCE OPERATING COST = $ 10154432.0
SURFACE HOURLY OPERATING COST = $ 31244400.0
SURFACE ADMINISTRATIVE COST = $ 17814784.0
SURFACE SYSTEM OPERATING COST = $ 59213616.0

FEEDER BUS ESTIMATES

DAILY FEEDER VEHICLE MILES = 141327.5
DAILY FEEDER VEHICLE HOURS = 10468.7
FEEDER VEHICLES REQUIRED = 1162.9
FEEDER MAINTENANCE OPERATING COST = $ 8458450.0
FEEDER HOURLY OPERATING COST = $ 25062064.0
FEEDER ADMINISTRATIVE COST = $ 14536541.0
FEEDER SYSTEM OPERATING COST = $ 48057040.0

CBD TRUNK LINE DISTRIBUTION COST = $ 17308608.0

GRAND ANNUAL OPERATING COST = $ 243264720.0
OPERATING COST PER PASSENGER = $ 0.658

MODE	PASS PER VEH MILE	COST PER PASSENGER	AVERAGE SPEED	MAINT COST PER MILE	HOURLY COST PER MILE	ADMIN COSTS PER MILE	TOTAL COST PER MILE	VEHICLE MILES	VEH MILES PER VEH
TRUNK	1.30	0.490	32.19	0.190	0.236	0.179	0.605	196127360.0	72014.3
SURFACE	2.50	0.465	13.00	0.190	0.585	0.333	1.108	53444384.0	37500.0
FEEDER	2.66	0.397	13.50	0.190	0.563	0.327	1.079	44518160.0	38281.3
SYSTEM	1.32	0.658	21.78	0.190	0.349	0.229	0.827	294089728.0	55603.5

R-2B BASIC MRT/BUSWAY SYSTEM OPERATING COST 1990 PRELIM 27FEB74 - BASE TEST

THIS IS THE R-2B BASE TEST
THIS IS NOT A VARIATION

CBD PRODUCTIONS = 0.0
SUPPORT COST / CBD PRODUCTION = $ 0.20
SUPPORT VEHICLE SPARES = 0.08

PEAK ONE-WAY/24-HOUR TWO-WAY PASSENGER RATIO (SURFACE) = 0.14
PEAK ONE-WAY/24-HOUR TWO-WAY PASSENGER RATIO (FEEDER) = 0.15
PEAK 2-HR/24-HR VEHICLE MILE RATIO = 4.5
NUMBER OF TRUNK MODES = 3
OPERATING DAYS PER YEAR = 315.0
TOTAL DAILY TRANSIT PASSENGERS = 1319257.0
TOTAL DAILY FEEDER TRANSIT PASSENGERS = 314227.0
TOTAL DAILY SURFACE (NON-TRUNK) PASSENGERS = 690804.0
FEEDER VEHICLE MILE GENERATION RATE PER FEEDER PASSENGER = 0.350
SURFACE VEHICLE MILE GENERATION RATE PER SURFACE PASSENGER = 0.400
AVERAGE DAILY SPEED PER FEEDER VEHICLE = 13.5
AVERAGE DAILY SPEED PER SURFACE VEHICLE = 13.0
SEATS PER NON-TRUNK VEHICLE = 45.0
NON-TRUNK VEHICLE PEAK LOAD FACTOR = 1.0
NON-TRUNK VEHICLE ANNUAL ADMINISTRATIVE COST = $ 12500.0
NON-TRUNK VEHICLE HOURLY CHARGE PER HOUR = $ 7.60
NON-TRUNK VEHICLE MAINTENANCE COST PER MILE = $ 0.19
PEAK HOUR TRIPS PER SURFACE VEHICLE = 1.00
PEAK HOUR TRIPS PER FEEDER VEHICLE = 1.25
REVENUE DAYS PER YEAR = 300.0

MODE	VEHICULAR SEATS	PEAK FACTOR	FRACT SPARE VEH	ADM COST PER VEH	COST PER VEH HR	COST PER VEH MILE	AVG DAILY SPEED	MODAL DESCRIPTION
1	75.0	1.6	0.10	0.0	0.0	1.26	41.0	MRT - FAST, LONG
2	75.0	2.0	0.10	0.0	0.0	1.26	36.0	MRT - SLOW, SHORT
3	40.0	0.9	0.12	13000.0	7.60	0.19	34.0	BUS ON FREEWAY

LINE	24-HR MAX LD PT VOLUME	PK-HR PK-DIR VOLUME	PK-HR VEHS AT MAX LD PT	PK-2HR VEHICLE MILES	DAILY VEHICLE MILES	ROUND TRIP TIME	VEHICLES REQUIRED + SPARES	MODE TYPE	LINE LENGTH	NET PK LINE SPEED	LINE PEAK O-W/24-HR PASS RATIO	TOTAL OP COST PER DAY
SMB	55000.0	7700.0	64.2	6625.2	29813.4	88.5	104.1	1	29.5	40.0	0.14	$ 37564.9
SFB	37000.0	5550.0	46.2	6523.6	29356.0	120.9	102.5	1	40.3	40.0	0.15	$ 36983.5
SLR	36000.0	4680.0	31.2	2293.2	10319.4	72.0	41.2	2	21.0	35.0	0.13	$ 13002.4
BSO	20000.0	3000.0	25.0	848.7	3819.4	29.1	13.3	1	9.7	40.0	0.15	$ 4812.4
SBB	78000.0	11700.0	97.5	16482.4	74170.6	144.9	259.0	1	48.3	40.0	0.15	$ 93454.9
APO	50000.0	8000.0	66.7	8166.7	36750.0	105.0	128.3	1	35.0	40.0	0.16	$ 46305.0
PO	68000.0	9520.0	79.3	5053.5	22740.9	54.6	79.4	1	18.2	40.0	0.14	$ 20053.5
1A	5500.0	880.0	24.4	2523.9	11357.5	104.1	47.5	3	29.5	34.0	0.16	$ 6057.3
1B	2000.0	320.0	8.9	690.7	3108.0	78.4	13.0	3	22.2	34.0	0.16	$ 1821.8
2A	1500.0	240.0	6.7	583.3	2625.0	88.2	11.0	3	25.0	34.0	0.16	$ 1538.7
2B	11000.0	1760.0	48.9	4568.7	20559.0	94.2	86.0	3	26.7	34.0	0.16	$ 12050.9
3	3400.0	544.0	15.1	1443.9	6497.4	96.4	27.2	3	27.3	34.0	0.16	$ 3908.5
4	1400.0	224.0	6.2	705.6	3175.2	114.4	13.3	3	32.4	34.0	0.16	$ 1801.2
5	6400.0	1024.0	28.4	1134.9	5107.2	40.2	21.4	3	11.4	34.0	0.16	$ 2993.6
6	8000.0	1280.0	35.6	2538.7	11424.0	72.0	47.8	3	20.4	34.0	0.16	$ 6696.3
7	1000.0	160.0	4.4	194.4	875.0	44.1	3.7	3	12.5	34.0	0.16	$ 512.9
8	300.0	48.0	1.3	26.6	119.7	20.1	0.5	3	5.7	34.0	0.16	$ 70.2
9	12500.0	2000.0	55.6	4316.7	19425.0	78.4	81.3	3	22.2	34.0	0.16	$ 11366.2
10	2000.0	320.0	8.9	454.2	2044.0	51.5	8.6	3	14.6	34.0	0.16	$ 1198.1
11	2000.0	320.0	6.9	124.4	560.0	14.1	2.3	3	4.0	34.0	0.16	$ 328.3

MODE	DAILY VEHICLE MILES	ANNUAL VEHICLE MILES	TOTAL VEHICLES REQUIRED	TOTAL ADMINIST COSTS	TOTAL HOURLY COSTS	TOTAL VEHICLE MILE COSTS
1	196650.1	61944784.0	686.7	0.0	0.0	78050368.0
2	10319.4	3250606.0	41.2	0.0	0.0	4095761.0
3	86876.8	27366176.0	363.4	4728274.0	6117144.0	5199573.0

LINE-HAUL TRUNK SYSTEM ANNUAL OPERATING COST = $ 98187104.0
(NOTE: EXTRA COST OF TRUNK LINE VEHICLES DUE TO HIGH VEHICLE MILEAGE NOT INCLUDED)

SURFACE BUS ESTIMATES -- (ALL NON-TRUNK, NON-FEEDER, NON-CBD DISTRIBUTION)

DAILY SURFACE VEHICLE MILES = 276321.6
DAILY SURFACE VEHICLE HOURS = 21255.5
SURFACE VEHICLES REQUIRED = 2321.1
SURFACE MAINTENANCE OPERATING COST = $ 16537842.0
SURFACE HOURLY OPERATING COST = $ 50885664.0
SURFACE ADMINISTRATIVE COST = $ 29013744.0
SURFACE SYSTEM OPERATING COST = $ 96437248.0

FEEDER BUS ESTIMATES

DAILY FEEDER VEHICLE MILES = 109979.4
DAILY FEEDER VEHICLE HOURS = 8146.6
FEEDER VEHICLES REQUIRED = 905.0
FEEDER MAINTENANCE OPERATING COST = $ 6582268.0
FEEDER HOURLY OPERATING COST = $ 19503008.0
FEEDER ADMINISTRATIVE COST = $ 11312167.0
FEEDER SYSTEM OPERATING COST = $ 37397424.0

CBD TRUNK LINE DISTRIBUTION COST = $ 0.0

GRAND ANNUAL OPERATING COST = $ 232021776.0
OPERATING COST PER PASSENGER = $ 0.586

MODE	PASS PER VEH MILE	COST PER PASSENGER	AVERAGE SPEED	MAINT COST PER MILE	HOURLY COST PER MILE	ADMIN COSTS PER MILE	TOTAL COST PER MILE	VEHICLE MILES	VEH MILES PER VEH
TRUNK	2.14	0.521	38.47	0.944	0.066	0.051	1.061	92561552.0	84817.4
SURFACE	2.50	0.465	13.00	0.190	0.585	0.333	1.108	87041280.0	37500.0
FEEDER	2.86	0.397	13.50	0.190	0.563	0.327	1.079	34643520.0	38281.3
SYSTEM	1.94	0.586	18.36	0.516	0.357	0.210	1.083	214246352.0	49624.2

R-2A BASIC MRT/BUSWAY SYSTEM OPERATING COST 1990 EST REV 11FEB74 - BASE TEST

THIS IS THE R-2A BASE TEST
THIS IS NOT A VARIATION

CBD PRODUCTIONS = 0.0
SUPPORT COST / CBD PRODUCTION = $ 0.20
SUPPORT VEHICLE SPARES = 0.08

PEAK ONE-WAY/24-HOUR TWO-WAY PASSENGER RATIO (SURFACE) = 0.14
PEAK ONE-WAY/24-HOUR TWO-WAY PASSENGER RATIO (FEEDER) = 0.15
PEAK 2-HR/24-HR VEHICLE MILE RATIO = 4.5
NUMBER OF TRUNK MODES = 3
OPERATING DAYS PER YEAR = 315.0
TOTAL DAILY TRANSIT PASSENGERS = 1317714.0
TOTAL DAILY FEEDER TRANSIT PASSENGERS = 306682.0
TOTAL DAILY SURFACE (NON-TRUNK) PASSENGERS = 616089.0
FEEDER VEHICLE MILE GENERATION RATE PER FEEDER PASSENGER = 0.350
SURFACE VEHICLE MILE GENERATION RATE PER SURFACE PASSENGER = 0.400
AVERAGE DAILY SPEED PER FEEDER VEHICLE = 13.5
AVERAGE DAILY SPEED PER SURFACE VEHICLE = 13.0
SEATS PER NON-TRUNK VEHICLE = 45.0
NON-TRUNK VEHICLE PEAK LOAD FACTOR = 1.0
NON-TRUNK VEHICLE ANNUAL ADMINISTRATIVE COST = $ 12500.0
NON-TRUNK VEHICLE HOURLY CHARGE PER HOUR = $ 7.60
NON-TRUNK VEHICLE MAINTENANCE COST PER MILE = $ 0.19
PEAK HOUR TRIPS PER SURFACE VEHICLE = 1.00
PEAK HOUR TRIPS PER FEEDER VEHICLE = 1.25
REVENUE DAYS PER YEAR = 300.0

MODE	VEHICULAR SEATS	PEAK FACTOR	FRACT SPARE VEH	ADM COST PER VEH	COST PER VEH HR	COST PER VEH MILE	AVG DAILY -SPEED	MODAL DESCRIPTION
1	75.0	1.6	0.07	0.0	0.0	1.26	41.0	MRT - FAST, LONG
2	75.0	2.0	0.07	0.0	0.0	1.26	36.0	MRT - SLOW, SHORT
3	40.0	0.9	0.12	13000.0	7.60	0.19	34.0	BUS ON FREEWAY

LINE	24-HR MAX LD PT VOLUME	PK-HR PK-DIR VOLUME	PK-HR VEHS AT MAX LD PT	PK-2HR VEHICLE MILES	DAILY VEHICLE MILES	ROUND TRIP TIME	LINE VEHICLES REQUIRED	MODE TYPE	LINE LENGTH	NET PK LINE SPEED	LINE PEAK O-W/24-HR PASS RATIO
SMB	64000.0	8960.0	74.7	13066.7	58800.0	150.0	199.7	1	50.0	40.0	0.14
SFB	36000.0	5400.0	45.0	6347.2	28562.6	120.9	97.0	1	40.3	40.0	0.15
SLR	37000.0	4810.0	32.1	2356.9	10606.0	72.0	41.2	2	21.0	35.0	0.13
BSO	20000.0	3000.0	25.0	848.7	3819.4	29.1	13.0	1	9.7	40.0	0.15
SBB	81000.0	12150.0	101.3	15486.2	69687.6	131.1	236.7	1	43.7	40.0	0.15
APO	41000.0	6560.0	54.7	3252.7	14637.0	51.0	49.7	1	17.0	40.0	0.16
PO	68000.0	9520.0	79.3	5053.5	22740.9	54.6	77.2	1	18.2	40.0	0.14
1A	5400.0	864.0	24.0	2478.0	11151.0	104.1	46.6	3	29.5	34.0	0.16
1B	6000.0	960.0	26.7	2072.0	9324.0	78.4	39.0	3	22.2	34.0	0.16
2A	1500.0	240.0	6.7	583.3	2625.0	88.2	11.0	3	25.0	34.0	0.16
2B	13000.0	2080.0	57.8	5399.3	24297.0	94.2	101.6	3	26.7	34.0	0.16
3	4900.0	784.0	21.8	2080.9	9363.9	96.4	39.2	3	27.3	34.0	0.16
4	4600.0	736.0	20.4	2318.4	10432.8	114.4	43.6	3	32.4	34.0	0.16
5	6400.0	1024.0	28.4	1134.9	5107.2	40.2	21.4	3	11.4	34.0	0.16
6	7400.0	1184.0	32.9	2348.3	10567.2	72.0	44.2	3	20.4	34.0	0.16
7	1000.0	160.0	4.4	194.4	875.0	44.1	3.7	3	12.5	34.0	0.16
8	200.0	32.0	0.9	17.7	79.8	20.1	0.3	3	5.7	34.0	0.16
9	7000.0	1120.0	31.1	2417.3	10878.0	78.4	45.5	3	22.2	34.0	0.16
10	2000.0	320.0	8.9	454.2	2044.0	51.5	8.6	3	14.6	34.0	0.16

MODE	DAILY VEHICLE MILES	ANNUAL VEHICLE MILES	TOTAL VEHICLES REQUIRED	TOTAL ADMINIST COSTS	TOTAL HOURLY COSTS	TOTAL VEHICLE MILE COSTS
1	198247.4	62447920.0	673.4	0.0	0.0	78684320.0
2	10606.0	3340901.0	41.2	0.0	0.0	4209532.0
3	96744.6	30474528.0	404.7	5260883.0	6811952.0	5790160.0

LINE-HAUL TRUNK SYSTEM ANNUAL OPERATING COST = $100756832.0
(NOTE: EXTRA COST OF TRUNK LINE VEHICLES DUE TO HIGH VEHICLE MILEAGE NOT INCLUDED)

SURFACE BUS ESTIMATES -- (ALL NON-TRUNK, NON-FEEDER, NON-CBD DISTRIBUTION)

DAILY SURFACE VEHICLE MILES = 246435.6
DAILY SURFACE VEHICLE HOURS = 18956.6
SURFACE VEHICLES REQUIRED = 2070.1
SURFACE MAINTENANCE OPERATING COST = $ 14749167.0
SURFACE HOURLY OPERATING COST = $ 45382032.0
SURFACE ADMINISTRATIVE COST = $ 25875696.0
SURFACE SYSTEM OPERATING COST = $ 86006880.0

FEEDER BUS ESTIMATES

DAILY FEEDER VEHICLE MILES = 107338.7
DAILY FEEDER VEHICLE HOURS = 7951.0
FEEDER VEHICLES REQUIRED = 883.2
FEEDER MAINTENANCE OPERATING COST = $ 6424219.0
FEEDER HOURLY OPERATING COST = $ 19034704.0
FEEDER ADMINISTRATIVE COST = $ 11040545.0
FEEDER SYSTEM OPERATING COST = $ 36499456.0

CBD TRUNK LINE DISTRIBUTION COST = $ 0.0

GRAND ANNUAL OPERATING COST = $ 223263168.0
OPERATING COST PER PASSENGER = $ 0.565

MODE	PASS PER VEH MILE	COST PER PASSENGER	AVERAGE SPEED	MAINT COST PER MILE	HOURLY COST PER MILE	ADMIN COSTS PER MILE	TOTAL COST PER MILE	VEHICLE MILES	VEH MILES PER VEH
TRUNK	2.30	0.479	38.32	0.921	0.071	0.055	1.047	96263344.0	86005.6
SURFACE	2.50	0.465	13.00	0.190	0.585	0.333	1.108	77627200.0	37500.0
FEEDER	2.86	0.397	13.50	0.190	0.563	0.327	1.079	33811680.0	38281.3
SYSTEM	2.00	0.565	18.90	0.529	0.343	0.203	1.075	207702224.0	51000.3

T-2D BASIC MRT/BUSWAY SYSTEM OPERATING COST 1990 EST REV 11FEB74 - BASE TEST

THIS IS THE T-2D BASE TEST
THIS IS NOT A VARIATION

CBD PRODUCTIONS = 0.0
SUPPORT COST / CBD PRODUCTION = $ 0.20
SUPPORT VEHICLE SPARES = 0.08

PEAK ONE-WAY/24-HOUR TWO-WAY PASSENGER RATIO (SURFACE) = 0.14
PEAK ONE-WAY/24-HOUR TWO-WAY PASSENGER RATIO (FEEDER) = 0.15
PEAK 2-HR/24-HR VEHICLE MILE RATIO = 4.5
NUMBER OF TRUNK MODES = 3
OPERATING DAYS PER YEAR = 315.0
TOTAL DAILY TRANSIT PASSENGERS = 1450000.0
TOTAL DAILY FEEDER TRANSIT PASSENGERS = 505000.0
TOTAL DAILY SURFACE (NON-TRUNK) PASSENGERS = 440000.0
FEEDER VEHICLE MILE GENERATION RATE PER FEEDER PASSENGER = 0.350
SURFACE VEHICLE MILE GENERATION RATE PER SURFACE PASSENGER = 0.400
AVERAGE DAILY SPEED PER FEEDER VEHICLE = 13.5
AVERAGE DAILY SPEED PER SURFACE VEHICLE = 13.0
SEATS PER NON-TRUNK VEHICLE = 45.0
NON-TRUNK VEHICLE PEAK LOAD FACTOR = 1.0
NON-TRUNK VEHICLE ANNUAL ADMINISTRATIVE COST = $ 12500.0
NON-TRUNK VEHICLE HOURLY CHARGE PER HOUR = $ 7.60
NON-TRUNK VEHICLE MAINTENANCE COST PER MILE = $ 0.19
PEAK HOUR TRIPS PER SURFACE VEHICLE = 1.00
PEAK HOUR TRIPS PER FEEDER VEHICLE = 1.25
REVENUE DAYS PER YEAR = 300.0

MODE	VEHICULAR SEATS	PEAK FACTOR	FRACT SPARE VEH	ADM COST PER VEH	COST PER VEH HR	COST PER VEH MILE	AVG DAILY SPEED	MODAL DESCRIPTION
1	75.0	1.6	0.10	0.0	0.0	1.26	39.0	MRT - FAST, LONG
2	75.0	2.0	0.10	0.0	0.0	1.26	35.0	MRT - SLOW, SHORT
3	45.0	0.8	0.12	13000.0	7.60	0.19	35.0	BUS ON BUSWAY

LINE	24-HR MAX LD PT VOLUME	PK-HR PK-DIR VOLUME	PK-HR VEHS AT MAX LD PT	PK-2HR VEHICLE MILES	DAILY VEHICLE MILES	ROUND TRIP TIME	LINE VEHICLES REQUIRED	MODE TYPE	LINE LENGTH	NET PK LINE SPEED	LINE PEAK O-W/24-HR PASS RATIO
SMB	96000.0	13440.0	112.0	18698.4	84142.8	143.1	293.8	1	47.7	40.0	0.14
SFB	99000.0	14850.0	123.8	17238.4	77572.6	119.4	270.9	1	39.8	40.0	0.15
SBR	74000.0	11100.0	92.5	5892.2	26515.1	54.6	92.6	1	18.2	40.0	0.15
LBB	74000.0	11100.0	92.5	11784.5	53030.2	109.2	185.2	1	36.4	40.0	0.15
SLR	56000.0	7540.0	50.3	2199.2	9896.2	42.9	39.5	2	12.5	35.0	0.13
BU1	74175.0	11868.0	329.7	6576.8	29595.8	20.1	123.8	3	5.7	34.0	0.16
BU2	58096.0	9295.4	258.2	18435.8	82961.0	72.0	347.0	3	20.4	34.0	0.16

MODE	DAILY VEHICLE MILES	ANNUAL VEHICLE MILES	TOTAL VEHICLES REQUIRED	TOTAL ADMINIST COSTS	TOTAL HOURLY COSTS	TOTAL VEHICLE MILE COSTS
1	241260.6	75997088.0	842.5	0.0	0.0	95756272.0
2	9896.2	3117316.0	39.5	0.0	0.0	3927815.0
3	112556.8	35455376.0	470.8	6120727.0	7698878.0	6736521.0

LINE-HAUL TRUNK SYSTEM ANNUAL OPERATING COST = $120240176.0
(NOTE: EXTRA COST OF TRUNK LINE VEHICLES DUE TO HIGH VEHICLE MILEAGE NOT INCLUDED)

SURFACE BUS ESTIMATES -- (ALL NON-TRUNK, NON-FEEDER, NON-CBD DISTRIBUTION)

DAILY SURFACE VEHICLE MILES = 175999.9
DAILY SURFACE VEHICLE HOURS = 13538.5
SURFACE VEHICLES REQUIRED = 1478.4
SURFACE MAINTENANCE OPERATING COST = $ 10533593.0
SURFACE HOURLY OPERATING COST = $ 32411040.0
SURFACE ADMINISTRATIVE COST = $ 18479968.0
SURFACE SYSTEM OPERATING COST = $ 61424592.0

FEEDER BUS ESTIMATES

DAILY FEEDER VEHICLE MILES = 176749.9
DAILY FEEDER VEHICLE HOURS = 13092.6
FEEDER VEHICLES REQUIRED = 1454.4
FEEDER MAINTENANCE OPERATING COST = $ 10578482.0
FEEDER HOURLY OPERATING COST = $ 31343632.0
FEEDER ADMINISTRATIVE COST = $ 18179968.0
FEEDER SYSTEM OPERATING COST = $ 60102080.0

CBD TRUNK LINE DISTRIBUTION COST = $ 0.0

GRAND ANNUAL OPERATING COST = $ 241766848.0
OPERATING COST PER PASSENGER = $ 0.556

MODE	PASS PER VEH MILE	COST PER PASSENGER	AVERAGE SPEED	MAINT COST PER MILE	HOURLY COST PER MILE	ADMIN COSTS PER MILE	TOTAL COST PER MILE	VEHICLE MILES	VEH MILES PER VEH
TRUNK	2.78	0.397	37.56	0.929	0.067	0.053	1.049	114569776.0	84689.8
SURFACE	2.50	0.465	13.00	0.190	0.585	0.333	1.108	55439968.0	37500.0
FEEDER	2.86	0.397	13.50	0.190	0.563	0.327	1.079	55676224.0	38281.3
SYSTEM	2.02	0.556	19.73	0.565	0.317	0.190	1.071	225685984.0	52661.3

T-10 BUS ON FREEWAY TOTAL OPERATING COST 1990 EST REV 11FEB74 - BASE TEST

THIS IS THE T-10 BASE TEST
THIS IS NOT A VARIATION

CBD PRODUCTIONS = 292359.0
SUPPORT COST / CBD PRODUCTION = $ 0.20
SUPPORT VEHICLE SPARES = 0.08

PEAK ONE-WAY/24-HOUR TWO-WAY PASSENGER RATIO (SURFACE) = 0.14
PEAK ONE-WAY/24-HOUR TWO-WAY PASSENGER RATIO (FEEDER) = 0.15
PEAK 2-HR/24-HR VEHICLE MILE RATIO = 4.5
NUMBER OF TRUNK MODES = 3
OPERATING DAYS PER YEAR = 315.0
TOTAL DAILY TRANSIT PASSENGERS = 1637263.0
TOTAL DAILY FEEDER TRANSIT PASSENGERS = 647893.0
TOTAL DAILY SURFACE (NON-TRUNK) PASSENGERS = 541477.0
FEEDER VEHICLE MILE GENERATION RATE PER FEEDER PASSENGER = 0.350
SURFACE VEHICLE MILE GENERATION RATE PER SURFACE PASSENGER = 0.400
AVERAGE DAILY SPEED PER FEEDER VEHICLE = 13.5
AVERAGE DAILY SPEED PER SURFACE VEHICLE = 13.0
SEATS PER NON-TRUNK VEHICLE = 45.0
NON-TRUNK VEHICLE PEAK LOAD FACTOR = 1.0
NON-TRUNK VEHICLE ANNUAL ADMINISTRATIVE COST = $ 12500.0
NON-TRUNK VEHICLE HOURLY CHARGE PER HOUR = $ 7.60
NON-TRUNK VEHICLE MAINTENANCE COST PER MILE = $ 0.19
PEAK HOUR TRIPS PER SURFACE VEHICLE = 1.00
PEAK HOUR TRIPS PER FEEDER VEHICLE = 1.25
REVENUE DAYS PER YEAR = 300.0

MODE	VEHICULAR SEATS	PEAK FACTOR	FRACT SPARE VEH	ADM COST PER VEH	COST PER VEH HR	COST PER VEH MILE	AVG DAILY SPEED	MODAL DESCRIPTION
1	40.0	0.9	0.12	13000.0	7.60	0.19	32.0	BUS ON FREEWAY
2	45.0	0.8	0.12	13000.0	7.60	0.19	35.0	BUS ON BUSWAY
3	40.0	0.9	0.12	13000.0	7.60	0.19	37.0	FREEWAY BUS ON BUSWAY (VEHS INC IN MODE 1)

