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Distribution and Allocation of Transit Subsidies in California

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ABSTRACT

The allocation of federal and state transit assistance on the basis of population, employment or other demographic or geographic characteristics promotes policies which may not correspond to state or federal policies toward transit. Allocation formulas must be designed to provide operators with an incentive to comply with governmental policy. In addition, existing allocation procedures fail to promote effectiveness and efficiency in transit service. Forty-nine performance indicators are analyzed on the basis of data availability, methodological correctness, and bias, and five are selected which measure system effectiveness and efficiency and allow comparison of one system against another. These indicators may be utilized in a subsidy allocation system providing both support for basic transit services and incentives for increased efficiency.

INTRODUCTION

State and Federal financial assistance is currently provided to transit operators with little or no guarantee as to the effectiveness or efficiency with which it will be used. Apportionments are usually based on population characteristics or operating deficits which result in inequities. If we assume that transit is a public good and eligible for governmental assistance, it is appropriate to ask how might government allocate funds so as to provide for the maintenance of a "basic" level of transit service while rewarding efficiency?

Governmental assistance is often a two-stage allocation: first to a governmental sub-entity (e.g., states, regions, or counties), then to the transit operator. Section 5 of the Urban Mass Transportation Act, as amended in 1974, provides assistance to states and metropolitan regions based upon population criteria for redistribution to transit operators. Similarly, sales tax revenues generated under the provisions of California's Transportation Development Act (TDA) are presently returned to the various counties and their Local Transportation Funds[1] according to the volume of taxable sales and then allocated to transit operators on the basis of population or route mileage. Do these procedures apportion the revenues where they are most needed or are there other formulas which could result in more appropriate allocation of funds to achieve transit improvement?

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[1]The Transportation Development Act established a Local Transportation Fund in each of California's counties as the accounting mechanism to which the tax revenues accrue. These funds are controlled by the County Board of Supervisors, the regional transportation planning agency, council of governments or Transportation Commission as determined by the Act's specification; see California Public Utilities Code, Section 29532.

Several recent studies have focused upon the problems of evaluating transit performance and allocating governmental subsidies. Jones[2] presents a detailed analysis of the sources and procedures of transit finance and finds that transit subsidies in general lack clear objectives, promote capital-oriented solutions, and fail to correspond to actual levels of need. Citing the failure of current subsidy systems to encourage efficiency and more effective service, the author outlines three possible strategies for the allocation of additional subsidy funding on the basis of output measures such as ridership or vehicle-miles. These strategies are then evaluated as they would affect California transit operators and as they would promote various objectives for transit.

Allen and DiCesare[3] discuss the need for evaluation of transit service and provide an overview of the theory of evaluation methodology. They conclude that transit service can be measured and that, while the development of a comprehensive evaluation system will require considerable effort, such effort is justified.

Gilbert and Dajani[4] examine possible perspectives which an evaluation system might take (federal, state, local, user and operator) and

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[2] David W. Jones, Jr., John Mollenkopf, and Hilary Rowen. Transit Operating Assistance: Options For A Second Generation Program Of State Aid. For the California Department of Transportation, Division of Transportation Planning. The Stanford Transportation Research Program and the Center for Interdisciplinary Research, Stanford University. February, 1976.

[3] William G. Allen and Frank DiCesare. Transit Service Evaluation: An Introduction and Preliminary Identification of Variables Characterizing Level of Service. Prepared for presentation at the 55th Annual Meeting of the Transportation Research Board, Washington, D.C., January, 1976.

[4] Gorman Gilbert and Jarir S. Dajani. Measuring the Performance of Transit Service. University of North Carolina, Chapel Hill, 1975.

determine that the interrelated nature of these perspectives necessitates a conceptual framework to assist in selecting appropriate performance indicators and combining their computed values into meaningful evaluations. Their conceptual framework emphasizes three levels of evaluation: efficiency, effectiveness, and impact. They recommend that a basic level of funding should be provided to systems with additional funding for those systems which achieve increased effectiveness.

The thesis of this paper is that present governmental funding to transit--and particularly that of California's Transportation Act--may be allocated through formulas ensuring the provision of a basic level of transit service while promoting more efficient and effective service through output-based incentives.

In California, operating assistance begins with apportionment of tax revenues to the counties. Therefore, the first section of this paper will discuss possible bases for this apportionment and the need to relate apportionment procedure to policy.

The second half of the paper will develop performance indicators and apply them to selected transit operators within California. The results of this application will be analyzed and the relationships between indicators discussed.