LINE	24-HR MAX LD PT VOLUME	PK-HR PK-DIR VOLUME	PK-HR VEHS AT MAX LD PT	PK-2HR VEHICLE MILES	DAILY VEHICLE MILES	ROUND TRIP TIME	VEHICLES REQUIRED + SPARES	MODE TYPE	LINE LENGTH	NET PK LINE SPEED	LINE PEAK O-W/24-HR PASS RATIO	TOTAL OP COST PER DAY
1A	35493.0	4614.1	128.2	4465.9	20186.6	40.0	95.7	1	10.0	30.0	0.13	$12898.9
1B	26677.0	4268.3	118.6	5809.7	26143.4	56.0	123.9	1	14.0	30.0	0.16	$16705.2
2A	42640.0	5543.2	154.0	7006.0	31526.9	52.0	149.5	1	13.0	30.0	0.13	$20145.2
2B	27865.0	4458.4	123.8	8669.1	39011.0	70.6	163.2	1	20.0	34.0	0.16	$22866.7
3A	30766.0	4915.0	136.5	9075.3	40839.0	76.0	193.6	1	19.0	30.0	0.16	$26095.4
3B	28666.0	4590.1	127.5	14726.5	66269.2	116.5	277.2	1	33.0	34.0	0.16	$38844.4
4A	27087.0	3521.3	97.8	3937.0	17716.6	46.0	84.0	1	11.5	30.0	0.13	$11320.6
4B	20793.0	3326.9	92.4	8086.2	36387.7	86.2	152.2	1	25.0	34.0	0.16	$21329.1
5A	19459.0	2529.7	70.3	3197.2	14387.5	44.6	58.5	2	13.0	35.0	0.13	$ 6270.5
5B	14494.0	2319.0	64.4	3156.5	14204.1	49.4	59.4	1	14.0	34.0	0.16	$ 8325.9
5C	14494.0	1884.2	52.3	2381.4	10716.5	42.2	41.2	3	13.0	37.0	0.13	$ 5937.4
6	68287.0	8877.3	246.6	8199.2	36696.3	38.0	174.9	1	9.5	30.0	0.13	$23576.1
7A	18345.0	2384.8	66.2	1043.4	4695.2	18.0	22.3	1	4.5	30.0	0.13	$ 3000.1
7B	24064.0	3850.2	107.0	6737.9	30320.6	63.5	126.8	1	18.0	34.0	0.16	$17772.8
8A	41341.0	5374.3	149.3	6270.0	26215.2	48.0	133.8	1	12.0	30.0	0.13	$16029.0
8B	22518.0	3602.9	100.1	8231.6	37042.1	82.9	154.9	1	23.5	34.0	0.16	$21712.6
9A	30953.0	4952.5	137.6	10111.3	45500.9	74.1	190.3	1	21.0	34.0	0.16	$26070.9
9B	23694.0	3791.0	105.3	12162.9	54733.1	116.5	228.9	1	33.0	34.0	0.16	$32082.4
10A	11083.0	1773.3	49.3	3275.6	14740.4	67.1	61.7	1	19.0	34.0	0.16	$ 8640.2
10B	35402.0	5624.3	161.8	15855.1	71347.9	98.8	298.4	1	28.0	34.0	0.16	$41821.4
11A	16507.0	2641.1	73.4	2567.8	11554.9	35.3	48.3	1	10.0	34.0	0.16	$ 6773.0
11B	20857.0	3337.1	92.7	8111.1	36499.7	88.2	152.7	1	25.0	34.0	0.16	$21394.7
12	37973.0	6075.7	168.8	10041.7	45187.8	60.0	189.0	1	17.0	34.0	0.16	$26487.4
13	20413.0	3266.1	90.7	6255.9	37151.6	91.8	155.4	1	26.0	34.0	0.16	$21776.8
14	16943.0	2710.9	75.3	2899.1	13046.1	38.8	54.6	1	11.0	34.0	0.16	$ 7647.1
15A	24697.0	3951.5	109.8	6338.9	28525.0	58.2	119.3	1	16.5	34.0	0.16	$16720.3
15B	16110.0	2577.6	71.6	1503.6	6766.2	21.2	28.3	1	6.0	34.0	0.16	$ 3966.1
15C	33750.0	5400.0	150.0	18637.5	83868.7	125.3	350.8	1	35.5	34.0	0.16	$49160.6
16	32762.0	5241.9	145.6	5504.0	24768.1	43.2	117.4	1	10.8	30.0	0.16	$15826.4
17	19233.0	3077.3	85.5	5684.4	25579.9	67.1	107.0	1	19.0	34.0	0.16	$14993.9
18	13859.0	2217.4	61.6	5389.6	24253.2	88.2	101.5	1	25.0	34.0	0.16	$14216.3
19	11629.0	1511.8	42.0	440.9	1984.2	12.0	9.4	1	3.0	30.0	0.13	$ 1267.9

MODE	DAILY VEHICLE MILES	ANNUAL VEHICLE MILES	TOTAL VEHICLES REQUIRED	TOTAL ADMINIST COSTS	TOTAL HOURLY COSTS	TOTAL VEHICLE MILE COSTS
1	954960.9	300812544.0	4124.5	53619056.0	71442960.0	57154368.0
2	14367.5	4532062.0	58.5	760025.1	984104.6	861091.8
3	10716.5	3375697.0	41.2	535502.9	693385.9	641382.4

LINE-HAUL TRUNK SYSTEM ANNUAL OPERATING COST = $186691824.0
(NOTE: EXTRA COST OF TRUNK LINE VEHICLES DUE TO HIGH VEHICLE MILEAGE NOT INCLUDED)

SURFACE BUS ESTIMATES -- (ALL NON-TRUNK, NON-FEEDER, NON-CBD DISTRIBUTION)

DAILY SURFACE VEHICLE MILES = 216590.8
DAILY SURFACE VEHICLE HOURS = 16660.8
SURFACE VEHICLES REQUIRED = 1819.4
SURFACE MAINTENANCE OPERATING COST = $ 12962955.0
SURFACE HOURLY OPERATING COST = $ 39886000.0
SURFACE ADMINISTRATIVE COST = $ 22742000.0
SURFACE SYSTEM OPERATING COST = $ 75590944.0

FEEDER BUS ESTIMATES

DAILY FEEDER VEHICLE MILES = 226762.5
DAILY FEEDER VEHICLE HOURS = 16797.2
FEEDER VEHICLES REQUIRED = 1865.9
FEEDER MAINTENANCE OPERATING COST = $ 13571733.0
FEEDER HOURLY OPERATING COST = $ 40212528.0
FEEDER ADMINISTRATIVE COST = $ 23324128.0
FEEDER SYSTEM OPERATING COST = $ 77108384.0

CBD TRUNK LINE DISTRIBUTION COST = $ 18418608.0

GRAND ANNUAL OPERATING COST = $ 357809408.0
OPERATING COST PER PASSENGER = $ 0.649

MODE	PASS PER VEH MILE	COST PER PASSENGER	AVERAGE SPEED	MAINT COST PER MILE	HOURLY COST PER MILE	ADMIN COSTS PER MILE	TOTAL COST PER MILE	VEHICLE MILES	VEH MILES PER VEH
TRUNK	1.32	0.480	32.09	0.190	0.237	0.178	0.605	308720128.0	73083.8
SURFACE	2.50	0.465	13.00	0.190	0.585	0.333	1.108	68226080.0	37500.0
FEEDER	2.86	0.397	13.50	0.190	0.563	0.327	1.079	71430176.0	38281.3
SYSTEM	1.29	0.649	22.24	0.190	0.342	0.225	0.798	448376320.0	56688.4

more costly per systemwide passenger than R1A. The fleet size of the R1 concept would require an approximate tripling of the current bus fleet, with just over one-half of the fleet operating on freeways. The surface street bus needs, including the buses operating as feeders to the freeway portion of express trips, would be about 50 percent greater than today's surface street bus fleet.

The R2 fixed-guideway-oriented concepts, defined as R2A and R2B, developed systemwide costs per passenger similar to T2, despite the shifting of passenger routings which took place between express and local services. R2A had the same 56¢ systemwide operating cost per passenger as T2, while R2B was slightly higher at 59¢. However, separation of the express system costs (running the trunk-line service only) and passengers from the total costs does reflect the change in the proportion of passengers using express service. The express system cost per passenger in T2 was 40¢. However, with lower express volumes, R2A had a figure of 48¢ and the R2B system, which examined the impact of a significant shift in the express route structure in some parts of the region, was up to 52¢.

The R2 concepts would require a bus fleet nearly double today's bus fleet. About 3,000 buses would be on the surface streets and about 400 more on freeways, depending on the specific R2 concept.

One of the reasons for differences in cost between any two systems would be a difference in the length of the average passenger trip--the shorter the trip, the lower the operating cost per passenger. In these tests, there is really a larger difference in passenger cost in favor of R2 over R1 because R1 trips are about 10 percent shorter than R2.

Several variations from the base test conditions, not reflected in the Task 8.1 Technical Working Paper, were made. With the R1A system concept, the variations were (1) reduced freeway bus speed, (2) reduced passenger loadings for freeway buses, and (3) use of double-decker buses, rather than conventional buses, on freeways.

Only one factor was varied from base conditions in each estimate; passenger volumes were held constant. The results were

- Variation--reduce bus-on-freeway peak-hour average speeds (including station stops) from 30 to 26 miles per hour for short lines and from 34 to 29 miles per hour for long lines--about a 13-percent reduction. Effect on systemwide operating costs was a 5-percent increase per passenger; bus fleet was increased by 420.

- Variation--reduce bus-on-freeway peak-hour passengers per average bus from 36 to 32--an 11-percent reduction. Effect on systemwide operating costs was a 6-percent increase per passenger; bus fleet was increased by 320.

- Variation--use double-decker buses with 63 passengers per average bus in peak hour for all freeways and busways. Effect on systemwide operating costs was an 18-percent reduction in systemwide costs per passenger, to a value slightly lower than that with fixed guideways in R2.

The amount of vehicle miles per bus and the operating cost per bus mile operated on the express systems are different from conventional bus systems. The specific alternative tested is not so important as the fact that

- Vehicle miles per SCRTD bus today total about 35,000 annually. Bus-on-freeway and bus-on-busway services are simulated in these tests to be about double that amount of mileage assuming that moderately high freeway speed would be achieved on a regular, everyday basis. With moderately slow freeway speed assumptions, however, a 50-percent increase can be expected.

- The SCRTD operating cost per bus mile, which is the most conventional and simple measure of costs, was in excess of $1.15 in 1973. The bus-on-freeway and bus-on-busway services as simulated in these tests would have bus-mile costs much lower than value. Rule-of-thumb techniques using the single bus-mile value would be misleading; the high freeway bus speed assumptions reduce the cost to about 60¢. The slower speeds on freeways, however, would bring down to 75¢.

DEVELOPMENT OF BASIC TRAVELER CRITERIA

To be consistent with the SCAG Transportation Plan Evaluation Process, AMV has developed measures of traveler criteria under the subcategories of Service Effectiveness, Congestion Relief Effectiveness, and Safety Effectiveness. The first subcategory pertains to users of transit; the second, to non-users (i.e., auto users); and the third, to both users and non-users. These measures were developed for R1 and R2 concept networks in full detail, using the complete LARTS 1325-zone system for analysis. (For a discussion of the relationship of R1 and R2 to SCAG's T1 and T2 networks, see the Task 8.1 Technical Working Paper.) For ease of interpretation and display, most measures were compressed to a system of 25 modified Regional Statistical Areas (RSA's). These districts are shown in the map on the next page. Twenty of them comprise the County of Los Angeles.

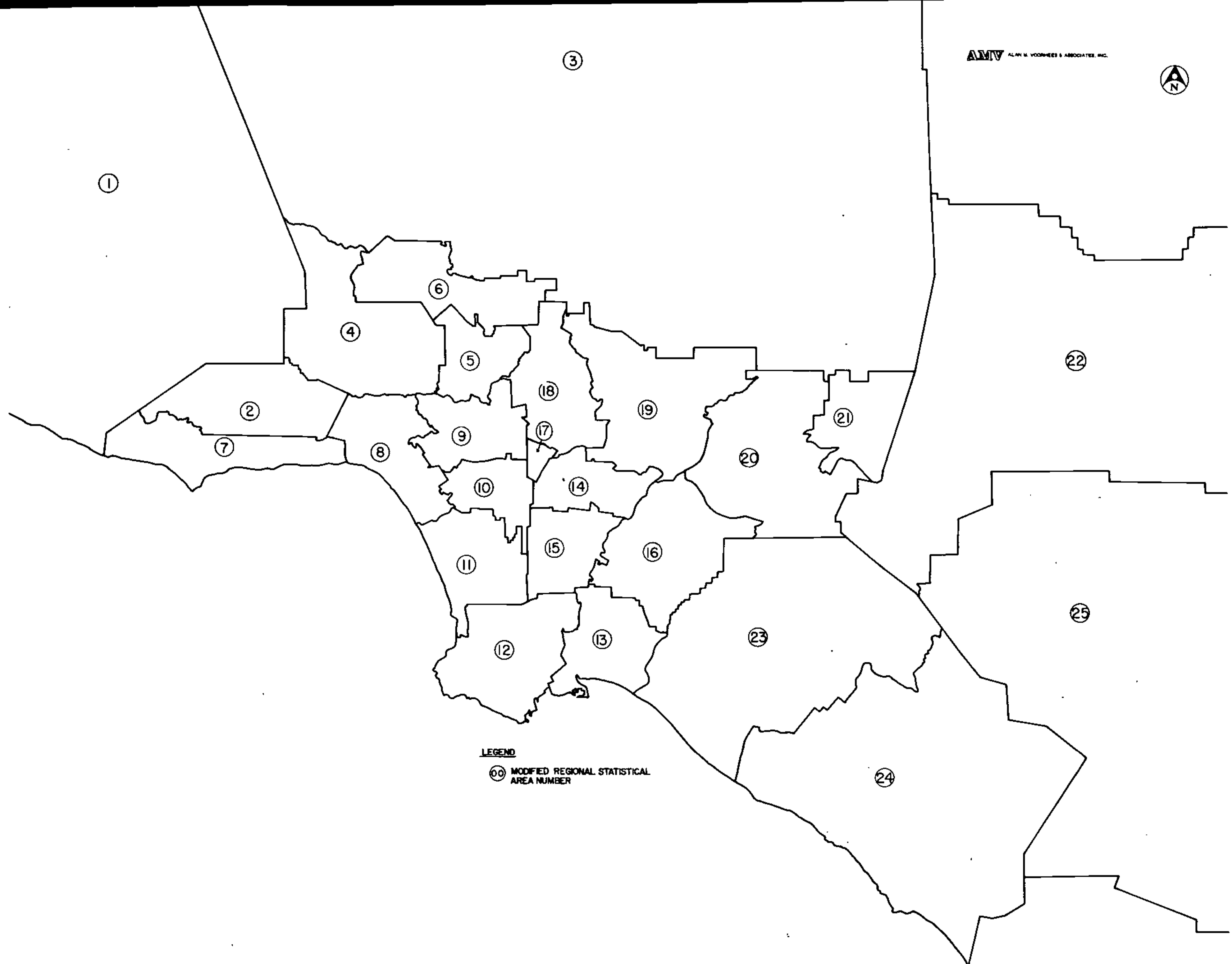
Within the time and resource constraints of the study, it was not possible to perform the precise exercises prescribed by the SCAG Evaluation Process. However, AMV feels that we have adequately covered the principal analytical intent of that process through utilization of data that were more readily available and more easily manipulated--most significantly by computer.

Service Effectiveness

The components of this subcategory include

- Demand satisfaction--projected demand
- Demand satisfaction--latent demand
- Choice satisfaction
- Service satisfaction

Although it appears likely that the intent of demand satisfaction--projected demand and choice satisfaction is to measure the same effect, AMV has separated the two components for the sake of clarity.


AMV ALAN M. VOORHEES & ASSOCIATES, INC.
N
LEGEND
00 MODIFIED REGIONAL STATISTICAL AREA NUMBER
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The measure of projected demand satisfaction can be simply a comparison of transit-trip productions or attractions across optional concepts. Figure 6, presented on the next five pages, is such a comparison for LARTS zones (1325-zone system) with the five districts (modified RSA's) in and around the regional core. It is within these areas that the variation in projected demand satisfaction is most significant. In general, the R2 networks (R2A and R2B are nearly identical; only R2B is shown) are consistently more effective in satisfying projected demand at the nonhome end of trips (attractions), while in some areas the R1 all-bus concept is more effective at the home end of trips (productions).

In measuring choice satisfaction, it became apparent that some indication of the relative satisfaction of latent demand could be obtained simultaneously. The key element in measuring these components is the modal split--the proportion of tripmakers choosing the transit system. In the process of network analysis, a modal split is calculated (from the relative attractiveness of specific transit and highway networks) for each possible trip. A possible trip is represented by linking two LARTS analysis zones. The modal split for a specific comparison of transit and highway networks can be expressed as a matrix of percentage values--one for each possible trip. These percentages may range from zero for trips not served by transit to a practical high of 60 to 70 percent for trips extraordinarily well served by transit.

For each one of the R1 and R2 concept networks, AMV prepared a frequency distribution of the corresponding modal split matrix versus each of three tables:

- Respective transit-trip table
- Person-trip table representing projected travel demand
- "Ones table" (or unit matrix) representing equal demand for every possible trip

Figure 6

Dist.	Zones	R1A		R1B		R2B	
		ATTRS	PRODS	ATTRS	PRODS	ATTRS	PRODS
9	341	0	0	0	0	40	588
9	342	0	239	0	231	C	259
9	343	0	3384	0	3325	71	3554
9	344	530	5637	506	5562	422	5807
9	345	1008	5775	973	5737	994	5689
9	346	2194	6321	2180	6290	1976	5167
9	347	486	531	477	524	572	628
9	348	1579	9345	1554	9295	1564	8625
9	349	3360	8874	3288	8806	3762	9109
9	350	23050	7252	22613	7184	22235	7031
9	351	7285	1985	7193	1977	6927	1886
9	352	9800	3372	9637	3348	10250	3357
9	353	6494	5812	6432	5792	6240	5590
9	354	8367	5334	8252	5309	8280	5102
9	355	1334	6868	1301	6839	1341	6767
9	356	3698	5449	3668	5430	3542	4708
9	357	2275	7387	2227	7358	2266	7211
9	358	127	128	119	118	99	90
9	359	5967	1434	5740	1402	6800	1498
9	360	449	354	444	344	556	429
9	361	510	160	515	158	575	184
9	362	124	238	127	237	117	259
9	363	[illegible]	5025	[illegible]	[illegible]	[illegible]	4951
9	364	4899	3553	4807	3525	5471	3561
9	365	9195	4227	9100	4211	8798	4011
9	366	1392	4040	1358	4018	1426	4009
9	367	4130	499	4063	490	4332	607
9	368	6012	6340	5931	6319	6556	6279
9	369	802	621	802	620	831	584
9	370	1250	4782	1250	4750	1253	4709
9	371	1530	9647	1480	9605	1452	9488
9	372	10306	7129	10176	7110	10369	6962
9	373	27192	13931	26817	13897	28340	14138
9	374	9035	2692	8924	2622	9487	2892
9	375	1114	2647	1092	2613	1137	2581
9	376	31051	3377	30777	3289	31796	3477
9	377	467	377	443	356	445	504
9	378	1657	6682	1610	6656	1995	7064
9	379	421	1913	426	1876	497	1986
9	380	1586	2936	1541	2920	1834	3046
9	381	953	3030	940	3006	962	2955
9	393	9201	6023	9062	5978	9746	6239
9	383	6930	4242	6850	4230	7449	4297
9	384	497	4053	519	4012	591	4098
9	385	2140	3846	2074	3822	2424	3912
9	386	4229	612	4177	605	4905	746
9	392	11902	5569	11779	5546	13253	5858
9	394	30067	13842	29613	13817	30966	14106
9	391	2710	4774	2657	4752	2762	4781
9		264862	212288	261094	210902	273701	211379

Figure 6 (cont)

Dist.	Zones	R1A		R1B		R2B	
		ATTRS	PRODS	ATTRS	PRODS	ATTRS	PRODS
10	389	976	6094	970	6073	1010	6091
10	390	1492	2570	1459	2543	1615	2492
10	382	1081	3712	1061	3661	999	3177
10	387	582	4141	540	4098	629	4131
10	388	1405	3603	1376	3574	1447	3506
10	395	828	3837	817	3823	880	3830
10	396	5413	5145	5316	5128	5454	5103
10	397	10312	4677	10102	4654	10482	4718
10	398	2013	3201	1991	3160	2498	3962
10	399	1246	3781	1228	3710	1309	3400
10	400	1578	3379	1543	3329	1761	3483
10	401	978	5385	953	5367	1004	5341
10	402	927	5207	919	5186	953	5173
10	403	1276	5217	1250	5197	1250	5152
10	404	3018	4021	2940	4002	3053	4022
10	405	2988	2122	2893	2108	3115	2130
10	406	144	200	135	189	184	357
10	407	783	1383	781	1358	752	1504
10	408	921	4950	908	4887	866	4601
10	409	2814	2576	2749	2546	2538	2428
10	410	1324	1931	1300	1896	1171	1852
10	411	0	0	0	0	169	0
10	412	548	843	512	818	492	950
10	413	1198	511	1183	493	1107	772
10	414	1097	1677	1064	1585	1001	1181
10	415	1060	2746	1042	2702	1187	2693
10	416	905	2420	893	2407	921	2374
10	417	791	2696	776	2682	816	2680
10	418	1105	3527	1078	3507	1096	3477
10	419	554	2081	545	2062	593	2055
10	420	724	2295	685	2270	720	2238
10	421	979	5239	962	5204	1057	5157
10	422	2567	2681	2545	2666	2589	2634
10	423	1346	2872	1316	2855	1453	2901
10	424	1362	1670	1335	1639	1316	1537
10	425	703	4281	691	4243	703	4025
10	426	457	1890	445	1875	466	1836
10	427	922	3289	884	3249	946	3157
10	428	800	1595	775	1566	813	1497
10	429	359	1669	347	1655	367	1585
10	430	256	2199	269	2177	326	2298
10	431	262	976	241	961	325	1013
10		60094	124289	58819	123105	61424	122503

Figure 6 (cont)

Dist.	Zones	R1A ATTRS	R1A PRODS	R1B ATTRS	R1B PRODS	R2B ATTRS	R2B PRODS
14	553	3080	637	2910	626	3595	664
14	554	1210	1675	1152	1665	1359	1716
14	555	3132	1468	3015	1447	3258	1462
14	556	632	4514	604	4480	696	4523
14	557	1094	3987	1055	3937	1156	3809
14	558	10998	572	10757	562	11715	558
14	559	7073	1055	6994	1050	7294	1062
14	560	10676	505	10495	496	11180	510
14	561	2925	639	2806	625	3299	625
14	562	596	1328	564	1310	885	1317
14	563	428	2385	393	2375	535	2459
14	564	946	3350	928	3323	1013	3368
14	565	186	1400	197	1387	286	1402
14	566	755	3140	719	3074	704	3033
14	567	879	1455	816	1420	999	1420
14	568	7605	496	7514	490	7646	477
14	569	7382	620	7275	614	7531	621
14	570	1096	3743	1063	3733	1212	3778
14	571	281	1041	284	1032	357	1060
14	572	791	293	772	284	941	278
14	573	2841	1160	2732	1144	3971	1202
14	574	1708	2029	1645	2009	2087	2177
14	575	952	4067	935	4019	1178	[illegible]
14	576	1995	989	1867	962	1733	871
14	577	404	2640	389	2628	470	2705
14	578	609	1407	583	1384	733	1519
14	579	1136	3025	1101	2971	1268	2970
14	580	422	2846	409	2776	438	2836
14	581	241	1337	218	1322	263	1366
14	582	463	1451	459	1362	415	1467
14	583	1539	2600	1461	2568	1243	1958
14	584	2071	1267	1961	1212	1692	1076
14	585	1277	3637	1241	3622	1350	3654
14	586	789	2121	810	2107	898	2110
14	587	4326	1767	4196	1758	4114	1743
14	588	3958	320	3882	311	4006	298
14	589	5416	1755	5265	1746	4953	1683
14	590	3322	1156	3276	1151	2934	1142
14	591	800	180	721	167	700	153
14	592	3349	988	3145	966	2051	813
14	593	6844	714	6520	693	4464	716
14	594	2060	651	1917	618	1348	548
14	595	478	1975	474	1960	472	1940
14	596	387	2053	382	2042	409	2039
14	597	1196	2240	1189	2227	1278	2248
14	598	798	3176	743	3109	846	3094
14	599	3030	2378	2996	2367	3185	2434
14	600	2305	2620	2268	2607	2569	2698
14	601	4519	3755	4462	3740	4872	3804
14		121010	90607	117580	89478	121601	89786

Figure 6 (cont)

Dist.	Zones	R1A		R1B		R2B	
		ATTRS	PRODS	ATTRS	PRODS	ATTRS	PRODS
17	700	1789	5575	1747	5564	1917	5657
17	701	10000	5389	9857	5379	10624	5486
17	702	6363	3682	6326	3673	6589	3758
17	703	8360	5599	8263	5585	9134	5791
17	704	20340	6184	20083	6170	20835	6313
17	705	2612	3011	2572	3004	2723	3035
17	706	1996	2980	1955	2969	2081	2987
17	707	12187	314	12019	311	12379	307
17	708	553	720	576	710	605	700
17	709	13374	255	13201	254	13699	256
17	710	21100	255	20859	254	21863	273
17	711	4801	4586	4748	4575	5192	4762
17	712	3969	2160	3892	2154	4170	2205
17	713	3361	772	3329	768	3620	784
17	714	3091	1539	3046	1534	3137	1558
17	715	0	0	0	0	5792	2251
17	716	44271	1076	43746	1058	45737	1094
17	717	34074	1306	33683	1284	36264	1318
17	718	35479	900	34841	871	36834	886
17	719	1040	2598	996	2576	1293	2645
17	720	4696	1866	4593	1858	5043	1894
17	721	8597	877	8480	871	8906	895
17	722	32687	1372	32580	1360	32986	1365
17		274740	53016	271192	52782	291423	56238

Figure 6 (cont)

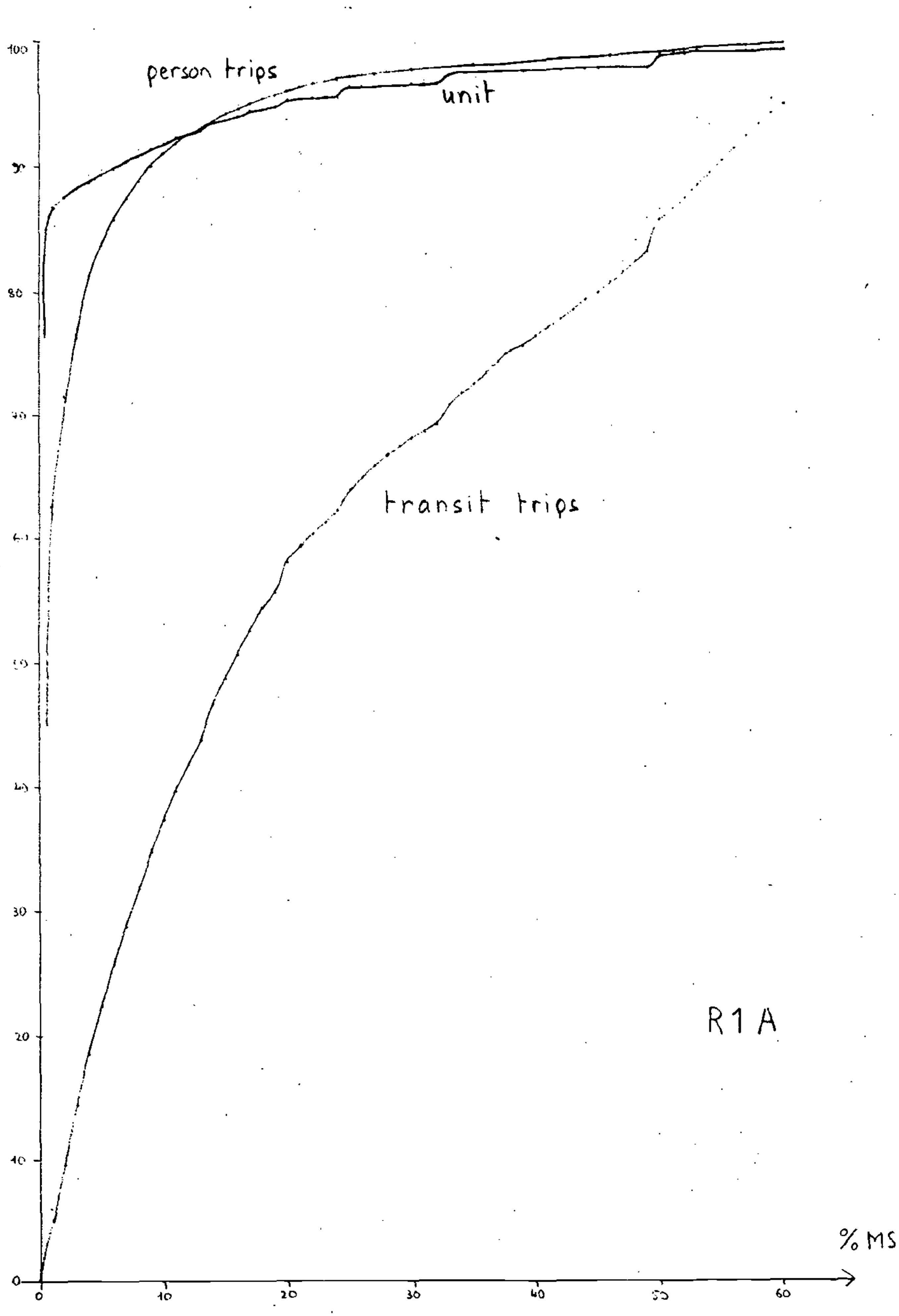
Dist.	Zones	R1A		R1B		R2B	
		ATTRS	PRODS	ATTRS	PRODS	ATTRS	PRODS
18	723	196	866	194	853	409	2816
18	724	330	706	295	625	305	551
18	725	191	1536	177	1475	205	1705
18	726	326	2086	319	2037	357	2466
18	727	3524	1305	3379	1265	2810	1155
18	728	1396	2756	1335	2707	1639	3030
18	729	0	0	0	0	36	490
18	730	2093	1602	2035	1575	2153	1426
18	731	2866	1864	2793	1809	2989	1838
18	732	124	770	133	748	166	971
18	733	326	476	287	455	486	565
18	734	52	164	63	160	93	182
18	735	4207	2954	4084	2918	3693	2659
18	736	1767	6218	1699	6100	2011	6433
18	737	233	857	201	828	306	1046
18	738	491	1178	466	1151	535	1290
18	739	146	555	145	527	143	502
18	740	597	2052	574	2010	904	2834
18	741	202	1474	189	1429	254	1588
18	742	1052	2958	1019	2879	978	3803
18	743	1905	4137	1851	4117	1799	4151
18	744	607	4144	594	4096	458	2529
18	745	402	1486	427	1459	370	1440
8	746	594	5970	551	5952	609	5915
8	747	1297	4568	1282	4554	1298	4505
8	748	689	5495	665	5476	646	5300
8	749	353	2696	332	2675	348	2624
8	750	508	4058	508	4046	537	4037
8	751	1382	2808	1306	2787	1826	2913
8	752	218	1762	220	1713	401	2768
8	753	542	2952	522	2857	629	2824
8	754	324	1485	277	1432	316	1852
8	755	222	1644	225	1613	287	1901
8	756	290	1159	240	1082	306	1806
8	757	459	1879	435	1852	398	1680
8	758	475	1765	468	1725	658	1958
8	759	2521	2613	2407	2591	2773	2709
8	760	392	2518	392	2494	437	2502
8	761	353	2725	345	2704	362	2733
8	762	329	1586	312	1528	297	1375
8	763	1383	3733	1350	3716	1555	3780
8	764	565	1177	536	1142	607	1087
8	765	681	1334	675	1291	644	1190
8	766	1362	994	1289	963	1746	1028
8	767	74	178	70	175	119	249
8	768	368	1637	348	1466	325	1753
8		38414	98880	37014	97057	40223	103959

These distributions are plotted on the next three pages. Inspection of the distributions reveals few significant differences among the R1 and R2 concept networks.