The formulas and indicators presented utilize generally available and accurate data. They minimize the possibility of manipulation and result in equitable funding allocations and ease of implementation.

This study will concentrate on the allocation of TDA funds to transit within California, although most aspects of this example are clearly and readily generalizeable to both Federal transit assistance and transit assistance in other states. Future research will validate these indicators by studies in California and elsewhere in the United States.

DISTRIBUTION FORMULAS

TDA funds are presently returned to each county's Local Transportation Fund according to the proportional volume of taxable transactions occurring within that county. This procedure returns the tax revenue to its source--a particularly sensitive political issue and one necessitated by the Act's legal structure through which the TDA revenue is actually a county-imposed sales tax [California Public Utilities Code, Section 99220(c)]. The fact that the tax is imposed by the various counties rather than the state introduces the important issue of whether these TDA funds may be reallocated on considerations other than return-to-source: as presently written, the tax revenues must be returned to their respective counties. Modification of this scheme will only follow the determination that the present formula fails to allocate funds in such a manner to assist in achieving the goals established by the state for transit.

To clarify the underlying philosophy of the Act, one must determine the impact the present scheme of apportionment has on transit services. Based as it is on proportional taxable transactions within each county, the existing procedure favors counties which have a high volume of taxable sales. Since basic necessities (food, medicine, and services) are not subject to the general sales tax in California, apportionment of tax revenues to the counties on the basis of taxable transactions volume tends to reward areas with higher levels of consumption of taxable goods. Under this formula, then, higher funding is available to develop transit in high-consumption areas. High levels of taxable-goods consumption tend to be associated with high volumes of consumer trips--exactly the trips which transit has been least effective in capturing. This allocation of TDA funds, therefore, may be inappropriate for developing basic transit service where it is most needed and has the greatest probability of high use: low income areas with a high degree of dependence on transit but a lower level of taxable-goods consumption.

Other apportionment formulas furthering different policies may be constructed out of readily available statistics. The first of these allocates TDA funds on the basis of county population. Use of a straight population-based formula would encourage the development of a basic level of transit regardless of the existence or nonexistence of more specific consumer or commuter requirements. It would, however, involve some inequity by ignoring the effects of population density on transit services: provision of the same level of service will be more expensive in a lower-density area. The comparative allocations using this formula and the present taxable transactions formula are shown in Figure 1. This figure shows the allocations of 1973-74 TDA receipts[5] to the eleven largest California counties--which presently account for almost 77% of all TDA funds--using each of the allocation formulas to be discussed. The variance in allocated amounts by the different formulas and between counties is further depicted in Figure 2.

A third formula for apportioning TDA funds is that which utilizes proportional employment within each county. This formula would provide significantly heavier funding to counties which contain a high number of jobs: Los Angeles, San Francisco, Santa Clara. The fallacy underlying

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[5]Figure used for receipts was basic tax revenue before inclusion of interest and retained receipts of the previous year.