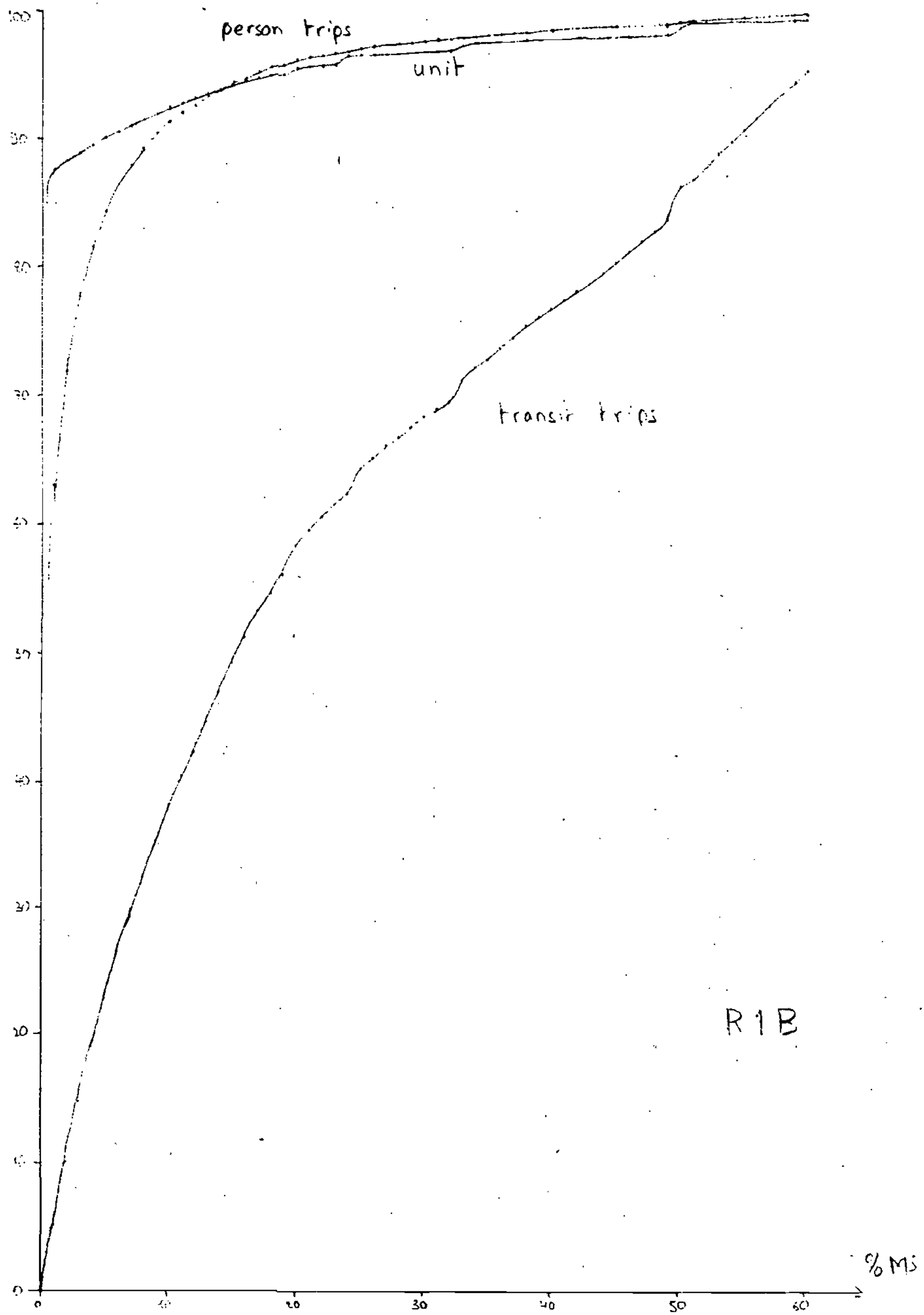
Choice satisfaction can be measured by comparison of the transit-trip distribution with the person-trip distribution. The disparity between the two can be construed as representing the wide variation in transit levels of service throughout the region. This is a direct result of configuring a regional transit system that endeavors to situate express facilities where they serve the greatest number of travelers while trying to minimize total costs.

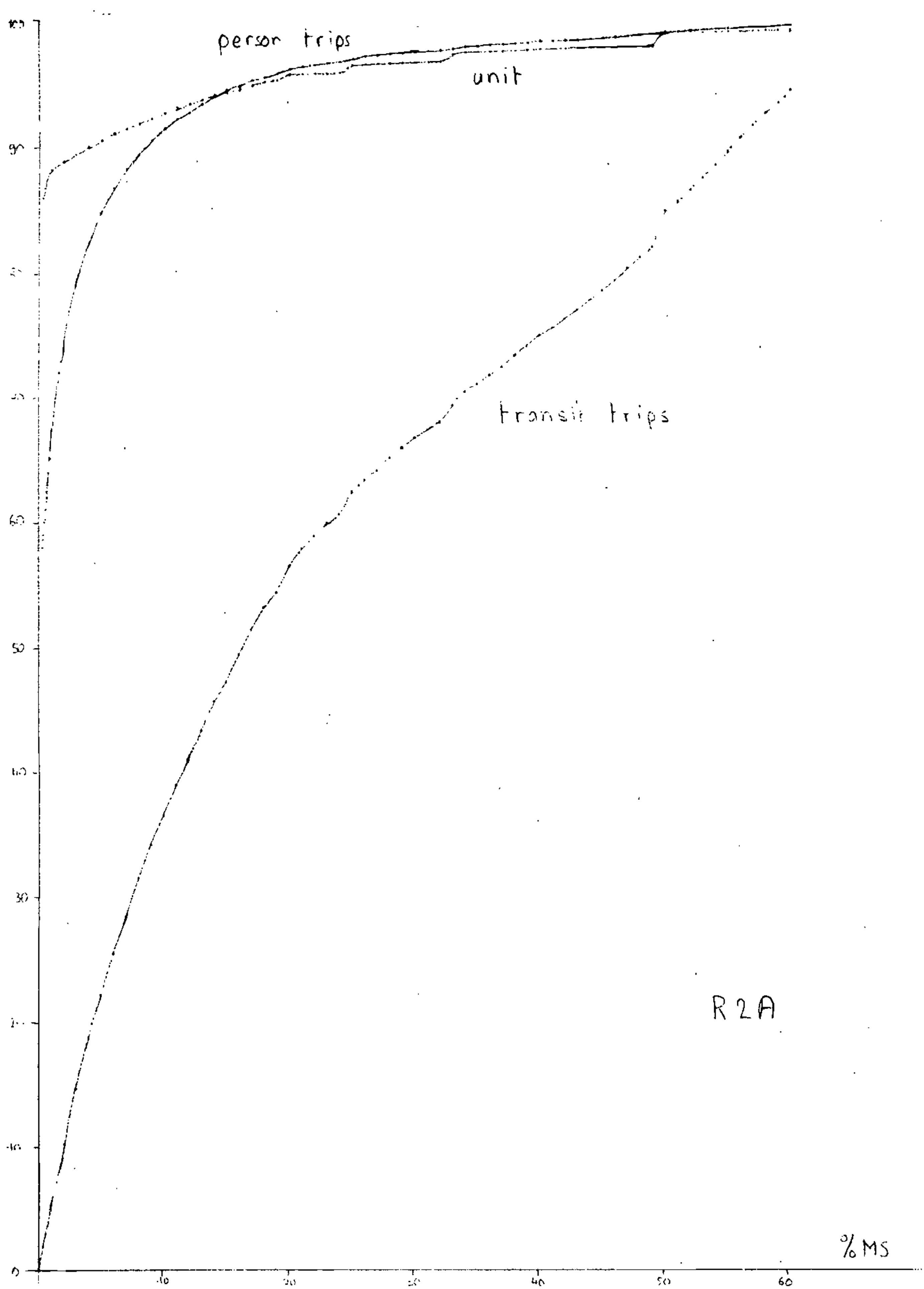
The highly indeterminate factor referred to as latent demand can be indicated to a very limited degree by comparison of the transit-trip distribution with the unit matrix distribution. The "ones table" can be thought of as representing a situation where demand for travel between any set of two points is equally likely. A refinement of this concept might be to introduce population into the matrix. However, it is sufficient to say that disparity between the transit and the unit curves might be an inverse indication of the extent to which a particular transit system concept might serve to foster travel not likely to be represented in state-of-the-art demand forecasting.

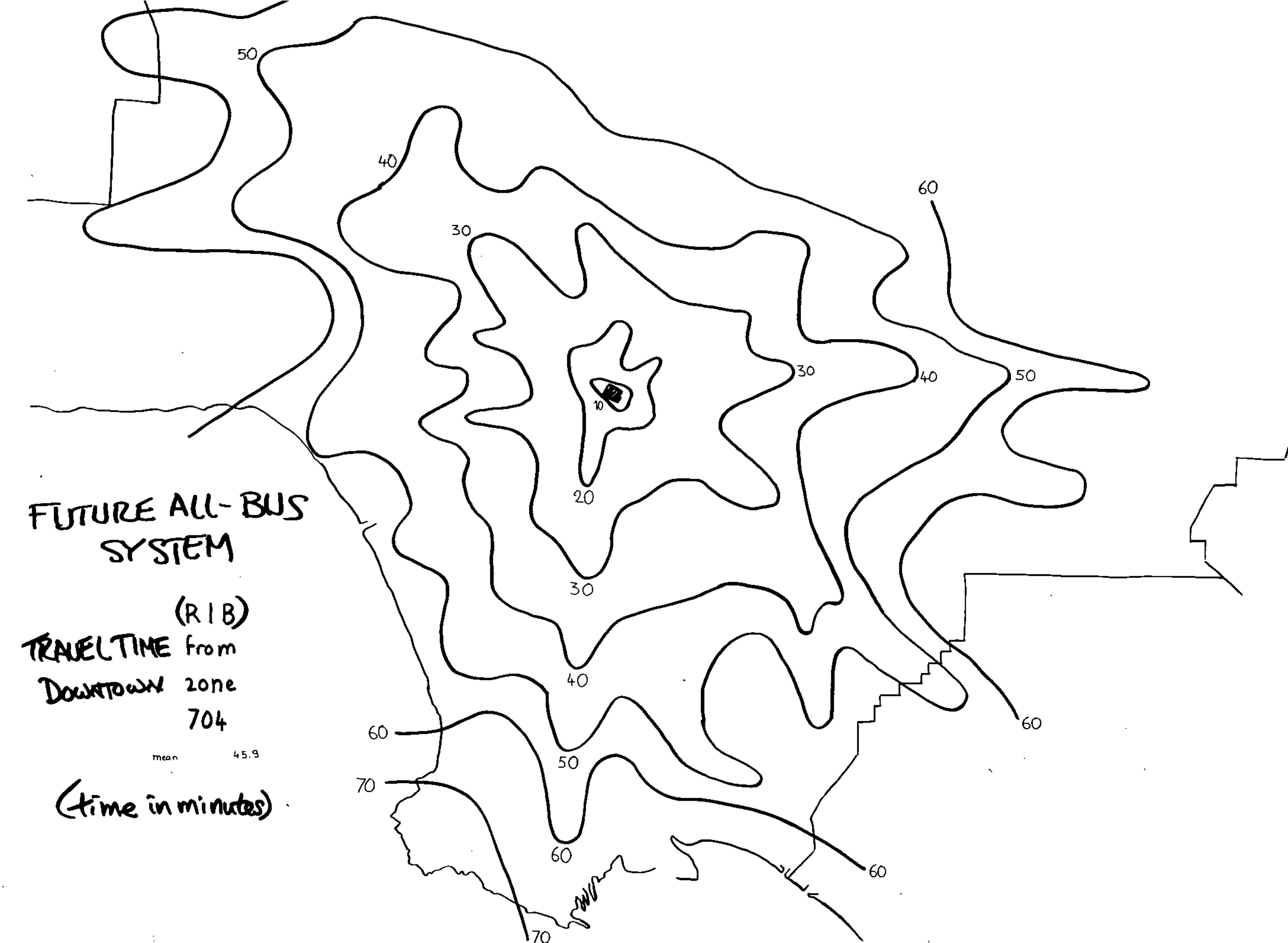
Service satisfaction is compared directly by measurement of performance results--chiefly travel time aspects. These measures were obtained for each test network by inspecting various travel-time matrices--both individually and conjointly with matrices of transit rider volumes. An indication of the relative stance of the R1 and R2 concepts on the basis of travel time is shown by the network maps on the next four pages. Contour lines of travel time via the transit system are plotted for travel to and from the Los Angeles Central City and to and from the suburban community of Lakewood. These plots are known as "isochronal" (equal time) maps.

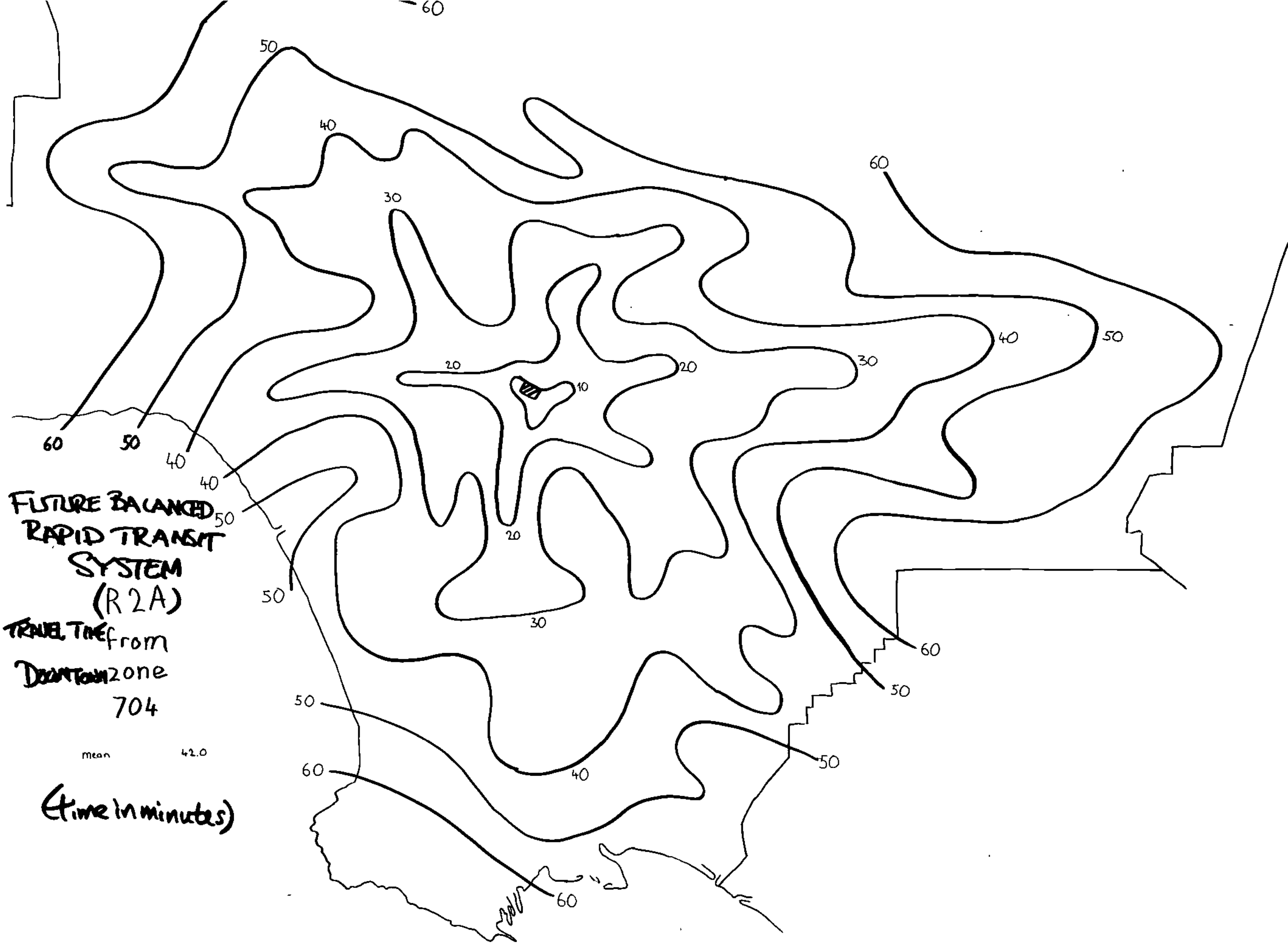


person trips
unit
transit trips
R1A
%MS
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60


person trips
unit
transit trips
R1B
% Mj
0
30
40
50
60

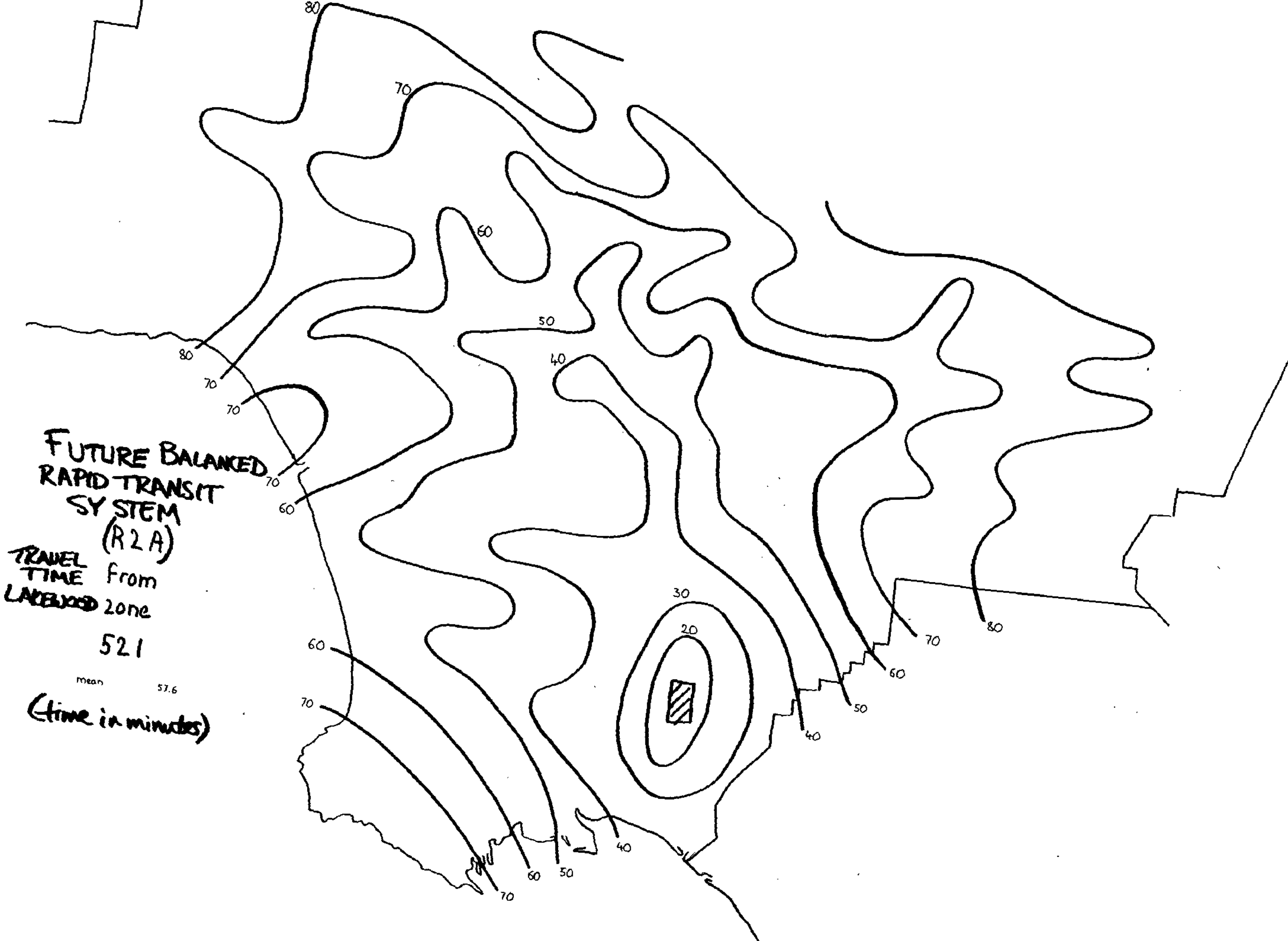

person trips
unit
transit trips
R2A
%MS
50
30
0
50
60


FUTURE ALL-BUS SYSTEM
(R I B)
TRAVELTIME from DOWNTOWN zone 704
mean 45.9
(time in minutes)
10
20
30
40
50
60
70



FUTURE BALANCED RAPID TRANSIT SYSTEM
(R2A)
TRAVEL TIME from DOWNTOWN zone 704
mean 42.0
(time in minutes)


FUTURE ALL-BUS
SYSTEM (R1B)
TRAVEL TIME from
LAKEWOOD zone
529
mean 57.8
(time in minutes)


FUTURE BALANCED RAPID TRANSIT SYSTEM (R2A)
TRAVEL TIME from LAKEWOOD zone 521
mean 57.6
(time in minutes)
80
70
60
50
40
30
20

Combination of the transit trip table for each test network with transit time tables yields another set of system performance results. Summarized in Figure 7 are statistics on total transit travel time and the transfer time component of that total for the R1 network tests and the R2A network concept. Figures 8 and 9 indicate the transit travel times and transit transfer times for trips originated in and trips attracted to each analysis district.

Congestion Relief Effectiveness

Measurement of congestion relief experienced by the highway system resulting from a particular transit system is a time-consuming and tedious process. Because of the compound effect of time constraints and problems using the Caltrans highway assignments, AMV employed a specially developed, sketch-plan highway network prepared for use in the Task 8.2 sensitivity analyses (see Task 8.2 Technical Working Paper). Highway trip tables were compressed to the 196 zones of the sketch-plan model. Trips were then assigned to the highway network using an average occupancy factor of 1.26 persons per auto.

Results of this sketch-plan analysis were plotted over the entire network for the R1 tests and on freeways for the R2 tests. Differences in impact among the test networks were found to be small, primarily because of variations in highway capacity due to differing assumptions concerning the method of managing the freeway facilities.

Freeway capacities were computed according to the following assumptions:

- R1A--major priority for buses: exclusive bus lane with 55 mph maximum speed; other auto lanes with maximum capacity
- R1B--moderate priority for buses: metering of all traffic with 40 mph maximum speed
- R2--fixed guideway with bus: metering of all traffic with 40 mph maximum speed on freeways with priority bus operation

FIGURE 7. TRANSIT TRAVEL TIME RESULTS

	Transit System Test Network		
	R1A	R1B	R2A
Total Transit Travel Time (minutes)	32, 807, 447	32, 259, 403	30, 165, 640
Average Travel Time (minutes)	28.5	29.6	27.4
Transfer Time (minutes)	3, 515, 367	3, 393, 109	4, 216, 529
Average Transfer Time (minutes)	3.1	3.0	3.8
Transfer Time As Percentage of Total Travel Time	10.7%	10.2%	14.0%

Figure 8

TRANSIT TIMES (in minutes)

(TR4 + TR5 + TR6 + TR7 + TR8 + TWT1 + TWT2 = TRANSIT RUN + TWT1 + TWT2)

DISTRICT	R1A		R1B		R2A	
	A	P	A	P	A	P
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	1 058 570	1 271 832	1 096 022	1 291 951	973 119	1 118 685
5	838 655	1 136 349	840 185	1 155 174	784 923	1 054 909
6	334 278	678 619	329 036	679 875	326 834	675 522
7	0	0	0	0	0	0
8	998 802	1 477 360	1 001 650	1 496 291	927 211	1 350 400
9	6 072 638	3 900 999	6 166 112	3 984 312	5 833 415	3 719 683
10	1 556 837	2 975 618	1 560 261	3 041 007	1 474 444	2 925 131
11	1 876 655	2 299 734	1 859 728	2 313 892	1 748 023	2 143 277
12	744 472	1 374 508	724 906	1 364 355	634 064	1 284 104
13	1 591 372	2 113 995	1 577 554	2 119 530	1 373 433	1 827 469
14	3 784 539	2 534 537	3 832 396	2 596 482	3 548 427	2 347 028
15	1 394 485	2 609 652	1 381 731	2 674 120	1 296 336	2 412 941
16	1 457 783	1 777 676	1 448 290	1 784 085	1 185 131	1 489 200
17	7 733 504	974 854	8 124 549	930 218	7 022 997	859 910
18	1 165 892	2 709 069	1 160 140	2 739 621	1 100 705	2 545 462
19	1 953 580	3 268 546	1 940 485	3 334 946	1 754 451	2 974 590
20	451 426	784 837	446 277	783 132	370 764	657 442
21	313 841	369 797	304 741	372 151	240 511	290 099
22	64 591	287 907	59 431	277 573	57 132	273 164
23	2 297 411	2 898 352	2 246 317	2 841 982	1 848 482	2 357 502
24	391 725	477 163	382 907	461 578	301 033	370 396
25	126 151	316 186	120 181	298 224	124 952	310 103
L.A.	33 357 312	32 257 582	33 794 663	32 724 142	30 655 418	29 675 862
Region	36 237 190	36 237 190	36 603 499	36 603 499	32 987 017	32 987 017

Figure 9

TRANSIT TRANSFER TIMES (in minutes) (TWT2)

DISTRICT	R1A		R1B		R2A	
	A	P	A	P	A	P
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	100 582	116 637	96 511	110 717	160 035	148 615
5	107 855	117 642	104 599	114 278	129 877	150 013
6	47 259	65 972	45 238	61 705	55 825	90 560
7	0	0	0	0	0	0
8	82 320	125 142	79 223	120 667	120 356	174 918
9	547 422	408 712	540 418	406 121	684 933	497 698
10	154 815	328 069	151 497	322 290	205 509	401 681
11	231 848	260 456	225 996	251 625	257 088	307 579
12	112 600	144 935	104 342	133 975	113 418	148 872
13	226 631	247 762	213 847	235 090	237 451	270 668
14	479 340	279 883	459 042	274 257	533 754	353 833
15	184 328	350 247	177 093	338 419	200 264	376 651
16	181 358	192 907	170 781	177 873	202 093	225 565
17	576 452	83 353	568 327	82 929	767 878	110 757
18	151 882	279 214	146 504	271 434	180 054	348 047
19	273 260	363 563	263 365	352 111	316 323	446 692
20	52 484	75 179	46 589	66 600	51 612	73 578
21	43 958	36 666	39 661	33 093	45 884	44 976
22	5 653	23 690	4 741	21 859	7 756	35 442
23	332 670	354 684	308 124	336 991	366 727	337 155
24	51 916	66 411	49 521	64 021	53 368	64 194
25	15 047	38 556	12 809	32 173	14 279	36 990
L.A.	3 554 394	3 476 339	3 433 033	3 353 184	4 262 354	4 170 703
Region	3 959 680	3 959 680	3 808 228	3 808 228	4 644 484	4 644 484

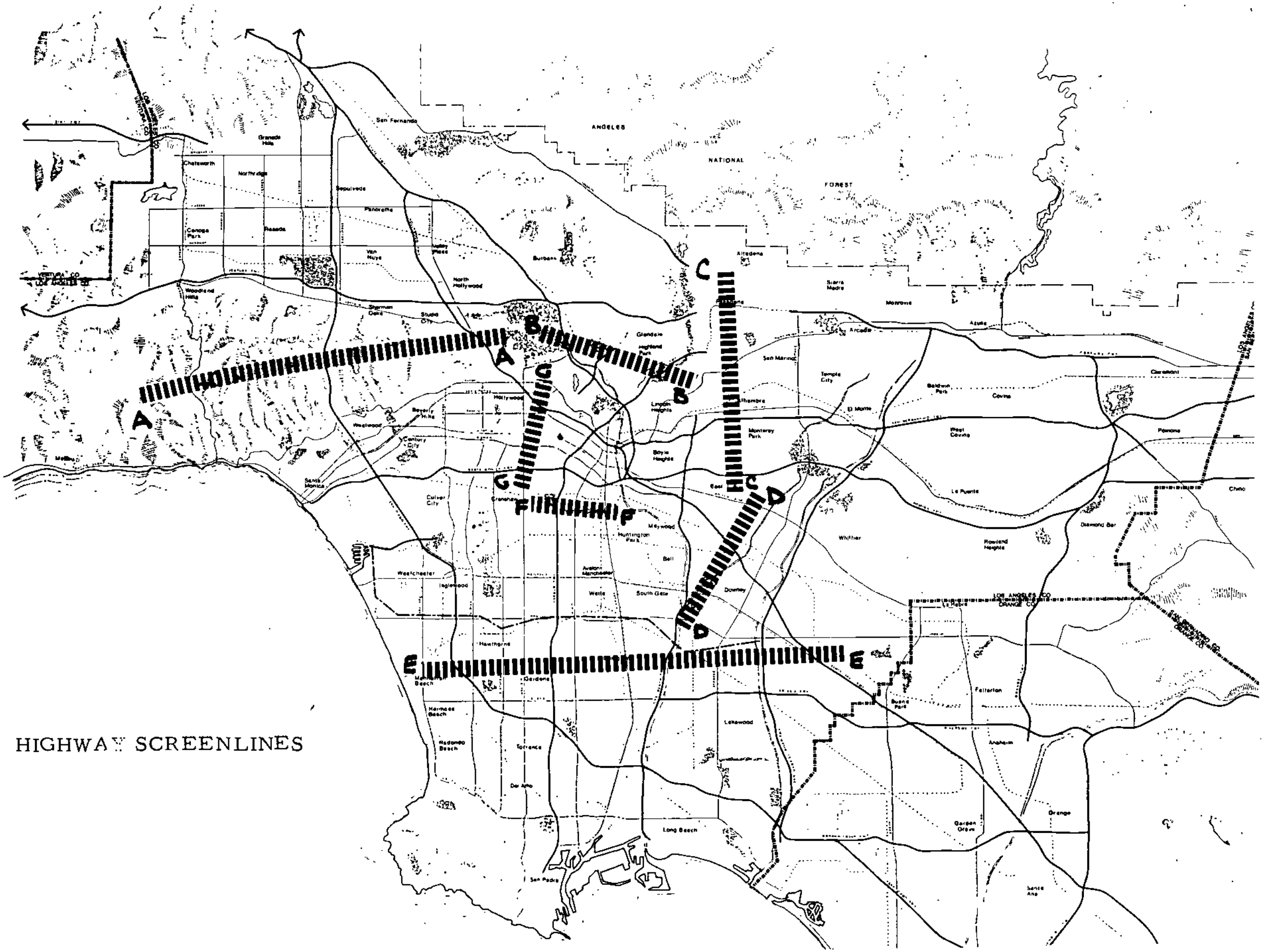
Capacity figures were adapted from the instructions included in the SCAG Transportation Plan Evaluation Process report. Major arterial streets were selected for inclusion in the analysis. Basic capacity for an arterial was assumed to be 45,000 vehicles per day; capacity for an individual arterial may have been adjusted because of special circumstances.

Because of the nature of the sketch-plan highway network, AMV felt that the best manner in which to analyze congestion relief effectiveness was to directly inspect a series of screenlines. A screenline represents an imaginary cross-section, cut across a system of arterials and freeways.

Sixteen screenlines were identified and inspected. Seven screenlines (representing combinations of the sixteen) were selected for discussion purposes and are shown in Figure 10. Comparison of highway travel demand with capacity for each of these screenlines is given in Figure 11. It is clear that greater congestion relief is obtained with the fixed-guideway concept of the R2 tests than with either of the all-bus-priority concepts. Even with fixed guideway, some of the screenlines retain a capacity deficiency. The difference in impact between fixed guideway and the R1B moderate-priority concept is not great because there is extensive moderate-priority bus service included in the R2 concept. The R1A major-priority concept of reserving an exclusive bus lane effects the least congestion relief. The impact of R1A is probably not as great as shown here, since in reality the auto traffic lanes might experience some further capacity reduction due to buses weaving to enter and leave the exclusive bus lane.

While the scope and time constraints of the study precluded the exercise, the next step beyond the comparison of highway travel demand and capacity attributable to each transit concept would be to revise the highway network parameters to reflect the degree of congestion relief. Following that, new transit patronage forecasts would be developed and the process would be repeated until a balanced state is reached.

Figure 9



HIGHWAY SCREENLINES

FIGURE 11. COMPARISON OF HIGHWAY TRAVEL DEMAND AND CAPACITY FOR SEVEN SCREENLINES

Screenlines	Travel Demand	R1B Moderate Priority		R1A Major Priority		R2A Fixed-Guideway	
		Capacity	Ratio(1)	Capacity	Ratio(1)	Capacity	Ratio(1)
A	389,530	400,000	0.974	380,000	1.025	450,000	0.866
B	527,638	530,000	0.996	500,000	1.055	580,000	0.910
C	890,146	830,000	1.072	810,000	1.099	830,000	1.072
D	637,804	540,000	1.181	520,000	1.227	540,000	1.181
E	1,783,721	1,620,000	1.101	1,570,000	1.135	1,650,000	1.081
F	390,567	430,000	0.908	420,000	0.930	430,000	0.908
G	694,720	730,000	0.952	725,000	0.958	780,000	0.891

Note: (1) Ratio = demand/capacity

Safety Effectiveness

While not attempting to quantify reduction of accidents in terms of dollars or even lives saved, AMV did measure the relative performance of the test networks in reducing vehicle-miles and vehicle-hours traveled by automobile. Application of accident rates (and values) by type to the resultant vehicle-mile (or vehicle-hour) statistics could give a projected safety benefit.

Residual highway statistics were developed by combining the highway trip table resulting once transit system trips were accounted for with the following two matrices:

- Highway distance matrix (for H3N) to get vehicle-miles traveled
- Highway travel-time matrix (for H3N) to get vehicle-hours traveled

These residual statistics are given in Figure 12 for the R1 and R2 concepts. The statistics compare very closely across test networks, varying by no more than one percent.

INTERIM EVALUATION OF TRANSIT SYSTEM CONCEPTS

Of the many proposals for Los Angeles transit, the two major technical approaches to the problem might be classified (for ease of exposition) as

- Fixed Guideway--high-speed vehicles on fixed guideway
- All-Bus--buses operating on highway lanes reserved for their use; exclusivity of use ranging from none to complete

To reach final recommendations, widely divergent schemes using these systems and combinations thereof have been investigated.

FIGURE 12. HIGHWAY STATISTICS AFTER ACCOUNTING FOR TRANSIT TRIPS(1)

	Transit System Test Network		
	R1A	R1B	R2A
Remaining Highway Trips:			
Persons	22, 187, 720	22, 215, 584	22, 136, 439
Vehicles	17, 609, 300	17, 631, 400	17, 568, 600
Vehicle-Miles	135, 217, 900	135, 637, 900	134, 480, 900
Vehicle-Hours	47, 665, 100	47, 808, 800	47, 420, 700

Note: (1) Statistics for Los Angeles County only.

Large-Scale Fixed-Guideway Systems

Heavy use of fixed-guideway systems could provide a reasonable response to the problem. Despite the fact that costs are high and the system takes time to build, most of the large cities in the world have reached this conclusion. The system is high speed and reliable and can be located in the most dense areas, especially with intensive use of subway operation, and it is compatible with environmental and energy issues.

Los Angeles is not, however, a typical city--with its large area, low density, extensive system of freeways--and, although a system of fixed guideway could generate reasonable volumes, an all-bus operation is warranted in conjunction with any fixed-guideway elements.

Bus Priority Approaches

The biggest single cost of a fixed-guideway system is typically the construction of the fixed guideway itself. Could all or some of it be replaced by an all-bus system making extensive use of freeways and streets? An all-bus system utilizes existing freeways and the street system in conjunction with operational restrictions on existing traffic; reserve lanes, ramps, and sometimes whole street sections are designated for the exclusive use of buses. These bus facilities allow buses to operate at high speed, separated from interaction with other traffic. Reserved lanes generally carry fewer vehicles than before and fewer than adjacent lanes. However, because of the high occupancy of buses as compared with other vehicles on the road, the passenger-carrying capacity of the lane is much increased. There are, however, a number of other factors to be carefully considered: rider attractiveness in terms of time and cost; image held by potential riders and the public at large; service reliability and dependability; proven operating record; and total annual cost (operating plus capital). In general, something of value will be relinquished in order to conserve scarce capital and substitute a low-cost solution.

For two decades, U. S. planners have sought ways to make use of the emerging urban freeway programs for express bus purposes, and in theory it should be a good idea. However, no city has developed more than a single bus-on-freeway project (i. e., a network of bus-on-freeway routes has never materialized) creating a vacuum of technical operating information on which to base decisions. The absence of such a large system has also created a sense of uncertainty among public officials on the wisdom of choosing bus-on-freeway transit at its lower initial cost over a proven rapid transit technology.

There are major technical questions for large bus-on-freeway systems in most large cities. Among them are (1) how to provide transfer of riders between buses while on the freeway and at freeway interchanges--because it is not feasible to give everyone a direct point-to-point bus ride and (2) how to handle the large number of buses downtown as well as in other major activity centers. These and other questions are discussed below. As there is little experience on which to draw, there are no real answers to all the questions surrounding large all-bus schemes. We must carefully weigh the probability of successful experimentation and then commit to forthright demonstration of the most attractive concepts. The risks are low, the payoff is potentially high.

Los Angeles is perhaps uniquely able to use an all-bus concept because of its large network of freeways. The use of exclusive lanes on the freeways of the Los Angeles basin, for example, at once provides an exclusive transit facility. Reservation of lanes for bus priority use can be accomplished on arterial streets also; in fact, reserve lanes on arterials are in operation currently in many cities throughout the world. A study of this subject last year indicated that there were a number of opportunities for such improvements in the Los Angeles area.[1] Experience with arterial exclusive bus lanes has shown their capability to provide faster bus service, often with only few disbenefits to other traffic. The recent

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[1]Alan M. Voorhees & Associates, A Special Program of Low-Capital-Cost Transit Improvements for Los Angeles, prepared for SCRTD, July 1973.

Los Angeles study indicated that average bus speeds could be increased from 12 to 15 mph through a combination of exclusive bus lanes and traffic signal improvements. By coupling these changes with express bus service, it is possible to increase the average speeds to as much as 20 or 25 mph in some cases.

Freeway bus lanes could potentially provide speeds of 45 to 55 mph, or in the same range as the line-haul portion of fixed-guideway systems. Trips of 10 miles or more would be accommodated within a 25- to 30-minute period. The need for service for trips in the 5- to 15-mile trip length (which in 1990 are expected to make up at least 20 percent of all trips and at least 60 percent of all person-miles of travel) is one justification for the major fast link segments of fixed guideways and/or freeway portions of an all-bus system. Arterial bus lanes are a necessary component of any all-bus system, but they do not replace or eliminate the need for the high-speed freeway links required to handle the longer trips.

Local officials should move aggressively toward development of several arterial bus priority projects to determine their feasibility in actual operation and especially to determine the actual savings achievable in travel time. For example, the operation of local and express buses in the same lane, while feasible, will probably result in some diminishing of the express bus potential speed. The recent proposal by the City of Los Angeles[1] for bus lanes in the Wilshire corridor called for several route jags to provide movement from a crowded street segment to a less-congested parallel segment. These and other necessary features of arterial bus lanes may reduce average express speeds to 20 mph or 3 minutes per mile.

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[1]Department of Traffic, City of Los Angeles, Priority Bus/Multi-Occupant Vehicle Priority Lanes on Arterial Streets, July 7, 1973.

In the R1B scheme, the same saturation bus approach was applied except that lower freeway bus speeds and off-freeway passenger stops were assumed, producing lower performance and lower patronage. Such freeway bus speeds in practice might be 20 to 40 percent lower than in the R1A concept.

The R1B scheme would utilize bus priority lanes on local streets and special exclusive ramps for access to freeways which were assumed to be metered to reduce delays and congestion. The lower-performance all-bus scheme analyzed would rely on a major freeway control system, with ramp-metering throughout the region. Such a scheme is a part of the development plans of Caltrans. The method involves limiting the number of vehicles entering the freeway through control signals so that the freeway never gets overloaded and relatively high speeds can be maintained. Lines of motorists awaiting their turn to enter the freeway would constitute a barrier for expeditious entry of transit vehicles. To overcome this, it is proposed that special exclusive bus entrance ramps be constructed. The buses gain a travel time advantage by bypassing the vehicles waiting at the entry ramps and by travelling on the controlled freeway at auto speeds. Buses on the freeway would be freely mixed with other traffic and travel at similar speeds. Where possible, park-and-ride parking lots would be provided at entrance ramps to encourage motorists to shift to buses.

Success with the Caltrans control scheme is essential to R1B bus-on-freeway schemes; it will be an experimental program without region-wide experience. It is assumed that this program would be moderately successful in providing congestion relief but would provide neither 100 percent free-flow conditions nor eliminate all congestion-producing incidents. Some delays would occur from time to time, and bus schedules would need to be based on occasional delay conditions rather than on average conditions.

In the R1B scheme, the buses would operate in two modes while on the freeway: (1) some would operate express to downtown and to a limited number of other major centers and (2) others would operate in a limited-stop mode, collecting and discharging passengers adjacent to the freeway in a skip-stop concept, with buses leaving the freeway by ramp to the local street. Simple bus shelters would be the only facility at most such stops. The bus would then re-enter the freeway via a ramp-meter bypass.

In both R1A and R1B schemes, most buses would collect passengers on local streets by cruising through local neighborhoods; they would then enter the freeway, stopping only at major transfer points, and leave the freeway for distribution on local streets. A dense network of regular fixed route buses operating on local streets would also provide for short trips and local circulation needs.

One of the potential advantages of all-bus schemes is the ability of a bus to perform both the collection/distribution and the line-haul function, eliminating the need for a passenger transfer. However, this advantage is more theoretical than real because a no-transfer ride requires a single vehicle to make the trip between the passenger's origin and his destination. Our studies have shown that over 1.7 million separate and distinct bus routes would be required to provide for nonstop service between all the potential service areas in Los Angeles. Moreover, the number of passengers moving between these points is such that a 50-passenger bus could be filled on the average only twice per day or less. Since 10- to 15-minute headways would be required to provide an acceptable passenger waiting time, it is clear that very few interpoint combinations would justify nontransfer service. Even the richest transit trip generation in Los Angeles, the central business district (CBD), would justify nonstop, nontransfer service from most areas only if headways of 1 hour or more were scheduled. Generally, the passenger would be better served by providing more frequent service with an intermediate transfer than with direct but infrequent service. Thus, while on cannot specify precisely the most effective method to operate an all-bus system, it is likely that major transfer points will be required at intersections of major links and passengers will be required to transfer at least once for most trips.

Alternative Systems

Two other test system networks were conceptualized, employing a mix of all-bus and fixed-guideway schemes. These networks--R2A and R2B--provide high-speed rail service to major corridors of the region and are responsive to the views expressed in citizen responses over the past several months. This concept assumed that an extensive network of local feeder buses would serve the stations. All-bus schemes are also assumed in those corridors where rail service does not exist.

Figure 11 has earlier shown the capacity estimated for each of the several concepts. It may be observed that all of the concepts serve patronage substantially above present levels. This can be explained in part by the fact that the area will be growing during the period between now and 1990; in addition, the added bus service included in all the systems tested results in additional riders. Restrictions on auto use, high parking taxes, altered land use, and so on will affect the alternatives proportionally; studies of these conducted in Task 8.2 will not select the preferred system but rather suggest the capacity of the recommended system.

R1B gains substantially less ridership than R1A, even though both represent all-bus schemes. The difference between the concepts lies in the differences in the assumptions about the speed performance to be expected on the freeway bus portions of the system. It was assumed, for example, that the R1B freeway bus links were metered freeway links with special bus entrance ramps. Average schedule speed of the freeway portion of the system was about 28 mph, whereas the equivalent rate for R1A was about 35 mph.

R1A is more attractive to nondowntown (i.e., crosstown) transit travel than the R2 networks. However, all concepts are equally attractive to the central city. Regional benefits in terms of travel time savings, reduced highway loads, and secondary benefits stemming from these measures thus should be similar for each concept. This has been documented in an earlier section of this volume.

Unanswerable Problems With All-Bus Schemes

Analysis of all-bus systems reveals a number of major problems which tend to subdue the otherwise strong attributes of the all-bus approach. The most serious concern about such systems is whether they will work, under what conditions they will work, and how well they will work. All-bus schemes have been recommended as the best low-cost method of establishing high-speed transit in a city at low expense for almost two decades. Thus advantages have been apparent ever since large freeway systems have been contemplated for large urban areas. In spite of its obvious advantages, however, no city has ever implemented such a system.

Accidents and other capacity-impairing incidents frequently occur on freeways. Delays will occur under bus-priority operation, but studies have shown that delays for buses under these conditions are fewer than if there were no priority lane on the freeway. Freeway operation in a priority lane with carpools is more likely to cause delays due to increased likelihood of accidents or breakdowns of cars. Priority operation is generally in the left-hand lane, which means for most Los Angeles freeways there is no breakdown lane. There are also no breakdown lanes on CBD streets or on ramps onto freeways. Delays caused to buses on freeways will increase if the ramps onto the freeway do not allow bus priority or if there is congestion in the streets near the ramps.

To make priority bus ramps[1] successful, there must be

- Adequate space for waiting vehicles
- Adequate alternate routes for traffic diverted from the entrance ramp

If no alternate routes exist, traffic is forced to either back up on the ramps, causing possible intersection congestion, or seek entrance ramps

[1]Everall, Paul F., Urban Freeway Surveillance and Control, November 1972.

further upstream. Extra capacity is generally available where the freeway has continuous frontage roads or on parallel arterial streets. Capacity at terminals and transfer stations downstream must be sufficient to prevent backups and consequent loss of travel time savings by use of priority ramps. When buses enter the freeway, they must weave to the median lane, which increases the congestion in lanes downstream from the entrance ramp and further increases travel time for local traffic entering the ramp.

Energy Consumption-- The all-bus system also is a greater user of oil and petroleum products than the fixed-guideway system. With current and future shortages of oil, any system that uses less oil per passenger-mile is advantageous. Tables of vehicle fuel consumption within the United States show the following consumptions for various vehicles:

Vehicular Fuel Consumption

		Vehicle Miles Per Gallon	Vehicle Occupancy	Person Miles Per Gallon
Car	National Average	12	1.4	16.8
	Congestion	7	1.4	9.8
	Urban Average	9.8	1.4	13.7
Bus	National Average	4.1	15 - All Day Average	62
	City in Peak	4	40 - Peak	160
	Intercity	6	40 - Peak Average	240
Rail		2	60 - All Day	120
			200 - Peak	400

$1/\frac{136,000}{3}$ BTU = 1 gallon, where 1/3 = efficiency of conversion of gas to electricity

Considering all-day averages, fixed guideway is the most economical user of energy, with twice the person-mileage per gallon of all-bus and seven times that of cars. Note, however, that these figures rely heavily on vehicle occupancy and efficient loading of vehicles. For example, in the peak hour, the efficiency of fuel consumption is much increased for both schemes. Figure 13 shows the fuel consumption as a function of mode split for all-bus operation.

Air Pollution--Improved transit will result in a reduction of automobile travel in the Los Angeles region and consequently a reduction in air pollution caused by automobiles (one of the major contributors). This reduction will be of greatest benefit in the CBD and other high-density locations. Fixed guideway does require electric power, and an amount of pollution will occur in the vicinity of the generating plants. All-bus operation will emit air pollutants on the freeways and city streets. The following table shows the major sources of air pollutants and their effects.[1]

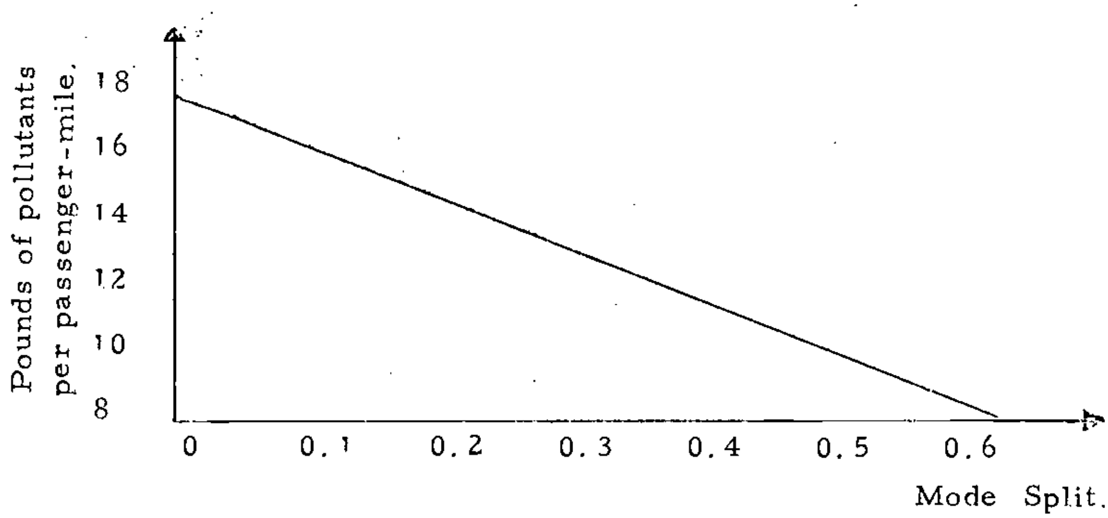
MAJOR COMPONENTS OF AIR POLLUTION AND ASSOCIATED EFFECTS IN THE TRI-STATE REGION

Pollutant	Primary Emitters	Effects	
		In Laboratory	In Present Regional Concentrations
Carbon monoxide	Motor vehicles	Kills animals	None verified
Sulfur oxides	Power plants, space heaters, industrial sources	Produces respiratory disease	Can shorten life of aged, chronically ill, and very young
Particulates	Power plants and incinerators	Produces infection	Irritating to membranes, increases cleaning cost
Sulfur oxides and particulates *combined*	Power plants and incinerators	Produces respiratory disease and infection	Can increase death rate of very old, very young, and chronically ill
Nitrogen oxides and hydrocarbons	Motor vehicles and power plants	Produces cancer	Minor eye smarting, due to good air drainage

The table on the following page shows vehicle emissions in grams per vehicle-mile in California.

[1] Bellomo and Edgerley, Highway Research Record 356, 1971.

Figure 13



Pollutants as a Function of Mode Split.
(B. P. S. Operation)

Vehicle Emissions in Grams Per Vehicle-Mile in California

	CO	HC	NO_x
Light-Duty Vehicles[1]			
1973-1974	19.0	2.70	2.30
1975	1.8	0.23	2.30
After 1975	1.8	0.23	0.31
Diesel Engines[2]			
Built before 1970	49.2	9.84	51.50
Built after 1970	32.5	3.80	76.40

Assuming a bus occupancy of 40 and a car occupancy of 1.4, the following table reflects pollutants produced per passenger-mile.

Pollutants Per Passenger-Mile in California

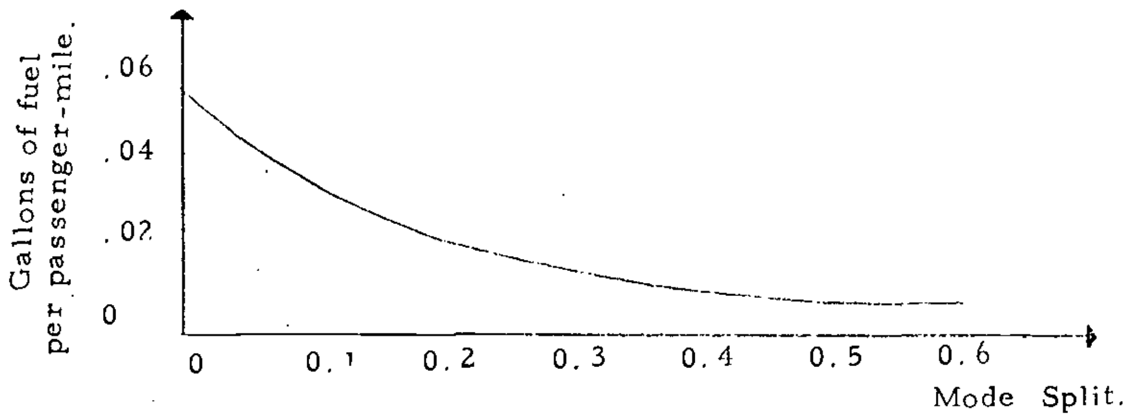
	CO	HC	NO_x
Light-Duty Vehicles			
1973-1974	13.6	1.93	1.70
1975	1.3	0.17	1.70
After 1975	1.3	0.17	0.22
Diesel Buses			
Built before 1970	1.25	0.25	1.29
Built after 1970	0.81	0.01	1.91

If buses are given priority on freeways, the mode choice will shift in favor of buses. Under 1973-1974 emission conditions, this will result in a considerable reduction in total pollutants emitted per passenger on the freeways. Figure 14 shows the effect of mode split on the amount of air pollutants per passenger-mile.

[1] U.S. Compilation (California), Air Pollutant Emission Factors, Second Edition, Research Triangle Park, North Carolina, 1973.

[2] Argonne National Laboratory, Transportation Air Pollutant Handbook, T.D. Wolsko, et al., Chicago, 1972.

Figure 14



Fuel Consumption as a Function of Mode Split.

(B. P. S. Operation)

By 1975 vehicle emission standards would result in a reduction of car emissions to slightly more than those for buses. After 1975 it is assumed emissions of nitrogen oxides will be considerably less per passenger-mile, while CO emissions will be slightly greater and HC emissions considerably greater. If it is assumed that these standards are attained and bus emissions are not controlled, or a pollution-free bus is not developed, then the effect of changing mode split is minimal. In addition, with promotion of higher car occupancy, the effect is further reduced. If a pollution-free bus is produced or bus emissions are reduced, then the bus system will result in a lessening of air pollutants. This will be important in the CBD and in stations.

Diesel buses are a well known source of unpleasant exhaust odor, particularly in congested traffic as in the CBD or in stations. The odor is easily identifiable by the public, and will be one of the issues most readily raised against high-volume bus operation. In contrast, there is no odor associated with rail operation.

Noise Pollution--The noise level of fixed guideway can be reduced to a minimum by modern design and construction techniques. Since the fixed guideway separates vehicles from other traffic, the noise impact would be small. For buses operating on freeways with other traffic and in downtown streets with other traffic and pedestrians, the noise level would be greater. Through careful design, however, engine and tire noises could be reduced to a minimum.

All-bus systems can only be implemented by initially reducing the capacity of existing highway facilities. Reserved lanes can only be truly effective where traffic congestion already exists such that transit traffic is impeded. To reduce road capacity by significant amounts at the very times and locations where traffic is at its worst is likely to be very unpopular with motorists. It is true that over the longer term, as motorists switch to the bus to take advantage of its now more favorable speeds, the greater passenger-carrying efficiencies of the bus will begin to be realized. If enough people shift to bus transportation, all traffic--both bus and car--will be improved over its original condition. Thus far, local officials throughout the country have judged that the risk of failure of an all-bus system was too great. Except in a few special circumstances, no significant all-bus schemes have been implemented on freeways where existing traffic would be likely to suffer.