Figure 1

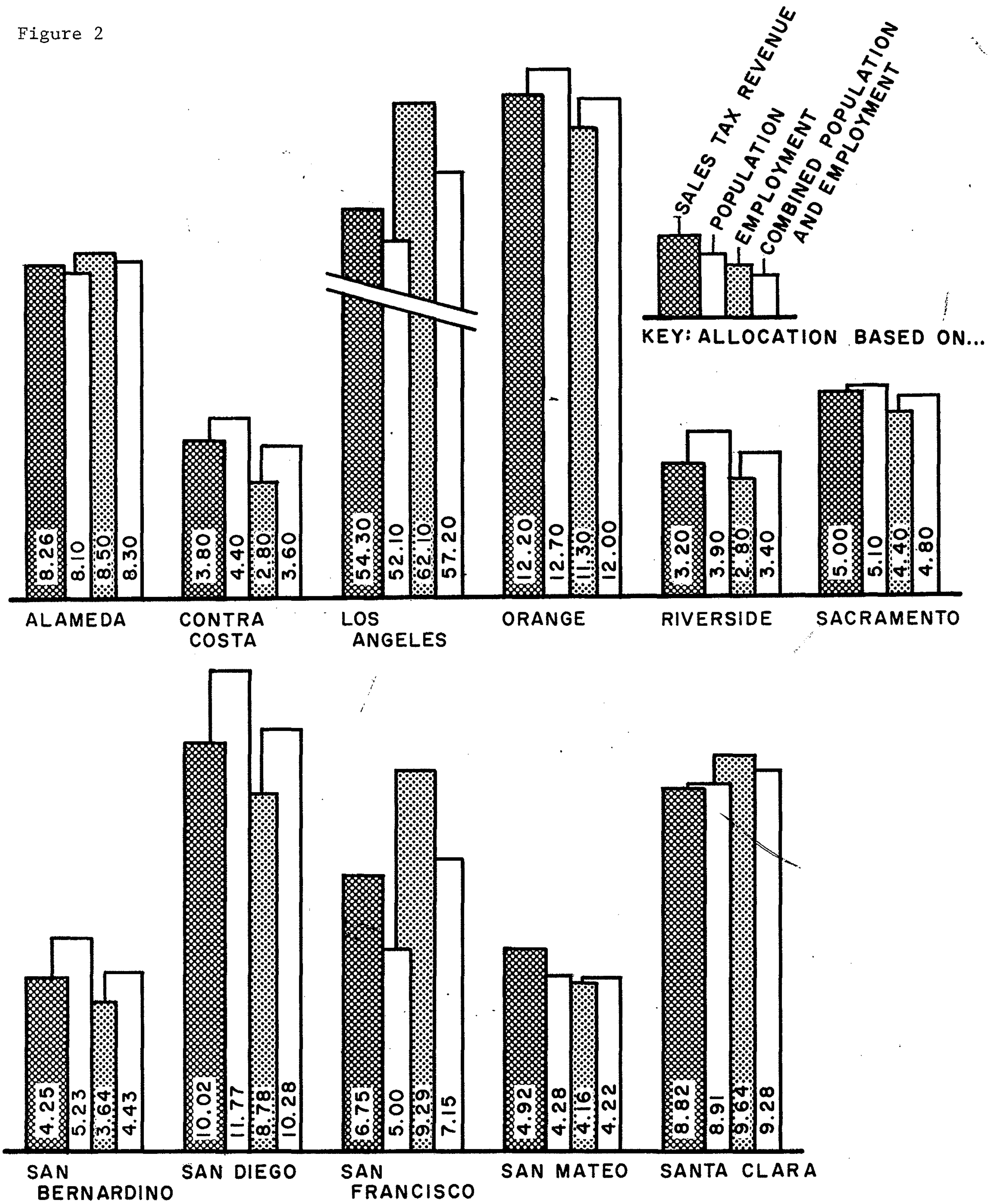
Allocations of FY 1973-4 TDA Funds # According To
Sales Tax Revenues, Population, Employment, and
Combination Formulas: (All Amounts In Millions Of Dollars)

County	Sales Tax	Population	Employment	Combination*
Alameda	$8.27	$8.14	$8.49	$8.31
Contra Costa	3.84	4.38	2.78	3.58
Los Angeles	54.31	52.19	62.12	57.16
Orange	12.15	12.69	11.32	12.00
Riverside	3.19	3.94	2.78	3.36
Sacramento	5.01	5.15	4.43	4.79
San Bernardino	4.25	5.23	3.64	4.43
San Diego	10.02	11.77	8.78	10.28
San Francisco	6.75	5.00	9.29	7.15
San Mateo	4.92	4.28	4.16	4.22
Santa Clara	8.82	8.91	9.64	9.28

*Combination Formula is an average of proportional population and employment of an area

#The amount allocated through these formulas is the total sales tax receipts of $158.1 million for FY 1973-4 for all California counties, which is the most recent year for which all supporting data is available.

Figure 2


SALES TAX REVENUE
POPULATION
EMPLOYMENT
COMBINED POPULATION AND EMPLOYMENT
KEY: ALLOCATION BASED ON...
8.26
8.10
8.50
8.30
ALAMEDA
3.80
4.40
2.80
3.60
CONTRA COSTA
54.30
52.10
62.10
57.20
LOS ANGELES
12.20
12.70
11.30
12.00
ORANGE
3.20
3.90
2.80
3.40
RIVERSIDE
5.00
5.10
4.40
4.80
SACRAMENTO
4.25
5.23
3.64
4.43
SAN BERNARDINO
10.02
11.77
8.78
10.28
SAN DIEGO
6.75
5.00
9.29
7.15
SAN FRANCISCO
4.92
4.28
4.16
4.22
SAN MATEO
8.82
8.91
9.64
9.28
SANTA CLARA

this employment-based formula is that the need for commuter transit services stops at the county line in which the job is located. As an alternative to the use of county boundaries, the urbanized areas as defined by the U.S. Bureau of the Census could be utilized. The urbanized area would more closely correspond to total transit needs than county boundaries.