Another problem that needs attention is reliability. When rail systems suffer a breakdown in rolling stock, it usually is in one motor on one car in a train several cars long. Thus, the broken train component is pushed by the others and the system continues to function. When new busways are designed, they normally have special lanes wherever possible to allow disabled vehicles to pull out of the main traffic pattern to avoid slowing the main system. On existing Los Angeles freeways, this breakdown lane may not be possible.

CONCLUSIONS ON A SYSTEM BASIS

One sees that beyond the question of public acceptability is the lack of operating experience with all-bus schemes on freeways. This deficiency causes a void in information on the best way to operate road systems using the all-bus approach. There are potentially major safety problems associated with buses moving at high speed along a lane which is not physically separated from lines of blocked cars. There are inherent problems in bus movement from freeway entrance ramps across several lanes of congested traffic to gain access to reserved transit median lanes. There are problems associated with locating special bus exit and entrance ramps for transfer stations in the midst of the most complicated freeway interchanges. There is also the problem of how to handle the large number of buses in downtown and other major activity centers. These are only a few of the problems which must be faced and resolved. Further, their resolution will require a number of experiments under actual operating conditions and, in some instances, at considerable financial risk (e.g., finding the best way to fit transfer stations within existing interchanges). This experimental nature further complicates the problem of public acceptance. It is difficult enough for local officials to force motorists into poor operating conditions when they are certain that the end result will improve conditions for all travelers and that they will not be exposed to embarrassment by an operating failure. It is almost impossible to arrive at such decisions when it is known at the outset that the end result is uncertain.

The history of all-bus systems is such that it borders on irresponsibility to recommend the deferral of a much-needed system that is certain of working in favor of a system that might or might not work. The problem is further complicated because of SCRTD's ability to make the decision to defer the construction of the fixed-guideway system, whereas they cannot unilaterally make the decision to test any all-bus scheme. One can easily imagine one agency deferring action on its plans, awaiting the outcome of experiments which another arm of local government cannot bring itself to accomplish.

Nevertheless, the benefits of the all-bus approach are of such magnitude that it should be tried before being abandoned. The conclusion of the interim evaluation of alternative concepts at the system level must be to refine the definition of the all-bus schemes and carry them into the final evaluation.

Alternative A: All-Bus Concept--Moderate Priority Measures

This alternative fully exploits the saturation bus concept, including extensive community-level circulation services, bus-on-freeway, and expanded arterial service. However, it assumes a limited degree of bus-priority measures and moderate success in terms of bus travel time performance. The concept would have the lowest capital cost of the four candidate concepts.

The limited improvement in bus performance specified here results from an assumption that a regionwide freeway metering program would be moderately successful in highway congestion relief but would provide neither free-flow conditions nor an absence of incidents, which would create congestion on some days. A bus schedule speed of about 25 mph on the freeway is assumed. Bus-on-freeway services would be given ramp-meter bypasses for priority entry at many locations, which would require construction in many cases. The buses would become mixed with other freeway traffic upon entry. New arterial services would operate as previously described in a modified grid pattern, approximately as coded in new computer tests R1 and R2.

The buses would operate in two modes: (1) while on the freeway, some would operate express to downtown and to a limited number of other major centers and (2) others would operate in a limited-stop mode, collecting/discharging passengers along the freeway in a skip-stop pattern, with buses leaving the freeway by a ramp to the local street. Simple bus shelters would be the only facility at most such stops. Major park-ride facilities would be provided. The bus would then re-enter the freeway via a ramp-meter bypass.

Near downtown, the buses would leave the freeways via bus-only ramps--some newly constructed, others existing and assigned to buses only. In the downtown area, some buses would use local streets only on a priority basis; however, many would rely primarily on off-street terminals for distribution. Operational feasibility of various ways to handle downtown distribution of bus system passengers is being investigated. New downtown bus distributor routes would be added, and a people-mover guideway distributor would be beneficial.

Alternative B: Saturation Bus Concept--Major Priority Measures

Like Alternative A, this alternative fully exploits local circulation services and the bus-on-freeway and bus-on-arterial saturation concept. However, it assumes a greater degree of success in improving bus travel time performance through greater priority for buses on the freeway. This would entail higher capital cost than Alternative A and would remove lanes from normal traffic use.

Implementation of such major priority measures would depend upon institutional, legislative, and local public policy changes concerning the manner in which the region's streets and freeways are operated. Specifically, an exclusive lane for buses would be created by using an existing lane of the freeway or arterial street. Stations, including a bus bypass lane, would be built at widely spaced intervals (probably each 2 to 3 miles) to directly serve the freeway exclusive bus lane. Development of these transfer facilities would require complete reconstruction of freeway overcrossings at a number of locations. Of course, on freeways not yet built bus lanes and transfer facilities could be designed for bus use (perhaps like the El Monte Busway or even more completely separated from other traffic).

As in Alternative A, a significant number of buses would operate in express mode, not stopping at all stations, although they would use the bus lane. Some buses would operate in the mixed freeway traffic, occasionally leaving the freeway, making a local street stop, and then returning to the freeway. Others would use only the exclusive lane stations. The exclusive lane users would weave across the freeway lanes when entering and leaving the freeway. As in Alternative A, it is assumed that an extensive and moderately successful freeway metering program is operational and peak-period congestion is reduced, making the use of freeway lanes a reasonable assumption. A bus schedule speed of about 35 mph on the freeway is assumed. Major park-ride facilities would also be provided at appropriate locations.

As with Alternative A, passenger distribution in the downtown area requires special analysis. Downtown ramps, terminals, distributor buses, and people-movers would need to be provided, but the terminals would be more extensive and costly, reflecting the greater passenger demand.

Subarea Evaluation

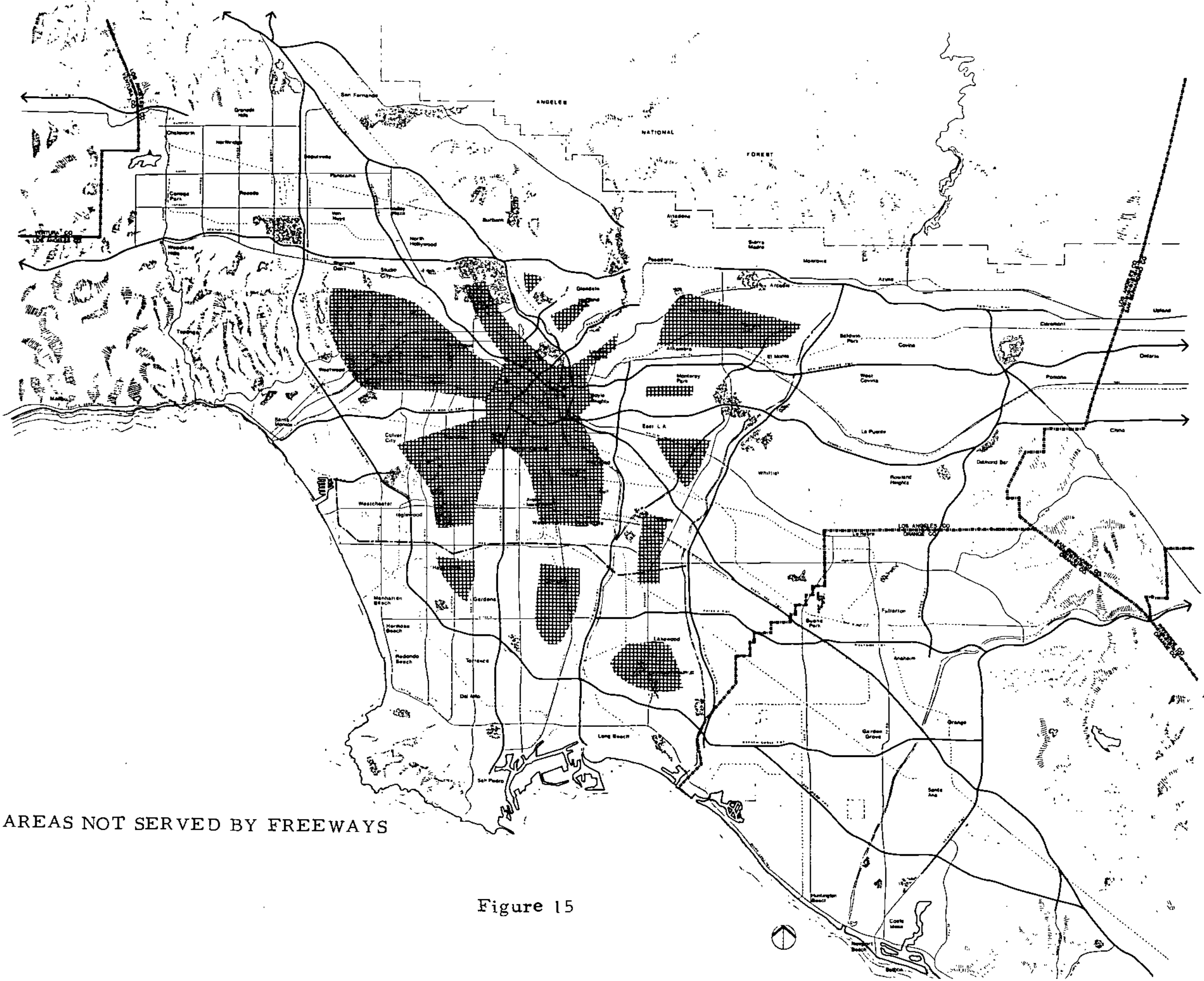
The previous sections of this report have described the service characteristics of the all-bus and fixed-guideway systems in terms of their aggregate impact on regional travel patterns. While such comparisons are useful in evaluating the overall effectiveness of a transit system, they do not provide an assessment of the levels of service provided to the various individual communities and activity centers of the region. The purpose of this section of the report is to examine the subarea service characteristics associated with all-bus to determine if, where, and how this system should be augmented to provide the desired levels of transit service to these principal subareas.

Service Area Limitations of an All-Bus System

In spite of Los Angeles' extensive freeway network, which forms the backbone of an all-bus system, there remain a number of intensely-developed areas which are not well served by a bus-on-freeway system. Figure 15 includes the extent and location of some of these poorly serviced or inaccessible sections of Los Angeles.

While the Wilshire Corridor is probably the most significant of these areas, other important areas include South Central Los Angeles, the South West Corridor, the San Fernando Valley Corridor and the Glendale-Pasadena Corridor. The characteristics of these areas relative to the need for improved transit service have been inventoried and documented since the outset of Phase I.

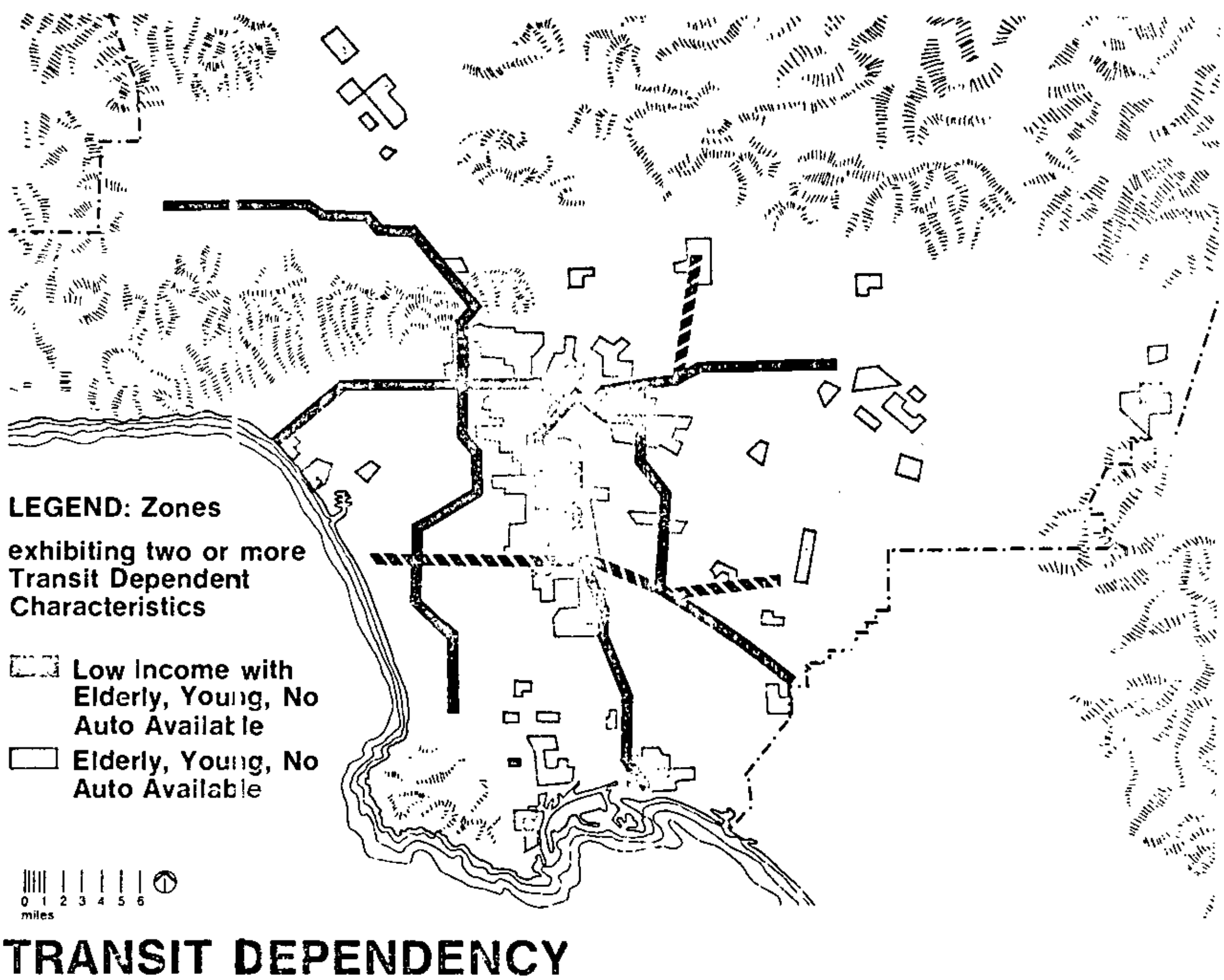
Recall Figure16 from the Phase II summary report which indicates that many of these areas exhibit high transit dependency rates. Improvement of regional mobility and accessibilities for these areas is a goal of this planning process.



AREAS NOT SERVED BY FREEWAYS

Figure 15

Figure 16


LEGEND: Zones
exhibiting two or more
Transit Dependent
Characteristics
Low Income with
Elderly, Young, No
Auto Available
Elderly, Young, No
Auto Available
0 1 2 3 4 5 6
miles
TRANSIT DEPENDENCY

Some of these areas are also major concentrations of land activity. Figure 17 from the Phase II summary report reminds us of the areas with high (ısity of population and employment. The regional core contains several of the greatest activity concentrations. The planning policy of the City of Los Angeles is to increase accessibility to and among these centers.

There are two ways that the all-bus system could be augmented to improve transit service in these corridors. The first consists of bus-on-arterial improvements. The second consists of providing limited segments of fixed-guideway transit.

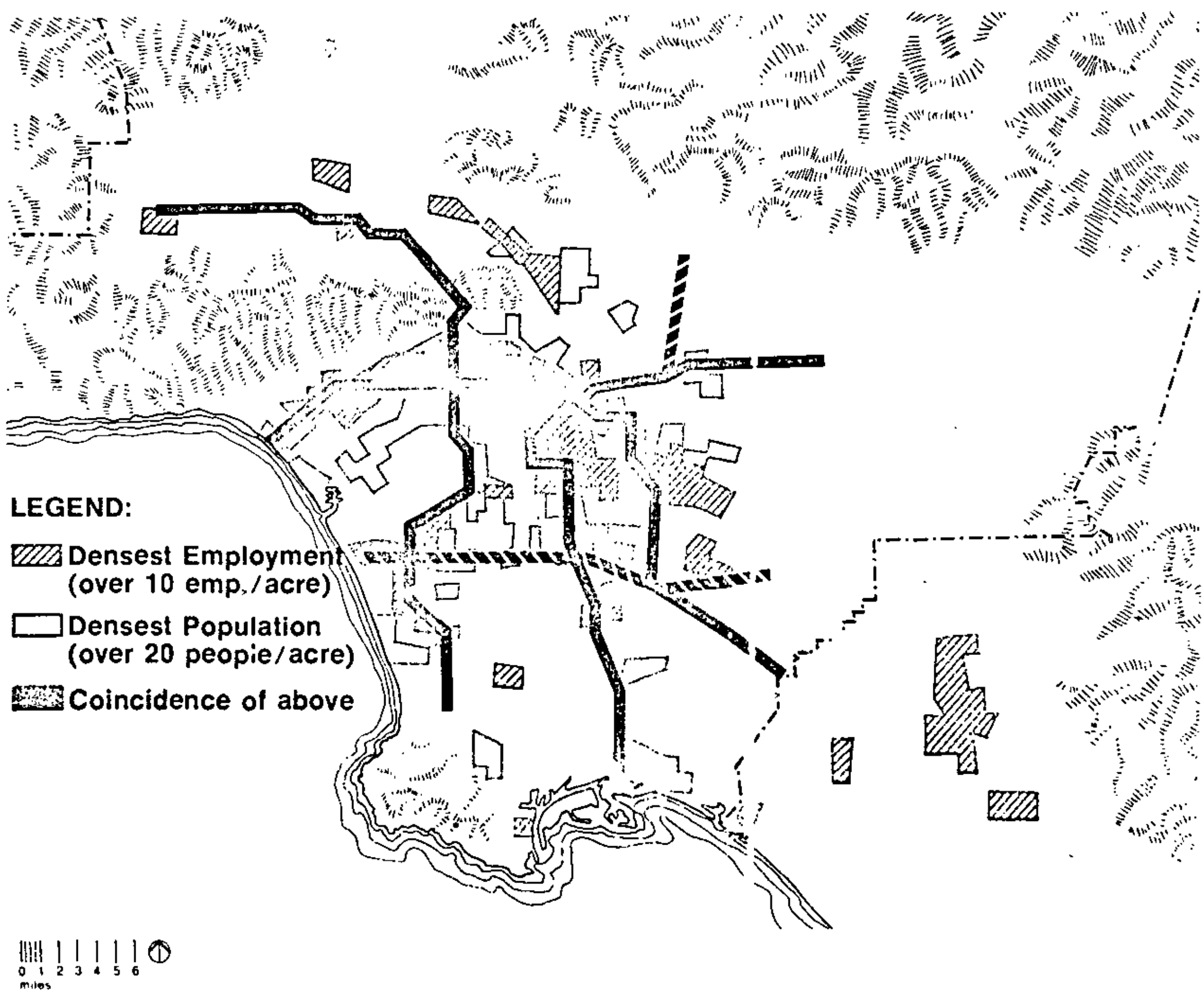
A previous study made an extensive examination of the extent to which transit service or arterials could be improved through various bus priority and operational measures. This analysis indicated that significant service improvements could be achieved when compared to existing bus speeds. Table18 indicates the speeds which could be achieved by various types of transit service through the use of bus priority lanes and signalization. As is shown in this table, limited stop service with priority lanes and signalization could achieve an overall speed of 20 miles per hour which is approximately equal to auto travel speeds.

While the concept of improved bus service on arterials appears to offer an opportunity service the previously described unserved corridors, it is unlikely that the full transit potential of these areas would be exploited by such a service. It would seem that such a program would best be used as near-term interim solution. The map on Figure19 indicates those street sections where such treatment appears applicable and feasible.

Central Area Bus Capacity Limitation

A second shortcoming of the all-bus system is the limited street capacity of the central area to accommodate a major increase in buses. Total person-trips to the CBD are expected to grow from 815,600 to 1,274,000

Figure 17



FORECAST POPULATION AND EMPLOYMENT CONCENTRATIONS 1990 (LARTS)

TABLE 18 TRAVEL TIME REDUCTION POTENTIAL

	NON-PRIORITY OPERATION	BUS PRIORITY REVERSIBLE LANE	BUS PRIORITY REVERSIBLE LANE PLUS BUS PRIORITY SIGNALIZATION
LOCAL SERVICE	12 MPH	14 MPH	15 MPH
LIMITED STOP SERVICE	16 MPH	19 MPH	20 MPH
EXPRESS SERVICE	20 MPH	25 MPH	27 MPH

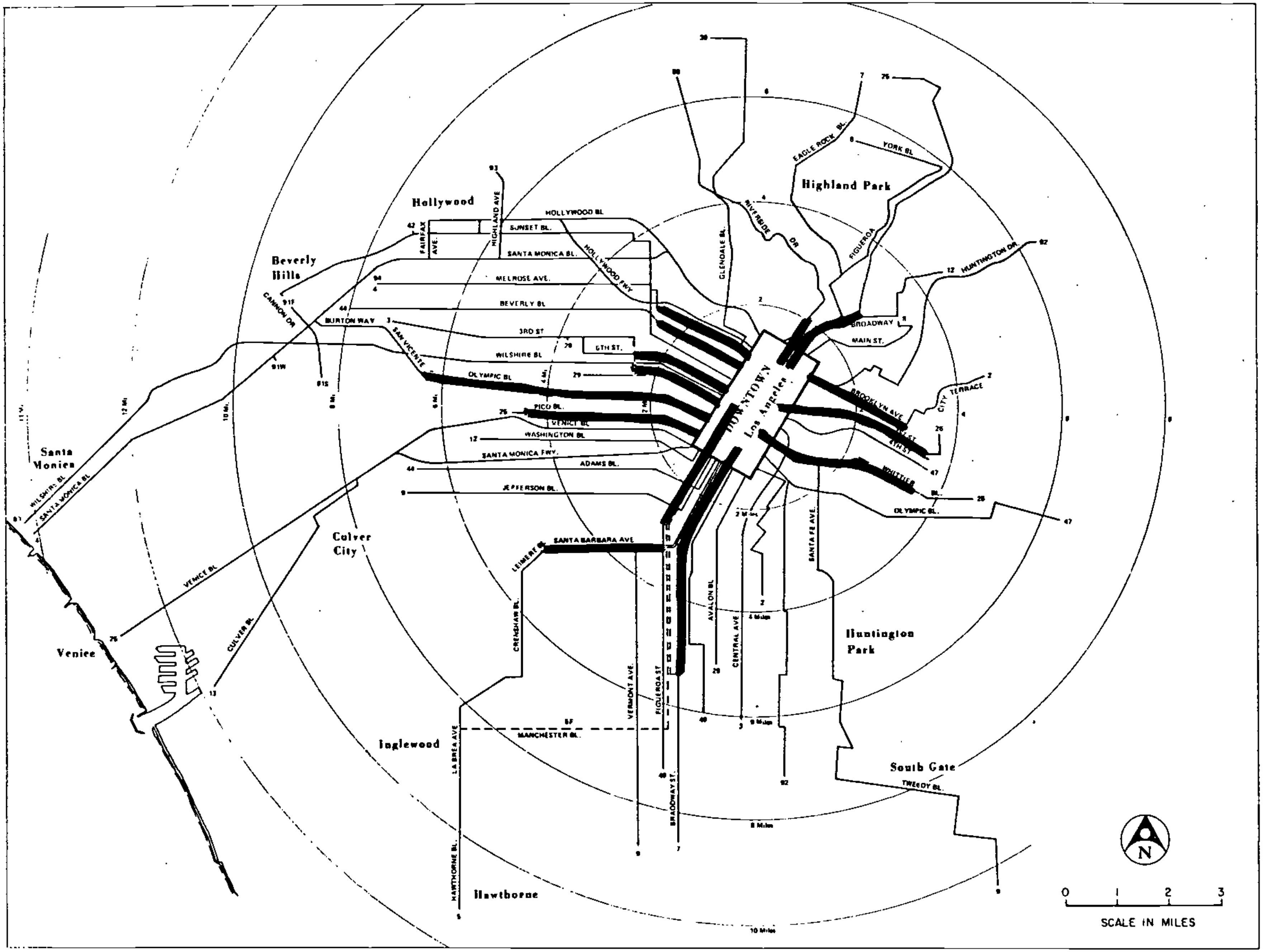


FIGURE 19 CANDIDATE BUS PRIORITY STREET LOCATIONS

or by 56 percent, from now until 1990. Construction of the MRT system provides additional transport capacity into this tight area by the high-capacity subway tunnels which would penetrate from several directions. The BPS schemes, however, must use the existing streets for distribution and collection of transit passengers within the CBD. The ability of the street system to accommodate this additional load is of considerable doubt. In 1967, the excess vehicle capacity of CBD streets was estimated to be 15 percent for level of service D and 25 percent for level of service E, while an increase in person trips of 56 percent at current modal split values results in an increase in vehicle trips of 50 percent.

Presently, some 600 buses leave the CBD during a typical weekday evening peak hour. Of these, about 250 move southbound on Hill, Broadway and Main. By 1990, these same streets, plus a few other parallel streets, will have to accommodate twice as many buses if the BPS scheme is implemented. Some additional capacity for buses could perhaps be obtained by rerouting them on Figueroa, Grand, and Olive and using bus priority on some streets. Bus priority and two lanes of traffic are possible only on First and Olive. First is a good candidate for median operation. Median operation is preferable to curb operation if the road width is sufficient, as it separates BPS from other traffic and creates a transit identify as well as a minimum of conflict.

There is insufficient road width on Broadway, Hill, Grand, and Seventh for an express lane and two lanes of traffic. Broadway, for example, has high transit volumes and pedestrian volumes. Running an express bus in the median lane cuts the through lanes for local traffic to one in the area of loading platforms and worsens overcrowded sidewalks. Curb operation would be impossible with the present corwding on sidewalks.

It would be possible to accommodate an express bus median lane and local buses in the curb lane and eliminate private vehicles from this street in the section with the express bus lane. Similar analysis could apply to Seventh Street, Grand, and Hill. This operation would improve local transit service too. If Hill and Olive are made a one-way pair, then these roads would be well suited to contraflow since they are each six lanes.

Fifth and Sixth are four to five lanes but could be used with contraflow lanes and Spring and Main, with five lanes each, would operate with contraflow lanes.

In the CBD, most curb areas are loading zones, taxi zones, off-peak parking or no parking or bus zones. Bus priority lanes, therefore, could be impacting the loading zones and taxi zones during peak hours.

First Street has unrestricted parking, which would no longer be available if a median priority lane were used. However, there is adequate parking in the area, and plans exist for new structures (Preliminary General Development Plan).

If routes are as direct as possible, in the peak hour on routes suitable for bus operation in the CBD, 1,350 buses can be accommodated. The maximum number of buses which can reasonably be moved along a curb lane during heavy loading periods is about 100. Total peak hour buses south bound would be 500 which would require 5 curb lanes.

By reserving 5 lanes for buses, it might be possible to operate the required buses if service standards were allowed to deteriorate to 5 miles per hour or less. However, the need for additional street space for cars and trucks will be even greater than for BPS scheme. It is the consultants judgment that attempts to carry all the additional buses resulting from the implementation of the BPS scheme is very risky and would be subject to a high failure potential.

Major bus transfer terminals required at the intersection of major freeway connections are likely to constitute a considerable problem that might indeed prove insolvable. It is estimated that a complete bus scheme might require 28 stations. Of these, 10 would require capacity to handle up to 400 buses per hour, 15 would need to handle from 400 to 800 buses per hour and 3 would need to handle over 800 buses per hour.

It is estimated that the first type of bus terminal would require many square feet of floor space to accommodate platforms, loading lanes, mezzanines and ramp space. Costs for such a structure would approximate 20 mill. dollars, not including land costs. Finding an appropriate location would be extremely difficult and designing the necessary ramps would likely prove even more vexing. Until a complete system were designed in some detail, it cannot be known whether such a scheme is feasible.

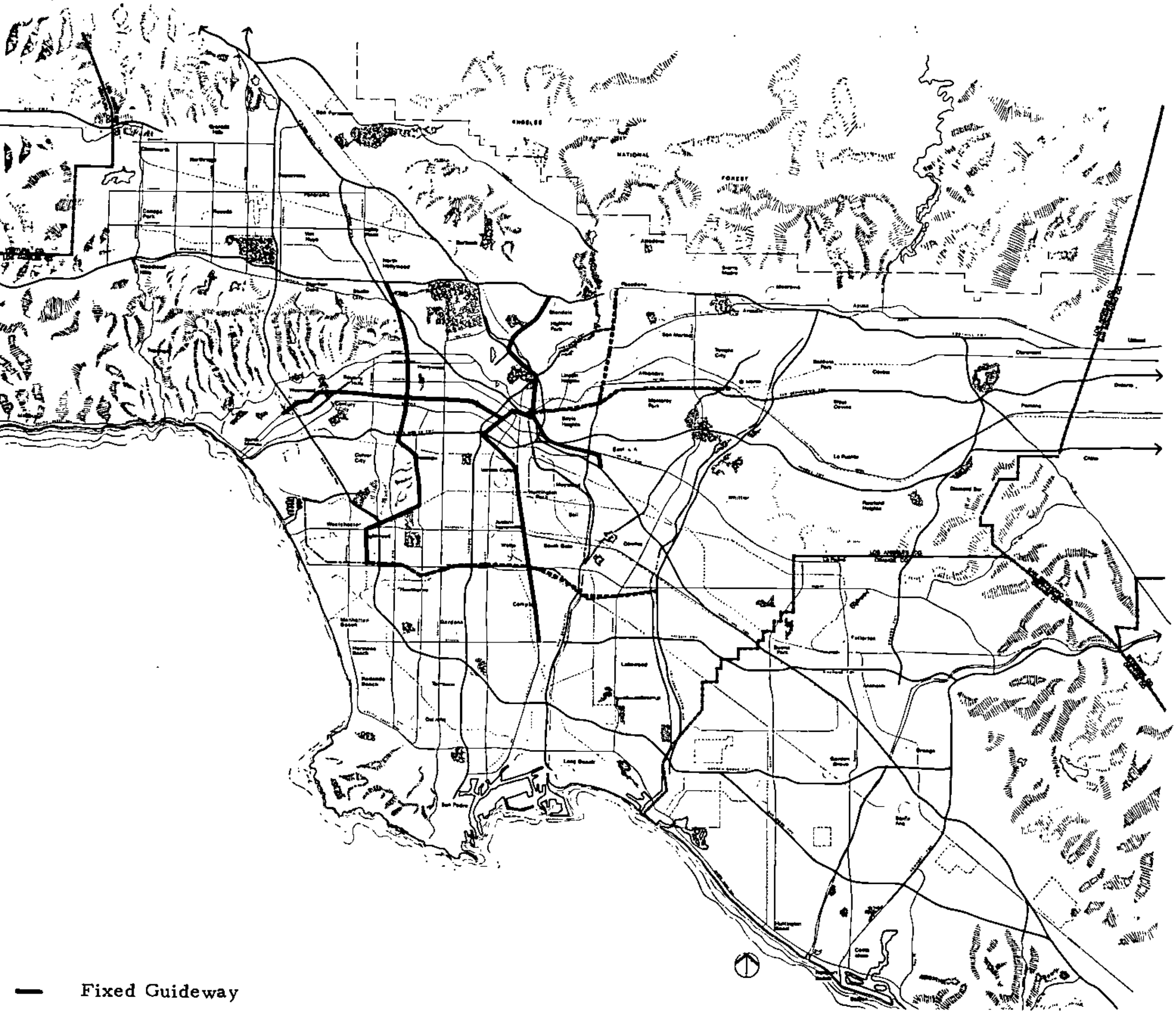
Conclusions on a Subarea Basis

From all the analyses that have been performed comparing all-bus and fixed-guideway systems, it is apparent that the final evaluation must address specifically two levels of fixed-guideway extent. The first should include guideway installation in the areas where the need to augment an all-bus system is most critical. The second should represent the extreme case of extensive commitment to fixed-guideway throughout the region. This configuring of two more top-rated alternatives should allow the most complete final evaluation of system concepts.

Alternative C. Medium-Scale Fixed-Guideway Concept

This alternative provides (1) fixed-guideway routes for the core of a regional rapid transit system and (2) bus-on-freeway routes for the outer portions of the regional system. Throughout the area, an extensive amount of local circulation transit--including feeder and distribution services--and new bus-on-arterial service is provided as in the other alternatives. The fixed-guideway elements are much less extensive than those in the Phase II proposed plan, although there is a high proportion of costly underground routes.

Bus-on-freeway routes will feed fixed-guideway stations where appropriate, requiring special facilities where passenger/bus volumes warrant them. The level of service for fixed guideway routes will be consistent with all recent SCRTD planning. For bus-on-freeway routes, buses will operate in mixed traffic, generally as in Alternative A.



— Fixed Guideway

...... Exclusive Busway

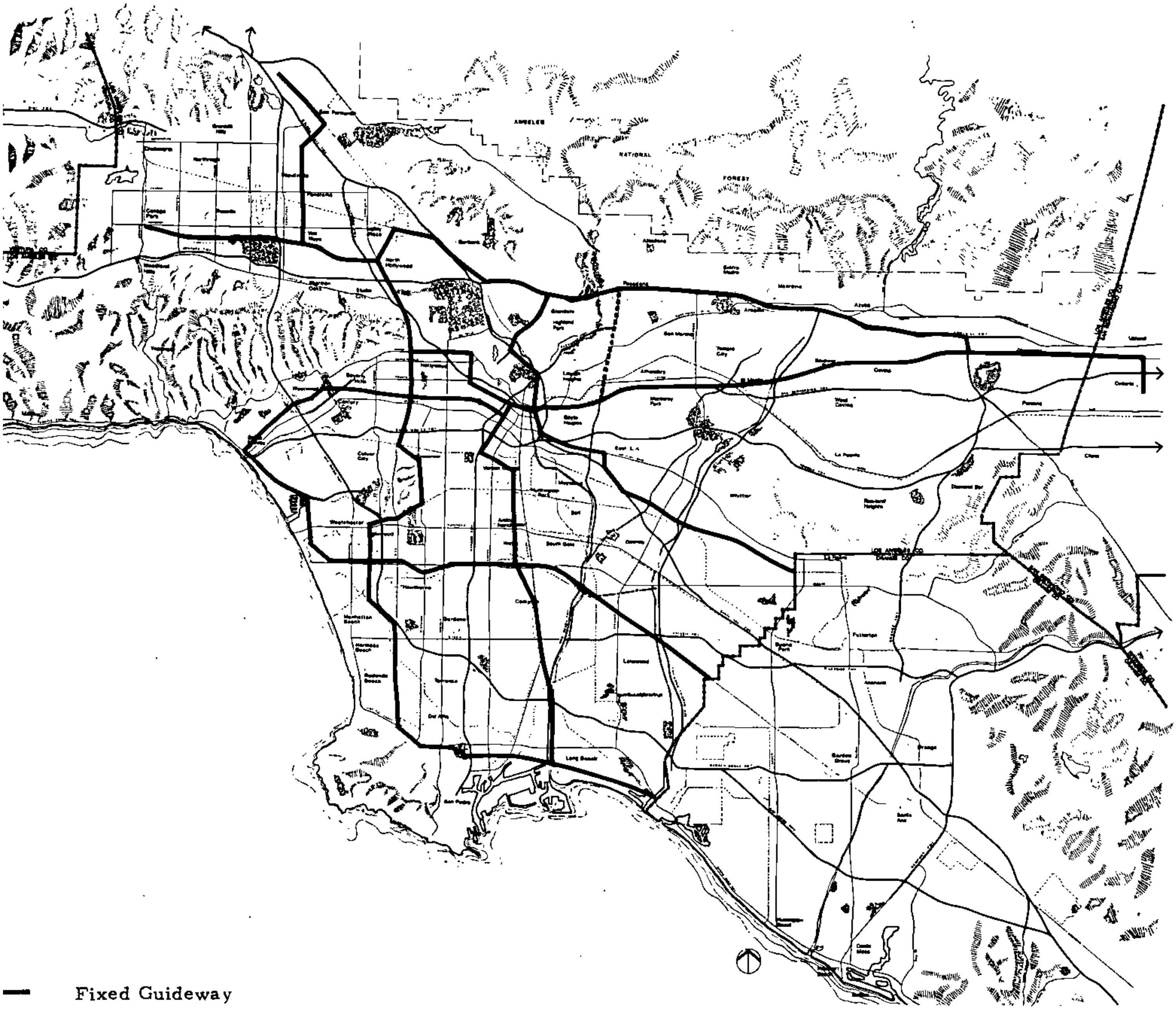
Figure 21

ALTERNATE C

Alternative D. Large-Scale Fixed-Guideway Concept

This alternative provides fixed-guideway routes for a very large part of the region. However, it too will be supplemented with bus-on-freeway service as needed to provide a complete regional system. Local circulation transit, feeder and distribution services and bus-on-arterial service will be provided as in the other alternatives. The fixed-guideway elements are much more extensive than those in the Phase II plan.

The level of service for each mode will be consistent with and similar to that of Alternative C.



Fixed Guideway

Exclusive Busway

Figure 22

ALTERNATE D

FINAL EVALUATION

Operating Results for Top-Rated Concepts

Estimates of patronage, revenue, and operating costs were made for the four top-rated concepts, identified as Alternatives A through D. Briefly, the alternatives are

- Alternative A--All-bus with lower freeway bus speeds (buses mixed with other traffic but with metered-ramp bypass)
- Alternative B--All-bus with higher freeway bus speeds (buses on exclusive lane)
- Alternative C--Medium-scale development of fixed guideways and substantial amounts of bus-on-freeway service
- Alternative D--Large-scale development of fixed guideways supplemented by limited bus-on-freeway service

All procedures used for the preliminary alternatives (R1 and R2) were used here. In addition, the following cost items were applied:

- Increase all estimates by 6 percent to reflect cost increases from 1973 to 1974.
- Add a lump sum estimate for freeway control costs which might be allocated to bus operations.
- Add a lump sum for the operation of freeway stations in the exclusive lane plan of Alternative B.

Patronage projections for the top-rated concepts have been based upon the detailed network analysis tests performed in Task 8.1. Necessary modifications to the test results have been made using a process similar to that set forth in the AMV Technical Report covering Phase II.[1] The ridership volumes utilized for cost and revenue analysis in the

[1] Alan M. Voorhees & Associates, Preliminary Estimates of System Usage, Revenue and Expenses, prepared for SCRTD, July 1973, pp. 23-36.

final evaluation are the lower values given in Figure 22 considering the length of an average trip on each system. Line profiles for major links in Alternatives C and D are presented in Figures 23 and 24. Bus-on-freeway volumes for Alternatives A and B are equivalent to those presented in the Task 8.1 Technical Working Paper for networks R1B and R1A, respectively.

Estimates of annual revenue are directly based upon patronage projections, as explained in the AMV Technical Report for Phase II.

Alternative Concept	Annual Revenue
A	$145 million
B	180 million
C	180 million
D	220 million

These estimates have been prepared assuming a mileage-based fare structure approximating that in effect in the SCRTD prior to April 1, 1974.

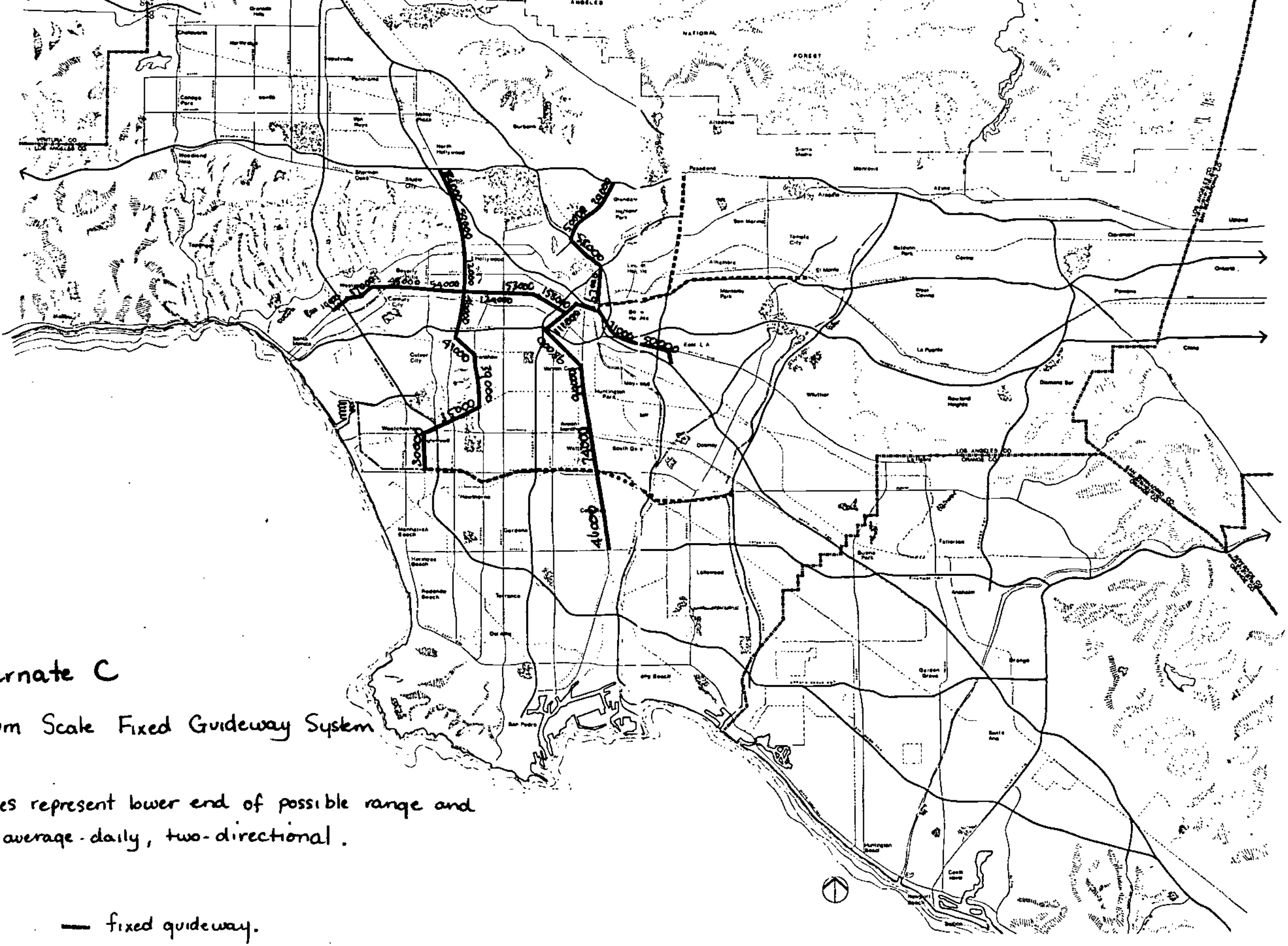
Operating cost results for the four alternative concepts are summarized in Figure 25. The estimates show a range in total system operating costs of about $250 to $300 million in 1990, at 1974 dollar value. The greater the extent of the fixed guideway, the lower the cost per passenger. This is true mainly because of the greater patronage, but also because of improved operating efficiency with an extensive fixed-guideway system at that volume of ridership. The two all-bus alternatives have the same cost per passenger.

On a cost-per-passenger-mile basis, Alternative D displays a somewhat greater cost advantage than on a cost-per-passenger basis because the average passenger trip being made is longer. The number of vehicles required is similar to the number estimated for comparable systems in the preliminary alternatives (R1 and R2) analysis--somewhat more than 5,000 buses for all concepts except Alternative D. For Alternative D,

FIGURE 22. TOP-RATED CONCEPTS: USAGE ESTIMATES FOR 1990

Alternative Concept	Average Daily Users (millions)(1)	Average Trip Length (miles)
A	1.10-2.0	8.0
B	1.30-2.25	8.8
C	1.28-2.6	9.0
D	1.50-3.1	9.5

Note: (1) The range of values reflects uncertainties inherent in projecting future conditions including auto operating costs, auto fuel availability, auto travel restrictions, special travel generators, etc. For elaboration see Sensitivity Analysis of Patronage Projections, Task 8.2 Technical Working Paper.



Alternate C

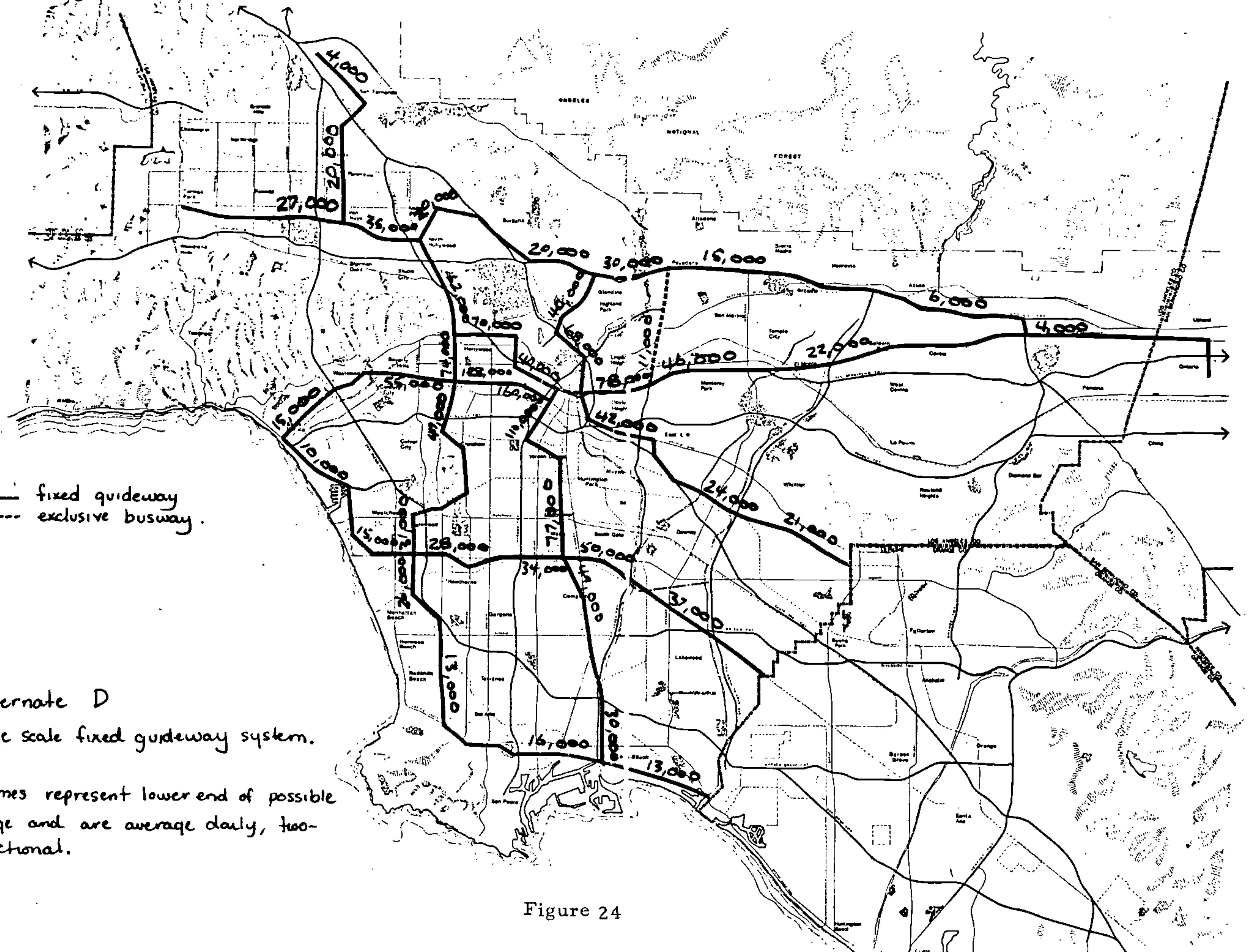
Medium Scale Fixed Guideway System

Volumes represent lower end of possible range and are average-daily, two-directional.

— fixed guideway.

..... exclusive busway.

Figure 23



Alternate D

Large scale fixed guideway system.

Volumes represent lower end of possible range and are average daily, two-directional.

Figure 24

FIGURE 25. 1990 OPERATING RESULTS FOR TOP-RATED CONCEPTS

Alternative Concept	Annual Cost[1] ($ million)	Dollar Cost[1]		Number of Vehicles	
		Per Passenger	Per Passenger Mile[2]	Fixed Guideway	Buses
A	255	0.76	0.09	--	5,320
B	295	0.76	0.09	--	5,582
C	280	0.73	0.08	334	5,491
D	270	0.60	0.06	816	3,927

Notes: (1) Costs are in 1974 dollars.

(2) Passenger mileage data were approximations developed from R1 and R2 patronage forecasts.

the number drops to less than 4,000 buses; however, approximately 800 guideway cars are required.

The development of operating cost estimates for the four top-rated concept alternatives is contained on the four worksheets that follow.

Representative Capital Costs for Top-Rated Concepts

For purposes of the final evaluation, AMV and Kaiser Engineers/Daniel, Mann, Johnson, Mendenhall (KE/DMJM) developed an approximate, representative range of capital investment required by each of the top-rated concept alternatives. All costs are estimated in 1974 terms unless otherwise noted. Principal unit cost assumptions pertaining to the all-bus concepts include

- $250,000-$500,000 per mile of freeway (or per average set of ramps) for ramp-meter bypass installation in Alternative A concept
- $10-$12 million per set for construction of new ramp structures for access to transfer stations in Alternative B concept
- $4-$5 million each for transfer stations including right-of-way and parking in Alternative B concept.

Derivation of representative capital cost estimates for the four concepts is presented in Figures 26 through 29. These numbers used for evaluation should be considered preliminary working estimates. Costs associated with the system recommendations of the study team need not necessarily concur with these estimates, since the study team cost recommendations underwent considerable refinement following the final evaluation.

THIS IS DERIVED FROM THE R-15 BASE TEST.
VOLUMES AND SPEEDS HAVE BEEN ADJUSTED.

CBD PRODUCTIONS = 270000.0
SUPPORT COST / CBD PRODUCTION = $ 0.20
SUPPORT VEHICLE SPARES = 0.08

PEAK ONE-WAY/24-HOUR TWO-WAY PASSENGER RATIO (SURFACE) = 0.14
PEAK ONE-WAY/24-HOUR TWO-WAY PASSENGER RATIO (FEEDER) = 0.15
PEAK 2-HR/24-HR VEHICLE MILE RATIO = 4.5
NUMBER OF TRUNK MODES = 3
OPERATING DAYS PER YEAR = 315.0
TOTAL DAILY TRANSIT PASSENGERS = 1100000.0
TOTAL DAILY FEEDER TRANSIT PASSENGERS = 330296.0
TOTAL DAILY SURFACE (NON-TRUNK) PASSENGERS = 439408.0
FEEDER VEHICLE MILE GENERATION RATE PER FEEDER PASSENGER = 0.350
SURFACE VEHICLE MILE GENERATION RATE PER SURFACE PASSENGER = 0.400
AVERAGE DAILY SPEED PER FEEDER VEHICLE = 13.5
AVERAGE DAILY SPEED PER SURFACE VEHICLE = 13.0
SEATS PER NON-TRUNK VEHICLE = 45.0
NON-TRUNK VEHICLE PEAK LOAD FACTOR = 1.0
NON-TRUNK VEHICLE ANNUAL ADMINISTRATIVE COST = $ 12500.0
NON-TRUNK VEHICLE HOURLY CHARGE PER HOUR = $ 7.60
NON-TRUNK VEHICLE MAINTENANCE COST PER MILE = $ 0.19
PEAK HOUR TRIPS PER SURFACE VEHICLE = 1.00
PEAK HOUR TRIPS PER FEEDER VEHICLE = 1.25
REVENUE DAYS PER YEAR = 300.0

MODE	VEHICULAR SEATS	PEAK FACTOR	FRACT SPARE VEH	ADM COST PER VEH	COST PER VEH HR	COST PER VEH MILE	AVG DAILY SPEED	MODAL DESCRIPTION
1	60.0	0.9	0.12	13000.0	7.60	0.19	25.0	BUS ON FREEWAY
2	45.0	0.8	0.12	13000.0	7.60	0.19	35.0	BUS ON BUSWAY
3	60.0	0.9	0.12	13000.0	7.60	0.19	37.0	FREEWAY BUS ON BUSWAY (VEHS INC IN MODE 1)

LINE	24-HR MAX LD PT VOLUME	PK-HR PK-DIR VOLUME	PK-HR VEHS AT MAX LD PT	PK-2HR VEHICLE MILES	DAILY VEHICLE MILES	ROUND TRIP TIME	VEHICLES REQUIRED + SPARES	MODE TYPE	LINE LENGTH	NET PK LINE SPEED	LINE PEAK O-W/24-HR PASS RATIO	TOTAL OP COST PER DAY
1A	25740.0	3346.2	93.0	3253.2	14639.6	55.6	96.4	1	10.0	21.6	0.13	$ 11910.6
1B	20160.0	3225.6	89.6	4390.4	19756.8	77.8	130.1	1	14.0	21.6	0.16	$ 16073.9
2A	24430.0	3825.9	106.3	4835.5	21759.6	72.2	143.3	1	13.0	21.6	0.13	$ 17703.5
2B	19530.0	3124.8	86.8	6076.0	27342.0	102.6	166.2	1	20.0	23.4	0.16	$ 20933.5
3A	31460.0	5112.0	142.0	5964.0	26838.0	66.7	176.7	1	12.0	21.6	0.16	$ 21635.0
3B	12780.0	2044.8	56.8	7952.0	35784.0	205.1	217.5	1	40.0	23.4	0.16	$ 27396.9
4A	4590.0	595.7	16.6	667.1	3002.1	63.9	19.8	1	11.5	21.6	0.13	$ 2492.5
4B	1080.0	172.8	4.8	420.0	1890.0	124.2	11.5	1	25.0	23.4	0.16	$ 1447.0
5A	20880.0	2714.4	75.4	3430.7	15438.1	44.6	62.7	2	13.0	35.0	0.13	$ 8874.5
5B	8370.0	1339.2	37.2	1822.8	8202.6	71.8	49.9	1	14.0	23.4	0.16	$ 6280.1
5C	17190.0	2234.7	62.1	2824.4	12709.9	42.2	48.9	3	13.0	37.0	0.13	$ 7041.6
6	37620.0	4890.6	135.8	4517.0	20326.5	52.6	133.8	1	9.5	21.6	0.13	$ 16537.4
7A	5760.0	748.8	20.8	327.6	1474.2	25.0	9.7	1	4.5	21.6	0.13	$ 1159.4
7B	9900.0	1584.0	44.0	2772.0	12474.0	92.3	75.8	1	18.0	23.4	0.16	$ 9550.3
8A	32760.0	4258.8	118.3	4968.6	22359.7	66.7	147.2	1	12.0	21.6	0.13	$ 16190.7
8B	15660.0	2505.6	69.6	5724.6	25760.7	120.5	156.6	1	23.5	23.4	0.16	$ 19722.9
8C	14400.0	1872.0	52.0	546.0	2457.0	16.7	16.2	1	3.0	21.6	0.13	$ 1944.0
9A	19260.0	3081.6	85.6	6291.6	28312.2	107.7	172.1	1	21.0	23.4	0.16	$ 21676.3
9B	7650.0	1224.0	34.0	3927.0	17671.5	109.2	107.4	1	33.0	23.4	0.16	$ 13529.6
10A	1710.0	273.6	7.6	505.4	2274.3	97.4	13.8	1	19.0	23.4	0.16	$ 1741.2
10B	18810.0	3009.6	83.6	8192.5	36867.6	143.6	224.1	1	28.0	23.4	0.16	$ 28226.5
11A	4140.0	662.4	18.4	644.0	2898.0	51.5	17.6	1	10.0	23.4	0.16	$ 2218.8
11B	9720.0	1555.2	43.2	3780.0	17010.0	128.2	103.4	1	25.0	23.4	0.16	$ 13023.2
12	15300.0	2448.0	68.0	4046.0	18207.0	87.2	110.7	1	17.0	23.4	0.16	$ 13939.6
13	7020.0	1123.2	31.2	2839.2	12776.4	133.3	77.7	1	26.0	23.4	0.16	$ 9781.8
14	4500.0	720.0	20.0	770.0	3465.0	56.4	21.1	1	11.0	23.4	0.16	$ 2652.9
15A	8550.0	1368.0	38.0	2194.5	9875.3	64.6	60.0	1	16.5	23.4	0.16	$ 7560.7
15B	11340.0	1814.4	50.4	1058.4	4762.8	30.8	28.9	1	6.0	23.4	0.16	$ 3646.5
15C	10710.0	1713.6	47.6	5914.3	26614.3	152.1	161.8	1	35.5	23.4	0.16	$ 20376.4
16	19170.0	3067.2	85.2	3220.6	14492.5	60.0	95.4	1	10.8	21.6	0.16	$ 11740.9
17	900.0	144.0	4.0	266.0	1197.0	97.4	7.3	1	19.0	23.4	0.16	$ 916.4
18	1400.0	224.0	6.0	700.0	3150.0	124.2	19.1	1	25.0	23.4	0.16	$ 2411.7
19	9000.0	1170.0	32.5	341.3	1535.6	16.7	10.1	1	3.0	21.6	0.13	$ 1244.4

MODE	DAILY VEHICLE MILES	ANNUAL VEHICLE MILES	TOTAL VEHICLES REQUIRED	TOTAL ADMINIST COSTS	TOTAL HOURLY COSTS	TOTAL VEHICLE MILE COSTS
1	445174.6	140230964.0	2741.0	36153024.0	42629920.0	25643696.0
2	15438.1	4863014.0	62.7	815526.2	1055968.0	923972.6
3	12709.9	4003504.0	48.9	635110.9	822361.5	760684.8

LINE-HAUL TRUNK SYSTEM ANNUAL OPERATING COST = $110440224.0
(NOTE: EXTRA COST OF TRUNK LINE VEHICLES DUE TO HIGH VEHICLE MILEAGE NOT INCLUDED)

SURFACE BUS ESTIMATES -- (ALL NON-TRUNK, NON-FEEDER, NON-CBD DISTRIBUTION)

DAILY SURFACE VEHICLE MILES = 175763.2
DAILY SURFACE VEHICLE HOURS = 13520.2
SURFACE VEHICLES REQUIRED = 1476.4
SURFACE MAINTENANCE OPERATING COST = $ 10519424.0
SURFACE HOURLY OPERATING COST = $ 32367440.0
SURFACE ADMINISTRATIVE COST = $ 18455120.0
SURFACE SYSTEM OPERATING COST = $ 61341984.0

FEEDER BUS ESTIMATES

DAILY FEEDER VEHICLE MILES = 115603.6
DAILY FEEDER VEHICLE HOURS = 8563.2
FEEDER VEHICLES REQUIRED = 951.3
FEEDER MAINTENANCE OPERATING COST = $ 6918872.0
FEEDER HOURLY OPERATING COST = $ 20500352.0
FEEDER ADMINISTRATIVE COST = $ 11890549.0
FEEDER SYSTEM OPERATING COST = $ 39309856.0

CBD TRUNK LINE DISTRIBUTION COST = $ 17009984.0

GRAND ANNUAL OPERATING COST = $ 228102048.0
OPERATING COST PER PASSENGER = $ 0.691

MODE	PASS PER VEH MILE	COST PER PASSENGER	AVERAGE SPEED	MAINT COST PER MILE	HOURLY COST PER MILE	ADMIN COSTS PER MILE	TOTAL COST PER MILE	VEHICLE MILES	VEH MILES PER VEH
TRUNK	1.40	0.557	25.46	0.190	0.299	0.252	0.741	149096672.0	51544.4
SURFACE	2.50	0.465	13.00	0.190	0.585	0.333	1.108	55365392.0	37500.0
FEEDER	2.66	0.397	13.50	0.190	0.563	0.327	1.079	36415120.0	38281.3
SYSTEM	1.44	0.691	18.80	0.190	0.404	0.242	0.947	240877184.0	45275.6

THIS IS DERIVED FROM THE R-1A BASE TEST.
VOLUMES HAVE BEEN ADJUSTED.

CBD PRODUCTIONS = 274740.0
SUPPORT COST / CBD PRODUCTION = $ 0.20
SUPPORT VEHICLE SPARES = 0.08

PEAK ONE-WAY/24-HOUR TWO-WAY PASSENGER RATIO (SURFACE) = 0.14
PEAK ONE-WAY/24-HOUR TWO-WAY PASSENGER RATIO (FEEDER) = 0.15
PEAK 2-HR/24-HR VEHICLE MILE RATIO = 4.5
NUMBER OF THREE HOURS = 3
OPERATING DAYS PER YEAR = 315.0
TOTAL DAILY TRANSIT PASSENGERS = 1300000.0
TOTAL DAILY FEEDER TRANSIT PASSENGERS = 426170.0
TOTAL DAILY SURFACE (NON-TRUNK) PASSENGERS = 447661.0
FEEDER VEHICLE MILE GENERATION RATE PER FEEDER PASSENGER = 0.350
SURFACE VEHICLE MILE GENERATION RATE PER SURFACE PASSENGER = 0.400
AVERAGE DAILY SPEED PER FEEDER VEHICLE = 13.5
AVERAGE DAILY SPEED PER SURFACE VEHICLE = 13.0
SEATS PER NON-TRUNK VEHICLE = 45.0
NON-TRUNK VEHICLE PEAK LOAD FACTOR = 1.0
NON-TRUNK VEHICLE ANNUAL ADMINISTRATIVE COST = $ 12500.0
NON-TRUNK VEHICLE HOURLY CHARGE PER HOUR = $ 7.60
NON-TRUNK VEHICLE MAINTENANCE COST PER MILE = $ 0.19
PEAK HOUR TRIPS PER SURFACE VEHICLE = 1.00
PEAK HOUR TRIPS PER FEEDER VEHICLE = 1.25
REVENUE DAYS PER YEAR = 300.0

MODE	VEHICULAR SEATS	PEAK FACTOR	FRACT SPARE VEH	ADM COST PER VEH	COST PER VEH HR	COST PER VEH MILE	AVG DAILY SPEED	MODAL DESCRIPTION
1	40.0	0.9	0.12	13000.0	7.60	0.19	32.0	BUS ON FREEWAY
2	45.0	0.8	0.12	13000.0	7.60	0.19	35.0	BUS ON BUSWAY
3	40.0	0.9	0.12	13000.0	7.60	0.19	37.0	FREEWAY BUS ON BUSWAY (VEHS INC IN MODE 1)

LINE	24-HR MAX LD PT VOLUME	PK-HR PK-DIR VOLUME	PK-HR VEHS AT MAX LD PT	PK-2HR VEHICLE MILES	DAILY VEHICLE MILES	ROUND TRIP TIME	VEHICLES REQUIRED + SPARES	MODE TYPE	LINE LENGTH	NET PK LINE SPEED	LINE PEAK O-W/24-HR PASS RATIO	TOTAL OP COST PER DAY
1A	31662.0	4116.1	114.3	4001.7	18007.8	40.0	85.4	1	10.0	30.0	0.13	$ 11506.6
1B	24475.0	3916.0	108.8	5330.1	23985.5	56.0	113.7	1	14.0	30.0	0.16	$ 15326.3
2A	40105.0	5213.6	144.8	6589.5	29652.6	52.0	140.6	1	13.0	30.0	0.13	$ 18947.5
2B	27609.0	4417.4	122.7	8589.5	38652.6	70.6	151.7	1	20.0	34.0	0.16	$ 22656.6
3A	47918.0	7666.9	213.0	8944.7	40251.1	48.0	190.8	1	12.0	30.0	0.16	$ 25719.6
3B	19292.0	3086.7	85.7	12003.9	54017.6	141.2	225.0	1	40.0	34.0	0.16	$ 31663.0
4A	6332.0	823.2	22.9	920.3	4141.5	45.0	19.6	1	11.5	30.0	0.13	$ 2646.4
4B	1542.0	246.7	6.9	599.7	2698.5	88.2	11.3	1	25.0	34.0	0.16	$ 1551.6
5A	27098.0	3522.7	97.9	4452.3	20035.6	44.6	81.4	2	13.0	35.0	0.13	$ 11517.3
5B	10554.0	1688.6	46.9	2298.4	10342.9	49.4	43.3	1	14.0	34.0	0.16	$ 6662.5
5C	21106.0	2744.0	76.2	3465.2	15606.7	42.2	60.0	3	13.0	37.0	0.13	$ [illegible]
6	42216.0	5488.1	152.4	5068.8	22809.6	38.0	108.1	1	9.5	30.0	0.13	$ 14575.1
7A	8443.0	1097.6	30.5	480.2	2160.9	18.0	10.2	1	4.5	30.0	0.13	$ 1380.8
7B	14167.0	2266.7	63.0	3966.8	17850.4	63.5	74.7	1	13.0	34.0	0.16	$ 10463.2
8A	47493.0	6174.1	171.5	7203.1	32414.0	48.0	153.7	1	12.0	30.0	0.13	$ 20712.0
8B	23546.0	3768.4	105.2	5666.4	34953.6	82.9	152.9	1	23.5	34.0	0.16	$ 22833.1
8C	21106.0	2744.0	76.2	800.3	3601.6	12.0	17.1	1	3.0	30.0	0.13	$ 2301.3
9A	26466.0	4659.4	126.6	9368.7	41557.1	74.1	175.2	1	21.0	34.0	0.16	$ 24553.8
9B	15115.0	1618.0	45.0	5192.4	23365.6	116.5	97.7	1	33.0	34.0	0.16	$ 13656.0
10A	3166.0	506.6	14.1	935.7	4210.8	67.1	17.6	1	19.0	34.0	0.16	$ 2466.2
10B	29551.0	4728.2	131.3	12871.1	57919.9	98.6	242.3	1	28.0	34.0	0.16	$ 33950.4
11A	3166.0	506.6	14.1	492.5	2216.2	35.3	9.3	1	10.0	34.0	0.16	$ 1299.1
11B	7385.0	1181.6	32.8	2871.9	12923.7	88.2	54.1	1	25.0	34.0	0.16	$ 7575.4
12	20846.0	3334.4	92.6	5511.0	24799.6	60.0	103.7	1	17.0	34.0	0.16	$ 14536.6
13	10554.0	1688.6	46.9	4266.5	19298.3	91.6	80.3	1	26.0	34.0	0.15	$ 11259.1
14	5277.0	844.3	23.5	903.0	4063.3	38.6	17.0	1	11.0	34.0	0.16	$ 2381.7
15A	12665.0	2026.4	56.3	3250.7	14628.1	56.2	61.2	1	16.5	34.0	0.16	$ 8574.4
15B	16866.0	2701.6	75.0	1576.0	7092.1	21.2	29.7	1	6.0	34.0	0.16	$ 4157.1
15C	15888.0	2542.1	70.6	8773.7	39481.7	125.3	165.2	1	35.5	34.0	0.16	$ 23142.6
16	23219.0	3715.0	103.2	3900.8	17553.6	43.2	83.2	1	10.8	30.0	0.16	$ 11216.4
17	1167.0	186.7	5.2	344.9	1552.1	67.1	6.5	1	19.0	34.0	0.16	$ 909.8
18	5277.0	844.3	23.5	2052.2	9234.7	66.2	38.6	1	25.0	34.0	0.16	$ 5413.6
19	10554.0	1372.0	38.1	400.2	1800.8	12.0	8.5	1	3.0	30.0	0.13	$ 1156.7

MODE	DAILY VEHICLE MILES	ANNUAL VEHICLE MILES	TOTAL VEHICLES REQUIRED	TOTAL ADMINIST COSTS	TOTAL HOURLY COSTS	TOTAL VEHICLE MILE COSTS
1	621478.9	195745840.0	2704.2	35219312.0	46494168.0	37195504.0
2	20035.6	6311202.0	81.4	1056356.0	1370432.0	1199128.0
3	15606.7	4916120.0	60.0	779867.7	1009797.2	934062.8

LINE-HAUL TRUNK SYSTEM ANNUAL OPERATING COST = $125260816.0
(NOTE: EXTRA COST OF TRUNK LINE VEHICLES DUE TO HIGH VEHICLE MILEAGE NOT INCLUDED)

SURFACE BUS ESTIMATES -- (ALL NON-TRUNK, NON-FEEDER, NON-CBD DISTRIBUTION)

DAILY SURFACE VEHICLE MILES = 179064.4
DAILY SURFACE VEHICLE HOURS = 13774.2
SURFACE VEHICLES REQUIRED = 1504.1
SURFACE MAINTENANCE OPERATING COST = $ 10717000.0
SURFACE HOURLY OPERATING COST = $ 32275376.0
SURFACE ADMINISTRATIVE COST = $ 19501744.0
SURFACE SYSTEM OPERATING COST = $ 62494112.0

FEEDER BUS ESTIMATES

DAILY FEEDER VEHICLE MILES = 149159.4
DAILY FEEDER VEHICLE HOURS = 11048.8
FEEDER VEHICLES REQUIRED = 1227.4
FEEDER MAINTENANCE OPERATING COST = $ 8927190.0
FEEDER HOURLY OPERATING COST = $ 26450912.0
FEEDER ADMINISTRATIVE COST = $ 15342108.0
FEEDER SYSTEM OPERATING COST = $ 50720192.0

CBD TRUNK LINE DISTRIBUTION COST = $ 17306508.0

GRAND ANNUAL OPERATING COST = $ 255783728.0
OPERATING COST PER PASSENGER = $ 0.656

MODE	PASS PER VEH MILE	COST PER PASSENGER	AVERAGE SPEED	MAINT COST PER MILE	HOURLY COST PER MILE	ADMIN COSTS PER MILE	TOTAL COST PER MILE	VEHICLE MILES	VEH MILES PER VEH
TRUNK	1.30	0.490	32.19	0.190	0.236	0.179	0.605	206993152.0	72614.3
SURFACE	2.50	0.445	13.00	0.190	0.585	0.333	1.108	56405264.0	37500.0
FEEDER	2.44	0.397	13.50	0.190	0.563	0.327	1.079	46985216.0	38261.3
SYSTEM	1.32	0.656	21.78	0.190	0.349	0.229	0.824	310383616.0	55603.5

ALT C MEDIUM FIXED GUIDEWAY SYSTEM OPERATING COST 1990 REV 19MAR74 - BASE TEST

THIS ASSUMES A 60 MILE VERSION. SUPPORTING TRUNK SYSTEM MOSTLY THAT OF R-1A.
SOME R-1A TRUNKS OUT OR LEN CHANGES. ALL R-1A VOLS CHANGED PLUS MORE BUSWAYS.

CBD PRODUCTIONS = 0.0
SUPPORT COST / CBD PRODUCTION = $ 0.20
SUPPORT VEHICLE SPARES = 0.06

PEAK ONE-WAY/24-HOUR TWO-WAY PASSENGER RATIO (SURFACE) = 0.14
PEAK ONE-WAY/24-HOUR TWO-WAY PASSENGER RATIO (FEEDER) = 0.15
PEAK 2-HR/24-HR VEHICLE MILE RATIO = 4.5
NUMBER OF TRUNK MODES = 4
OPERATING DAYS PER YEAR = 315.0
TOTAL DAILY TRANSIT PASSENGERS = 1280000.0
TOTAL DAILY FEEDER TRANSIT PASSENGERS = 268918.0
TOTAL DAILY SURFACE (NON-TRUNK) PASSENGERS = 742164.0
FEEDER VEHICLE MILE GENERATION RATE PER FEEDER PASSENGER = 0.350
SURFACE VEHICLE MILE GENERATION RATE PER SURFACE PASSENGER = 0.400
AVERAGE DAILY SPEED PER FEEDER VEHICLE = 13.5
AVERAGE DAILY SPEED PER SURFACE VEHICLE = 13.0
SEATS PER NON-TRUNK VEHICLE = 45.0
NON-TRUNK VEHICLE PEAK LOAD FACTOR = 1.0
NON-TRUNK VEHICLE ANNUAL ADMINISTRATIVE COST = $ 12500.0
NON-TRUNK VEHICLE HOURLY CHARGE PER HOUR = $ 7.60
NON-TRUNK VEHICLE MAINTENANCE COST PER MILE = $ 0.19
PEAK HOUR TRIPS PER SURFACE VEHICLE = 1.00
PEAK HOUR TRIPS PER FEEDER VEHICLE = 1.25
REVENUE DAYS PER YEAR = 300.0

MODE	VEHICULAR SEATS	PEAK FACTOR	FRACT SPARE VEH	ADM COST PER VEH	COST PER VEH HR	COST PER VEH MILE	AVG DAILY SPEED	MODAL DESCRIPTION	
1	40.0	0.9	0.12	13000.0	7.60	0.19	32.0	BUS ON FREEWAY	
2	45.0	0.8	0.12	13000.0	7.60	0.19	35.0	BUS ON BUSWAY	
3	40.0	0.9	0.12	13000.0	7.60	0.19	37.0	FREEWAY BUS ON BUSWAY	(VEHS INC IN MODE 1)
4	75.0	2.0	0.10	0.0	0.0	1.25	35.0	MRT - SLOW. SHORT	

LINE	24-HR MAX LD PT VOLUME	PK-HR PK-DIR VOLUME	PK-HR VEHS AT MAX LD PT	PK-2HR VEHICLE MILES	DAILY VEHICLE MILES	ROUND TRIP TIME	VEHICLES REQUIRED + SPARES	MODE TYPE	LINE LENGTH	NET PK LINE SPEED	LINE PEAK O-W/24-HR PASS RATIO	TOTAL OP COST PER DAY
5RR	84472.0	11596.1	79.3	7522.3	33850.2	61.3	118.2	4	27.1	40.0	0.14	$ 42651.3
4RD	49478.0	6926.9	46.2	3070.9	13819.2	57.0	48.3	4	19.0	40.0	0.14	$ 17412.2
6RR	84472.0	11595.1	79.3	5662.5	25481.4	61.2	69.0	4	20.4	40.0	0.14	$ 32106.5
6LR	72065.0	10089.1	67.3	5014.3	22564.2	63.9	78.8	4	21.3	40.0	0.14	$ 28430.9
1A	16134.0	2097.4	58.3	2039.2	9176.2	50.0	54.4	1	10.0	24.0	0.13	$ 6693.4
1B	5372.0	860.5	23.9	1171.2	5270.4	70.0	31.2	1	14.0	24.0	0.16	$ 3559.3
2B	11432.0	1893.1	52.6	3681.1	16564.8	92.3	98.6	1	20.0	26.0	0.16	$ 11726.8
3A	38722.0	6195.5	172.1	5421.1	24394.6	45.0	144.6	1	9.0	24.0	0.16	$ 16326.1
4A	5376.0	699.1	19.4	713.7	3211.7	52.5	19.0	1	10.5	24.0	0.13	$ 2412.7
4B	2151.0	344.2	9.6	803.0	3613.7	110.8	19.8	1	24.0	26.0	0.16	$ 2588.7
5A	54856.0	7131.3	198.1	9013.1	40559.1	44.6	164.8	2	13.0	35.0	0.13	$ 23315.1
5B	13983.0	2237.3	62.1	3045.2	13703.3	64.6	75.0	1	14.0	26.0	0.16	$ 9702.7
5C	13983.0	1817.6	50.5	2297.5	10338.7	42.2	39.7	3	13.0	37.0	0.13	$ 5728.0
6	10756.0	1398.3	38.8	1291.5	5811.6	47.5	34.4	1	9.5	24.0	0.13	$ 4365.8
7B	12907.0	2065.1	57.4	3212.4	14455.8	73.8	79.1	1	16.0	26.0	0.16	$ 10235.6
8B	13983.0	2237.3	62.1	3589.0	16150.4	76.2	88.3	1	16.5	26.0	0.16	$ 11435.4
9A	27961.0	4666.6	129.1	9466.7	42600.3	96.9	233.5	1	21.0	26.0	0.16	$ 30227.1
9B	12907.0	2065.1	57.4	6625.6	29815.2	152.3	163.1	1	33.0	26.0	0.16	$ 21113.8
10A	2689.0	430.2	12.0	794.7	3576.4	87.7	19.6	1	14.0	26.0	0.16	$ 2532.3
10B	32268.0	5162.9	143.4	11544.8	51951.5	106.2	284.2	1	23.0	26.0	0.16	$ 36784.6
10C	11432.0	1538.2	42.7	747.7	3364.7	17.1	13.7	2	5.0	35.0	0.13	$ 1934.2
11A	12907.0	2065.1	57.4	2007.8	9034.9	46.2	49.4	1	10.0	26.0	0.16	$ 6397.2
11B	7529.0	1204.6	33.5	2927.9	13175.7	115.4	72.1	1	25.0	26.0	0.16	$ 9329.2
12	26890.0	3495.7	97.1	2209.1	9940.9	30.0	54.4	2	6.5	26.0	0.13	$ 7038.7
13	32268.0	5162.9	143.4	6023.4	27105.1	55.4	148.3	1	12.0	26.0	0.16	$ 19192.0
15A	13983.0	2237.3	62.1	5329.1	23980.8	113.1	131.2	1	24.5	26.0	0.16	$ 16979.6
15C	21512.0	3441.9	95.6	7529.2	33881.4	105.5	185.3	1	22.5	26.0	0.16	$ 23990.0
16	5378.0	860.5	23.9	251.0	1129.4	15.0	6.7	1	3.0	24.0	0.16	$ 845.4
17	645.0	103.2	2.9	190.6	857.8	87.7	4.7	1	14.0	26.0	0.16	$ 607.4
18	1076.0	172.2	4.8	200.9	903.8	55.4	4.9	1	12.0	26.0	0.16	$ 640.0
19	10756.0	1398.3	38.8	407.4	1835.2	15.0	10.9	1	3.0	24.0	0.13	$ 1378.7

MODE	DAILY VEHICLE MILES	ANNUAL VEHICLE MILES	TOTAL VEHICLES REQUIRED	TOTAL ADMINIST COSTS	TOTAL HOURLY COSTS	TOTAL VEHICLE MILE COSTS
1	352229.6	110971264.0	1350.2	25352924.0	26355664.0	21094528.0
2	53664.8	16867392.0	232.9	3027203.0	3684347.0	3223804.0
3	10336.7	3256554.0	39.7	516623.2	668940.1	614769.9
4	95714.9	30150192.0	334.2	0.0	0.0	37989216.0

LINE-HAUL TRUNK SYSTEM ANNUAL OPERATING COST = $122521968.0
(NOTE: EXTRA COST OF TRUNK LINE VEHICLES DUE TO HIGH VEHICLE MILEAGE NOT INCLUDED)

SURFACE BUS ESTIMATES -- (ALL NON-TRUNK, NON-FEEDER, NON-CBD DISTRIBUTION)

DAILY SURFACE VEHICLE MILES = 296865.6
DAILY SURFACE VEHICLE HOURS = 22835.8
SURFACE VEHICLES REQUIRED = 2493.7
SURFACE MAINTENANCE OPERATING COST = $ 17767392.0
SURFACE HOURLY OPERATING COST = $ 54668912.0
SURFACE ADMINISTRATIVE COST = $ 31170864.0
SURFACE SYSTEM OPERATING COST = $103607168.0

FEEDER BUS ESTIMATES

DAILY FEEDER VEHICLE MILES = 94121.3
DAILY FEEDER VEHICLE HOURS = 6971.4
FEEDER VEHICLES REQUIRED = 774.5
FEEDER MAINTENANCE OPERATING COST = $ 5633156.0
FEEDER HOURLY OPERATING COST = $ 16690822.0
FEEDER ADMINISTRATIVE COST = $ 9681042.0
FEEDER SYSTEM OPERATING COST = $ 32005008.0

CBD TRUNK LINE DISTRIBUTION COST = $ 0.0

GRAND ANNUAL OPERATING COST = $ 258134144.0
OPERATING COST PER PASSENGER = $ 0.672

MODE	PASS PER VEH MILE	COST PER PASSENGER	AVERAGE SPEED	MAINT COST PER MILE	HOURLY COST PER MILE	ADMIN COSTS PER MILE	TOTAL COST PER MILE	VEHICLE MILES	VEH MILES PER VEH
TRUNK	1.05	0.759	33.08	0.390	0.190	0.179	0.759	161345520.0	63097.8
SURFACE	2.50	0.465	13.00	0.190	0.585	0.333	1.108	93512640.0	37500.0
FEEDER	2.66	0.397	13.50	0.190	0.563	0.327	1.079	29648192.0	38281.2
SYSTEM	1.42	0.672	19.94	0.303	0.359	0.245	0.907	284506112.0	48840.4

ALT D LARGE FIXED GUIDEWAY SYSTEM OPERATING COST 1990 REV 19MAR74 - BASE TEST

THIS IS THE SATURATED MRT SYSTEM. THE SUPPORTING (NON-MRT) TRUNK SYSTEM IS BASED ON THAT OF THE MEDIUM SCALE FIXED GUIDEWAY SYSTEM.

CBD PRODUCTIONS = 0.0
SUPPORT COST / CBD PRODUCTION = $ 0.20
SUPPORT VEHICLE SPARES = 0.08

PEAK ONE-WAY/24-HOUR TWO-WAY PASSENGER RATIO (SURFACE) = 0.14
PEAK ONE-WAY/24-HOUR TWO-WAY PASSENGER RATIO (FEEDER) = 0.15
PEAK 2-HR/24-HR VEHICLE MILE RATIO = 4.5
NUMBER OF TRUNK MODES = 3
OPERATING DAYS PER YEAR = 315.0
TOTAL DAILY TRANSIT PASSENGERS = 1500000.0
TOTAL DAILY FEEDER TRANSIT PASSENGERS = 357498.0
TOTAL DAILY SURFACE (NON-TRUNK) PASSENGERS = 765025.0
FEEDER VEHICLE MILE GENERATION RATE PER FEEDER PASSENGER = 0.350
SURFACE VEHICLE MILE GENERATION RATE PER SURFACE PASSENGER = 0.400
AVERAGE DAILY SPEED PER FEEDER VEHICLE = 13.5
AVERAGE DAILY SPEED PER SURFACE VEHICLE = 13.0
SEATS PER NON-TRUNK VEHICLE = 45.0
NON-TRUNK VEHICLE PEAK LOAD FACTOR = 1.0
NON-TRUNK VEHICLE ANNUAL ADMINISTRATIVE COST = $ 12500.0
NON-TRUNK VEHICLE HOURLY CHARGE PER HOUR = $ 7.60
NON-TRUNK VEHICLE MAINTENANCE COST PER MILE = $ 0.19
PEAK HOUR TRIPS PER SURFACE VEHICLE = 1.00
PEAK HOUR TRIPS PER FEEDER VEHICLE = 1.25
REVENUE DAYS PER YEAR = 300.0

MODE	VEHICULAR SEATS	PEAK FACTOR	FRACT SPARE VEH	ADM COST PER VEH	COST PER VEH HR	COST PER VEH MILE	AVG DAILY SPEED	MODAL DESCRIPTION
1	75.0	1.6	0.10	0.0	0.0	1.26	41.0	MRT
2	45.0	0.8	0.12	13000.0	7.60	0.19	35.0	BUS ON BUSWAY
3	40.0	0.9	0.12	13000.0	7.60	0.19	34.0	BUS ON FREEWAY

LINE	24-HR MAX LD PT VOLUME	PK-HR PK-DIR VOLUME	PK-HR VEHS AT MAX LD PT	PK-2HR VEHICLE MILES	DAILY VEHICLE MILES	ROUND TRIP TIME	VEHICLES REQUIRED + SPARES	MODE TYPE	LINE LENGTH	NET PK LINE SPEED	LINE PEAK O-W/24-HR PASS RATIO	TOTAL OP COST PER DAY
SMR	62562.0	8750.3	72.9	10923.3	49154.7	128.4	171.7	1	42.8	40.0	0.14	$ 61934.5
SDY	53411.0	7477.5	62.3	9181.4	41314.1	125.3	144.3	1	42.1	40.0	0.14	$ 52060.7
SFG	52274.0	7318.4	61.0	7705.6	34675.3	108.3	121.1	1	36.1	40.0	0.14	$ 43690.5
SFO	56820.0	7954.8	66.3	6194.8	27876.6	80.1	97.3	1	26.7	40.0	0.14	$ 35124.5
APR	56820.0	7954.8	66.3	4385.1	19732.9	56.7	68.9	1	18.9	40.0	0.14	$ 24863.4
PAR	52274.0	7318.4	61.0	7598.9	34195.0	106.8	119.4	1	35.6	40.0	0.14	$ 43085.7
RRP	47729.0	6682.1	55.7	5963.7	26836.8	91.8	93.7	1	30.6	40.0	0.14	$ 33514.4
PDY	12500.0	1625.0	45.1	821.5	3696.9	17.8	15.0	2	5.2	35.0	0.13	$ 2125.1
1A	2273.0	295.5	8.2	224.1	1008.4	31.2	4.8	3	7.8	30.0	0.13	$ 644.3
1B	1136.0	147.7	4.1	159.4	717.2	44.4	3.4	3	11.1	30.0	0.13	$ 455.3
2A	10228.0	1329.6	36.9	1370.3	6166.2	42.4	29.2	3	10.6	30.0	0.13	$ 3940.1
2B	1136.0	147.7	4.1	252.7	1137.1	70.4	5.4	3	17.6	30.0	0.13	$ 725.5
3	9091.0	1181.8	32.8	1103.0	4963.7	38.4	23.5	3	9.6	30.0	0.13	$ 3171.7
4	1136.0	147.7	4.1	357.5	1608.8	99.6	7.6	3	24.9	30.0	0.13	$ 1028.0
6	4546.0	591.0	16.4	448.2	2016.7	31.2	9.6	3	7.8	30.0	0.13	$ 1288.6
7	5682.0	738.7	20.5	955.1	4298.1	53.2	20.4	3	13.3	30.0	0.13	$ 2746.4
8	2273.0	295.5	8.2	304.5	1370.3	42.4	6.5	3	10.6	30.0	0.13	$ 875.5
9	3409.0	443.2	12.3	956.5	4304.2	88.8	20.4	3	22.2	30.0	0.13	$ 2750.4
10A	2273.0	295.5	8.2	583.2	2624.3	81.2	12.4	3	20.3	30.0	0.13	$ 1676.9
10B	3409.0	443.2	12.3	555.8	2501.1	51.6	11.9	3	12.9	30.0	0.13	$ 1598.2
11	3409.0	443.2	12.3	986.7	4440.0	91.6	21.0	3	22.9	30.0	0.13	$ 2837.1
12	12500.0	1625.0	45.1	442.4	1990.6	11.2	9.4	3	2.8	30.0	0.13	$ 1272.0
13	2273.0	295.5	8.2	382.1	1719.4	53.2	8.2	3	13.3	30.0	0.13	$ 1098.7
15A	2273.0	295.5	8.2	1235.3	5558.9	172.0	26.4	3	43.0	30.0	0.13	$ 3552.0
15B	2273.0	295.5	8.2	686.6	3089.7	95.6	14.6	3	23.9	30.0	0.13	$ 1974.3
16	5682.0	738.7	20.5	229.8	1034.1	12.8	4.9	3	3.2	30.0	0.13	$ 660.8
17	682.0	88.7	2.5	66.4	298.7	30.8	1.4	3	7.7	30.0	0.13	$ 190.6
18	1136.0	147.7	4.1	152.2	684.9	42.4	3.2	3	10.6	30.0	0.13	$ 437.6

MODE	DAILY VEHICLE MILES	ANNUAL VEHICLE MILES	TOTAL VEHICLES REQUIRED	TOTAL ADMINIST COSTS	TOTAL HOURLY COSTS	TOTAL VEHICLE MILE COSTS
1	233759.1	73643552.0	816.4	0.0	0.0	92790816.0
2	3696.9	1164515.0	15.0	195288.6	252860.1	221257.8
3	51532.5	16232725.0	244.3	3175926.0	3624490.0	3084217.0

LINE-HAUL TRUNK SYSTEM ANNUAL OPERATING COST = $103348816.0
(NOTE: EXTRA COST OF TRUNK LINE VEHICLES DUE TO HIGH VEHICLE MILEAGE NOT INCLUDED)

SURFACE BUS ESTIMATES -- (ALL NON-TRUNK, NON-FEEDER, NON-CBD DISTRIBUTION)

DAILY SURFACE VEHICLE MILES = 314009.9
DAILY SURFACE VEHICLE HOURS = 26154.6
SURFACE VEHICLES REQUIRED = 2647.7
SURFACE MAINTENANCE OPERATING COST = $ 18793488.0
SURFACE HOURLY OPERATING COST = $ 57826112.0
SURFACE ADMINISTRATIVE COST = $ 32971008.0
SURFACE SYSTEM OPERATING COST = $109590605.0

FEEDER BUS ESTIMATES

DAILY FEEDER VEHICLE MILES = 125120.6
DAILY FEEDER VEHICLE HOURS = 9269.2
FEEDER VEHICLES REQUIRED = 1029.6
FEEDER MAINTENANCE OPERATING COST = $ 7488474.0
FEEDER HOURLY OPERATING COST = $ 22188064.0
FEEDER ADMINISTRATIVE COST = $ 12869561.0
FEEDER SYSTEM OPERATING COST = $ 42546080.0

CBD TRUNK LINE DISTRIBUTION COST = $ 0.0

GRAND ANNUAL OPERATING COST = $ 255485504.0
OPERATING COST PER PASSENGER = $ 0.568

MODE	PASS PER VEH MILE	COST PER PASSENGER	AVERAGE SPEED	MAINT COST PER MILE	HOURLY COST PER MILE	ADMIN COSTS PER MILE	TOTAL COST PER MILE	VEHICLE MILES	VEH MILES PER VEH
TRUNK	2.47	0.482	39.46	1.056	0.043	0.037	1.135	91040764.0	64631.7
SURFACE	2.50	0.445	13.00	0.190	0.585	0.333	1.108	98913120.0	37500.0
FEEDER	2.66	0.397	13.50	0.190	0.563	0.327	1.079	39413024.0	38281.2
SYSTEM	2.06	0.568	17.87	0.534	0.366	0.215	1.114	229366944.0	48359.3

FIGURE 26. ALTERNATIVE A: REPRESENTATIVE CAPITAL COSTS (1974 TERMS)

	Cost Range ($ million)
Bus-Priority Ramp Installation	
400 ramps @ $250,000-$500,000	$100-200
Parking Without Stations	
25,000 spaces @ $1,000	25
Stations at a Few Major Transfer Points	
10 stations @ $15 million	150
LA/CBD Distribution	
3-4 terminals @ $25 million	75-100
1-2 mi. people-mover @ $25 million	25-50
Other ramps, special roadways	1-10
Bus Fleet Investment	
5,300 buses @ $50,000	265
TOTAL	$641-800

FIGURE 27. ALTERNATIVE B: REPRESENTATIVE CAPITAL COSTS (1974 TERMS)

	Cost Range ($ million)
Transfer Stations	
100 major stations @ $14-$17 million	$1,400-1,700
30 minor stations @ $5 million	150
LA/CBD Distribution	
3-4 terminals @ $25 million	75-100
1-2 mi. people-mover @ $25 million	25-50
Other ramps, special roadways	1-10
Bus Fleet Investment	
5,600 buses @ $50,000	280
TOTAL	$1,931-2,290

FIGURE 28. ALTERNATIVE C: REPRESENTATIVE CAPITAL COSTS (1974 TERMS)

	Cost Range ($ million)
Fixed-Guideway Construction	
(Estimate obtained from KE/DMJM)	$1,800-2,500
Rapid Transit Vehicles	
400 vehicles @ $400,000	160
Bus-Priority Ramp Installation	
400 ramps @ $250,000-$500,000	100-200
Parking Without Stations	
25,000 spaces @ $1,000	25
Bus Fleet Investment	
5,500 buses @ $50,000	275
TOTAL	$2,360-3,160

FIGURE 29. ALTERNATIVE D: REPRESENTATIVE CAPITAL COSTS (1974 TERMS)

	Cost Range ($ million)
Fixed-Guideway Construction	
(Estimate obtained from KE/DMJM)	$5,000-6,500
Rapid Transit Vehicles	
900 vehicles @ $400,000	360
Bus-Priority Ramp Installation	
400 ramps @ $250,000-$500,000	100-200
Parking Without Stations	
25,000 spaces @ $1,000	25
Bus Fleet Investment	
3,900 buses @ $50,000	195
TOTAL	$5,680-7,280

Comparative Cost Evaluation for Top-Rated Concepts

Figure 30 presents a basic cost comparison of the four top-rated concept alternatives. The data are preliminary order of magnitude values satisfactory for this comparison but should not be used outside this context. More refined data have been presented for the recommended program.

The cost data show the approximate total cost differences between the low-, moderate-, and high-capital-cost approaches. Even the lowest capital cost plan is not insignificant but would mean a major cost reduction if all performance measures were satisfactory. Both Alternatives A and B have been assigned significant costs for distribution facilities in and near downtown because of the large number of additional buses and passengers to be serviced.

Today 600 buses leave downtown in the afternoon peak hour. Alternative B creates a demand for buses in downtown three times that number; Alternative A also creates a demand nearly three times that number. The patronage consultant believes that this number is in excess of the street capacity that could be made available for bus priority streets and lanes, and that a major distribution system with off-street terminals and special ramps would be required. This is not to say that such facilities are needed initially, but they would be needed in the 1980's.

Ridership today is about 500,000 (not including transfers to maintain data comparability); it therefore can be said that transit riding would increase at least by a factor of between two and three. This growth can be attributed to three elements: (1) general growth of the region, (2) substantial increase in local bus services, and (3) addition of rapid transit service--either bus-on-freeway or fixed guideway.

Supplementary patronage studies have been made to learn more about the range of possible future riding levels if outside factors were to be changed--such as restrictions on auto use, high parking taxes, altered

FIGURE 30. COST COMPARISON OF TOP-RATED CONCEPTS (1974 COSTS FOR 1990 OPERATIONS)

Alternative	Net Annual Cost of Operation[1] ($ million)	Range of Total Capital Costs ($ million)
A	$110	$ 640-$ 800
B	$115	$1, 930-$2, 290
C	$100	$2, 360-$3, 160
D	$ 50	$5, 680-$7, 280

Note: (1) Difference between annual operating cost and annual operating revenue.

land use, etc. These seem to affect all alternatives more uniformly than uniquely. In most instances, these studies will be more important to designing the capacities of the system recommendation than to selecting among candidate system concepts.

Only Alternative A might be markedly less attractive to riders than the others. The difference between it and Alternative B is the speed-on-freeway assumptions, admittedly arbitrary values, selected by the patronage consultant from the best information available. The patronage for Alternative A could be higher if Caltrans is more successful with managing freeway congestion than the consultant has been willing to assume. Alternative A has shorter average trip lengths because it fails to compete for longer trips--its bus speeds cannot compete as well on long trips with automobile speeds.

The fact that Alternatives B, C, and D attract nearly similar riding levels means that most measures of regional benefits--travel time savings, reduced highway loads, reduced cost of auto ownership, and others--will be similar under 1990 conditions. We saw this in detail earlier for the test networks R1 and R2. However, the larger scale fixed guideway could produce proportionally more riding and regional benefits in the years following 1990 as the region becomes more oriented to high-quality rapid transit service and the effect it can have on locational decisions and regional mobility. The work of the environmental and community consultant members of the team has been aimed at specifically addressing these types of impacts. See their technical documentation for elaboration and further comparative evaluation.

It is still a matter of conjecture as to how well Alternatives A and B would work, and there is question as to their acceptance by the community and local public officials. This concern aside, our studies make it clear that from a broad regional perspective cost analysis alone can contribute significant insight into the preferred concept. The operating cost requirements are higher for all-bus systems.

Studies of operating costs were made to determine how sensitive the costs might be as assumptions were varied. The data presented here represent the patronage consultant's best judgment of probable 1990 conditions, but it is possible to have variations from those shown. An important point, nevertheless, is that bus-on-freeway operations are not much more expensive than fixed guideway at the projected traffic levels until bus speeds are slowed considerably. That is, if express buses could operate at about the same speed as fixed guideway, say averaging 40 mph, there would be little difference in the operating cost per passenger. However, when bus speeds on the freeway drop to about 25 mph, the cost per passenger increases by as much as 50 percent.

While the higher operating cost requirements for buses do not immediately offset the capital cost savings, it is clear that once committed to a major all-bus program such as represented by the Alternative B concept, the annual operating cost requirements could prove to be high enough to make a significant impact on total system costs. Total annual cost includes both the net annual operating cost requirement (after operating revenues have been subtracted) and the actual capital investment made during a given year. In Figure 31, total annual costs, at present value, are plotted over 40 years (the expected life of the transit system) for the all-bus system concept (Alternative B) and for a rapid transit system concept (Alternative C). "Balance" is achieved by 60 miles of fixed guideway together with an all-bus system in all parts of the region.

Summation of the total costs incurred over 40 years indicates that the all-bus system would cost on the order of 38 percent more than the balanced rapid transit system. This revelation depends entirely upon the assumptions, conditions, and results worked within the course of this study and is not intended as generally applicable under any circumstances. Nonetheless, the comparison results in the conclusion to a rigorous, systematic investigation of alternative system concepts for Los Angeles.

COMPARISON OF TOTAL COSTS TO THE YEAR 2014 (40 YEARS) FOR ALL-BUS vs. BALANCED RAPID TRANSIT SYSTEM

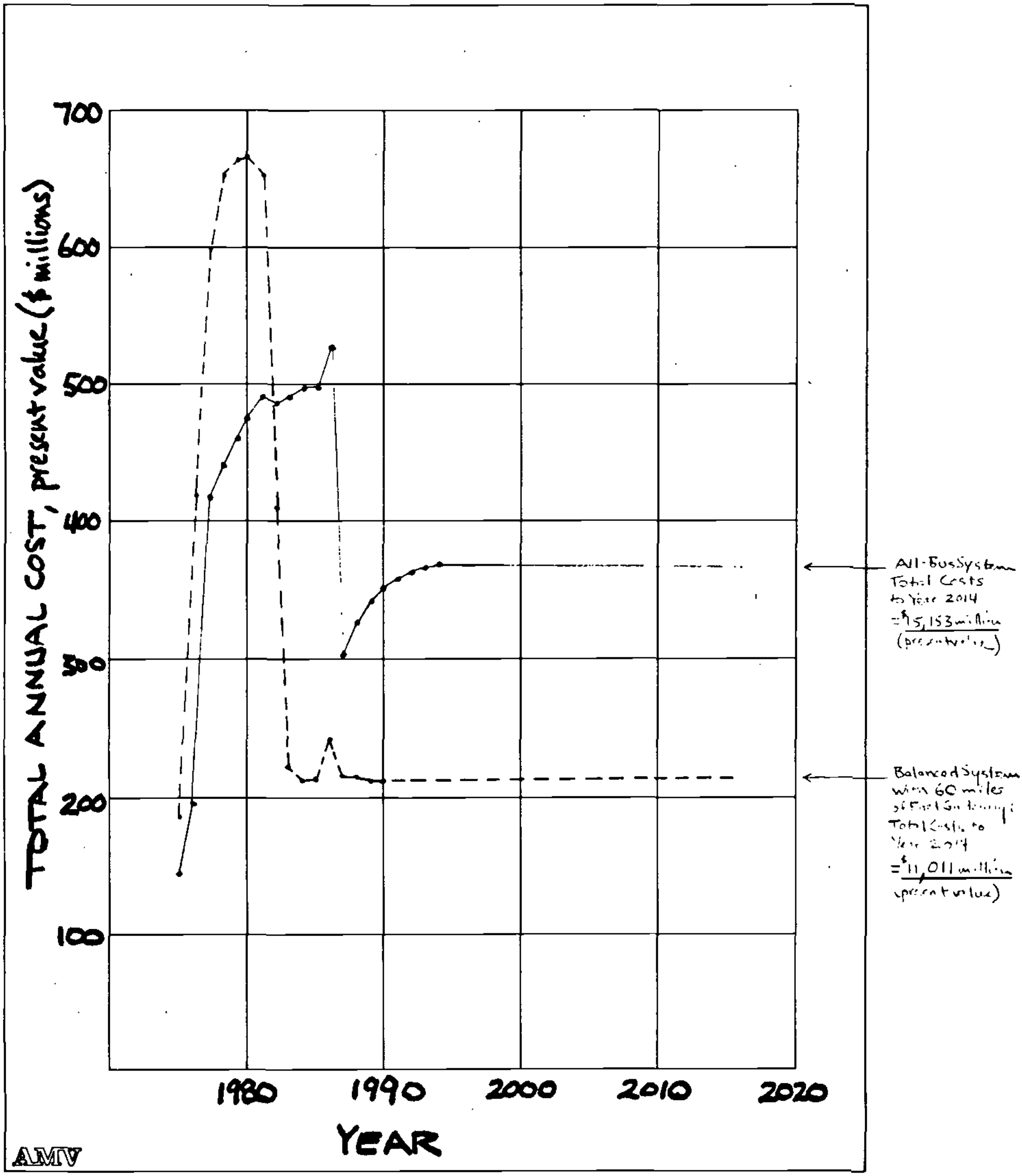


Figure 31

Furthermore, the samé comparison has been made for other balanced combinations of fixed guideway and bus services (those which were included in the system recommendation of the study team). In all cases, the all-bus system concept is more costly:

System Composition	Present Value of Total Costs Over 40 Years ($ million)
All-Bus System (Alternative B)	$15, 153
Balanced System With About	
36 miles fixed guideway	$ 9, 545
60 miles fixed guideway	$11, 010
80 miles fixed guideway	$11, 330
120 miles fixed guideway	$11, 245

All systems include costs involved in substantial expansion of the existing bus system to create a high-quality regional bus system.

Conclusions

The application of the all-bus and bus-on-freeway concepts to Los Angeles rapid transit needs is thought by many to theoretically reduce capital costs markedly and offer much better service than that provided today. There are a number of reasons that indicate that a regional all-bus system would be uneconomical, inadequate, and insufficient as the primary and permanent solution.

Not least of the reasons is the results of cost comparison over 40 years, indicating a great excess in total costs of an all-bus system over other balanced rapid transit systems including varying amounts of fixed guideway. Other questionable aspects of an all-bus system include the following:

- There would be limitations placed on motorists' use of freeways.

- Plans are not fully developed for local street control of traffic near metered ramps.

- There could be safety problems with a high-speed, high-volume operation.

- The number of buses entering the downtown area would be nearly triple today's number.

- There are unanswerable questions as to how well buses could operate through major interchanges, especially near downtown, and how well the interchanges can be made to work generally.

This Working Paper has outlined the reasons for the consultants' concluding that full reliance could not be placed on bus-on-freeway concepts as a general substitute for fixed-guideway routes in the Los Angeles area. The history of bus-on-freeway efforts is so questionable, and the workability of fixed guideway so certain, that one could not justify postponing a start on the fixed guideway while experiments with bus-on-freeway were being launched. At the same time, there is opportunity to apply the concept in part to supplement the fixed-guideway program and to attempt to bring early benefits to travelers.

The work of AMV and the environmental and community consultants has indicated--and has been documented both in this volume and in the technical documentation of the latter--that all-bus system service difficulties and localized impact on circulation and the community in some areas are extreme. In these areas, high-quality service simply cannot be provided by buses alone. Fixed guideway development to adequately serve these areas amounts to approximately the 60-mile extent proposed in system concept Alternative C. There can be little doubt about the economic justification and rationale of benefits attributable to fixed guideway in these areas.

Because funding, at the Federal level in particular, will likely be less than needed in the near future, the consultants conclude that the soundest approach is to begin the fixed-guideway program with projects that are located in these areas which bus-on-freeway services can least well serve.

These rapid transit projects can be made much more effective by use of bus-on-freeway and bus-on-arterial projects to extend the benefits of fast-link transit service well beyond the fixed-guideway terminals. A joint program with Caltrans to promote and develop bus-on-freeway operation is warranted in order to provide this coverage. It is possible that many projects could be tried and established in three to five years, if Caltrans plans for freeway controls are advanced.

Consultant evaluation processes have developed data which indicate that while extension and augmentation of the 60 miles of fixed guideway with high-quality bus services might be adequate for some years to come, there is indication that fixed-guideway development of between 60 and 120 miles is at least as attractive. In general, at issue is whether it is necessary and desirable for the region to commit to fixed-guideway development beyond 60 miles at this time. Specifically at issue are not technical assessment of level of service (bus versus fixed-guideway attractiveness) or cost (total costs appearing to be only marginally different), but rather basic policy questions such as

- Which areas get guideway service before others?
- To what extent would needed resources have to be diverted from community-level improvements?
- What is the region's approach to energy and air quality issues?

While fixed guideway appears highly attractive up to 120 miles, these policy issues will have to be addressed by the region to determine the extent of the commitment to be made at this time. In areas beyond the extent of about 120 miles of fixed guideway (say, the Phase II recommendation or the 120-mile level discussed in the Phase III recommendations), it becomes rather difficult to focus on the tradeoffs involved in discerning the relative attractiveness of one approach versus another. The expense required to install fixed guideway is apparent. Also apparent, but perhaps not as clearly, is the rather small marginal increase in patronage effected by adding such incremental guideway links to a transit network for computer testing. The degree of precision with which one is able to forecast response to these additions under 1990 conditions leaves one short of a clear warrant for either a fixed guideway or an all-bus approach in these areas.

The study team has recognized the opportunity to reserve for commitment, based upon future conditions, upwards of 200 miles of separate facilities for public transportation vehicles to serve all parts of the Southern California Rapid Transit District. Extension of high-speed transit service in some form might be the public transportation goal of the region.

Implementation Considerations

Recognizing that the fixed guideway for which a commitment might be made now will depend upon Federal assistance for timely completion, the study team endeavored to configure various example levels of system development for the SCRTD's consideration. The purpose of these levels would be to indicate how commitment to system development might respond to the commitment of Federal assistance. The development levels--or "building blocks"--are not intended to be alternative recommended systems, but rather should be viewed as possible approaches to flexible commitment of local resources in order to warrant, and contingent upon, Federal commitment of resources to Los Angeles.

Any commitment to improving public transportation must begin with immediate-action projects to introduce and demonstrate the potential for success of transit that responds to community-level needs as well as expansion of regional express bus operations. A concurrent step must be establishment of a continuing mechanism for gauging how and where to expand the scope of community-responsive transit services. Likewise, procedures must be developed for the continual expansion and establishment of successful bus priority measures and new express services.

Commitment of resources to implementation of fixed-guideway elements can, of course, be made at any point during the early years of bus system expansion. The building-block development levels represent the type of flexibility which can be employed by the region in making these commitments. The intent of Phase III study was not to develop priorities for implementation. The people of the region, through their SCRTD and SCAG policy-makers, will set their own priorities. However, unavoidably, when the study team sets forth example levels for commitment, creedance is lent to the notion that these should represent the region's priorities.

In this context, it is probably advisable to summarize the process through which the study team determined the extent of these levels. The primary consideration was to demonstrate what might be an attractive use of a particular level of total resources--local, state, and federal; capital and operating support.

Another factor was attention to the utility or system implications of each particular link included. For example, a single small link unconnected to any others could hardly be considered "usable." Also part of this consideration is whether a particular link or combination, while connected, would be viable, due to its shortness, traffic congestion or other factors.

Clearly, cost considerations had to be included in assembling links to fulfill a particular funding level. Together with costs, were consideration of construction sequence and feasibility. The time required before beginning revenue service is part of this factor. Finally, integrated into all these considerations were the service aspects: who benefits first, what level of usage might be expected, how would those not close to the link gain access, and could the link be supplanted by an interim service using an already existing facility.

Application of all these considerations led the study team to present the set of development levels presented as "building blocks" in the summary report of March, 1974, A Public Transportation Improvement Program.

Projected operating results for each of these levels are presented in Figure 32. Profiles of the line ridership volumes for the fixed guideway component might be expected to be conservatively estimated as follows.

PROJECTED OPERATING RESULTS
(1990 Conditions, 1973 Costs)

Level	Miles of Fixed Guideway	Range of Average Daily Patronage (millions)	Revenue Service		Annual Maintenance & Operating Costs(millions)				
			Start	Full	Surface Bus	Feeder Bus	Freeway Bus	Fixed Guideway	TOTAL
I	36	1.1-2.0	1981	1982	$ 61.	$39.	$110.	$25.	$235.
II	57	1.28-2.5	1981	1983	104.	32.	84.	38.	258.
III	81	1.35-2.6	1981	1984	100.	34.	65.	51.	250.
IV	121	1.5-3.0	1981	1987	96.	37.	16.	70.	219.

Level	
I	Approximately one-half to two-thirds the volumes presented earlier for Alternative C
II	Approximately those volumes presented for Alternative C
III	Approximately 90% of the volumes presented earlier for Alternative D
IV	Approximately those volumes presented for Alternative D

These volumes would constitute a lower bound on the range of patronage projections with which we are constrained to work because of uncertainties over future conditions.

For the use of the consultants responsible for facility sizing and capital cost estimates, AMV has endeavored to develop a basis upon which those consultants could prepare refined cost estimates that reflect the requirements for "expandability" and "extendability" of fixed guideway elements. For major links envisioned as opportunities for development within the public transportation goal of the region, AMV has projected a reasonable upper bound on patronage that might someday be realized. As discussed earlier in this volume, this upper bound was estimated based partially upon consideration of special generation of transit trips and transit time improvements beyond SCRTD and partially upon the results of the Task 8.2 Sensitivity Analysis reflecting possible automobile operating costs, fuel availability and travel restriction. These "ultimate-design type" volumes are presented in Figure 33

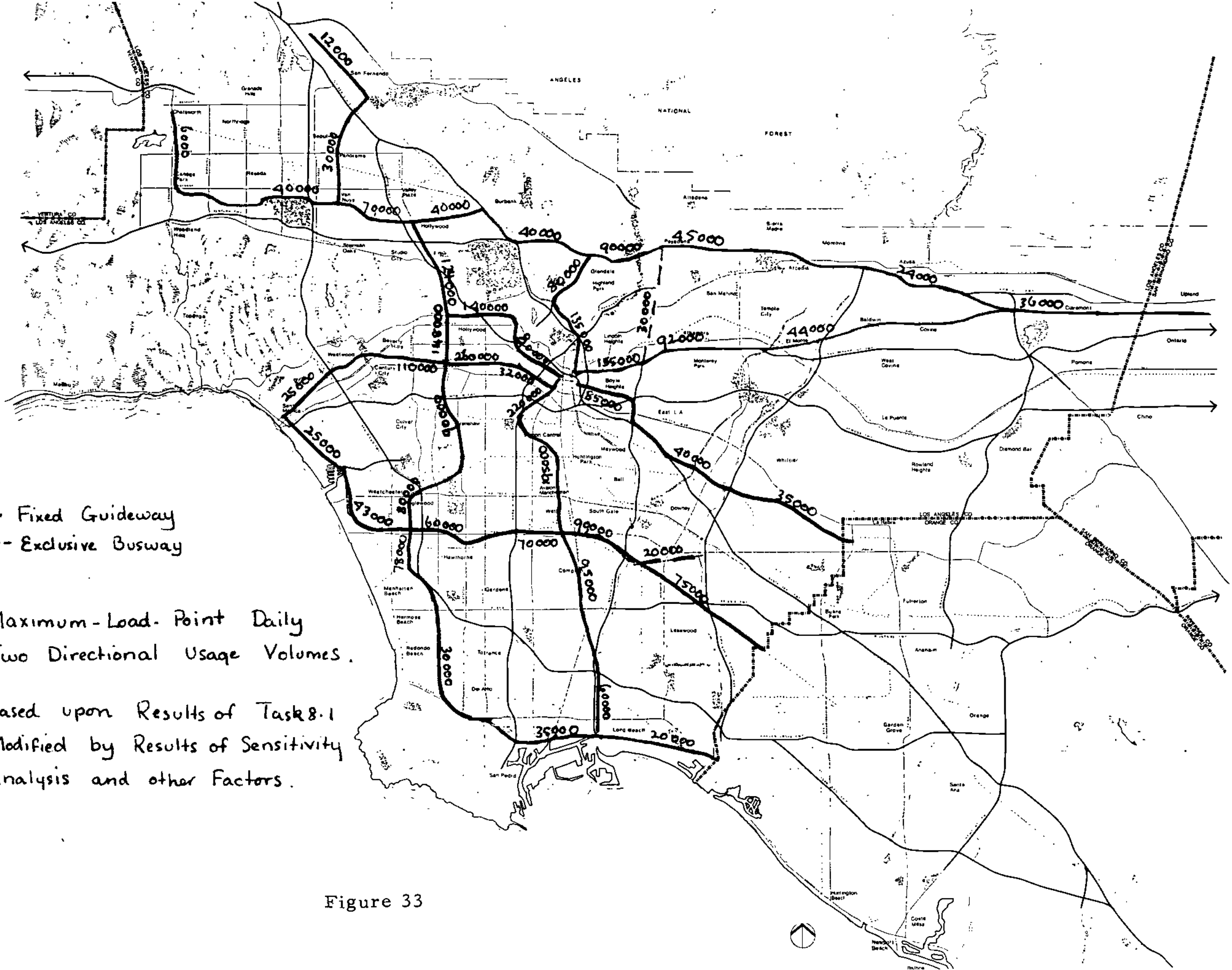


Figure 33

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Local Circulation and System Access

The public transportation improvement program set forth by the study team includes budget and project specification sufficient to build a comprehensive, balanced transit system starting at present. Recognizing the need for transit improvements well in advance of new regional rapid transit system, the SCRTD and many local jurisdictions have begun a process of implementing immediate-action projects to satisfy many important local circulation needs and opportunities which can be readily identified. This implementation must be a continuing program shared jointly by the municipalities, the County and SCRTD. Such a mechanism will provide the foundation for the development of a balanced transit system. The Task 8.6 Technical Working Paper, Implementation Schedule for a Public Transportation Improvement Program explains the present status of the program in much greater detail. That document also lays out a budget of expenditures required to continue development of local circulation services which may become the basis for access to and distribution from whatever trunk-line rapid transit facilities are implemented.

As noted previously, the Task 8.3 Technical Report, Conceptual Planning of Local Circulation and Feeder Transit Systems, addresses potential ways of developing community-oriented transit services that can both provide for local circulation and serve a feeder/distributor function relative to line-haul rapid transit. While the analytical methodology presented there is only one possible approach, the indications from the Task 8.3 work are that the most economic local circulation as well as feeder/distributor element for the vast majority of the communities in the County utilizes bus service. Whether the bus is operated over fixed routes or in response to demand is largely a matter of very local concern. The improvement process that would follow from the study team recommendations includes ample budget for providing a high level of fixed-route local bus services in all communities. Demand-responsive approaches typically cost much more than fixed-route services and it ought to be the decision of an individual community whether to opt for a more costly approach. SCRTD will have to decide how far it will be able to go toward helping the community meet the extraordinary costs of, for example, a demand-responsive approach.