A fourth formula--a composite of the population and employment formulas--permits a weighting of both population and employment-generated transit requirements. Using an average of each county's proportional population and proportional employment, an allocation scheme may be devised which heavily favors neither high population areas nor high employment areas. The construction of a formula integrating more than one factor holds significant potential for promoting transit policy in that multiple objectives may be encouraged. However, the weighting of the various objectives becomes increasingly difficult as additional factors are included.

The sample allocations contained in Figure 1 and depicted in Figure 2 demonstrate that each of these four allocation formulas results in a different allocation of funds among the counties considered. Different counties receive larger allocations from particular formulas: San Francisco, Los Angeles, and Santa Clara receive higher allocations from the employment-based formula, while Contra Costa, Orange, San Bernardino and San Diego benefit from the population--based formula.

Allocation formulas in themselves will not bring about particular orientations in the delivery of transit services unless the level of funds allocated by them is crucial to transit operations. Formulas should be designed to augment specified governmental policy to bring about desired objectives.

The selection of the statistical base upon which to construct the allocation formula must be determined by the policy of the state toward transit: Is it the intention of the state to encourage a basic level of transit, to encourage development of commuter-oriented transit, or to encourage development of shopper-oriented services? If alternative formulas exist for encouraging the state's goals for transit, selection of the formula to be used may be done on the basis of ease of calculation. If the state goals for transit in California were judged to be equally promoted through all four formulas, then the sales tax-based formula would be the most easily administered: it is already utilized to return other sales tax revenues to local government.

PERFORMANCE INDICATORS

The allocation of TDA funds to the operators in each county is accomplished through a population-based formula except in the case of operators within Los Angeles County and operators within the counties covered by the Metropolitan Transportation Commission.[6] Allocations within LA County are based on route miles, while operators within the MTC area who meet specified service criteria are allocated funds on the basis of population in their service areas.

While simple population provides some indication of an area's absolute need for transportation, such a formula provides no indication of operational characteristics or extent of service provided by existing transit properties. Route-miles, on the other hand, provide a rough measure of the extent of service provided, yet controls are necessary to prohibit manipulation. The extent of service provided by a property, its achieved ridership, and its utilization of resources provide additional indicators of a property's service effectiveness and efficiency.

Funding for transit should be connected to performance through indicators which measure system efficiency and effectiveness. In proposing such performance indicators, it is realized that they are inappropriate for transit properties just being created or for demand-responsive and rail transit systems. Such limitations will exist with any scheme focusing on efficiency and effectiveness of service, and may be dealt with through special provisions.

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[6]The Metropolitan Transportation Commission is a statutorily created body with responsibility for transportation planning and development in the nine San Francisco Bay counties: Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma.

INDICATOR SELECTION CRITERIA

The objective of this project is to identify measures of transit performance which can be used in comparisons between transit properties and between divisions of the same property. This objective has meant the omission of traditional indicators like passengers per mile or passengers per employee because these indicators are indefensible on methodological grounds.

It is taxonomically incorrect to combine measures of efficiency and effectiveness in a single indicator of transit performance. Efficiency considers the organizational processes and the relation of inputs to outputs, while effectiveness addresses the system output.

Failure to distinguish between efficiency and effectiveness commonly results in the use of methodologically incorrect performance measures. Efficiency must be evaluated on the basis of produced output rather than consumed output.[7] Total output, regardless of the utilization of that output by the population, is the only just way to evaluate how efficiently an organization uses available resources. Effectiveness, on the other hand, measures the consumption of output: vehicle-miles, vehicle-hours of service, and seat-miles are measures of produced output, while passengers, and passenger-miles are measures of consumed output.

An example of such an incorrect indicator would be the use of revenue passengers per mile as a measure of system productivity. This indicator measures productivity not on the actual output of the system, but on the success--i.e., the achieved ridership--of the system. This mistake is made

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[7]For a comprehensive discussion of the use of produced versus consumed output measures, see Anthony R. Tomazinis, Productivity, Efficiency, and Quality in Urban Transportation Systems (Lexington, Mass: D. C. Heath and Company, 1975), pp. 164-165.

in a performance audit manual developed by Peat, Marwick, Mitchell and Co., for the San Diego Comprehensive Planning Organization when it lists "Revenue Passengers Per Mile" as a productivity measure.[8] They mix a consumption measure with production. While this type of indicator can prove useful in evaluating the performance of one system over time, it is not conceptually sound as an indicator between systems.

Any system of performance indicators will receive careful scrutiny by the transit industry. Therefore, it is essential that validity not be jeopardized by using measures which are conceptually inappropriate.

Efficiency:

Efficiency concerns the organizational processes involved in, and the use of inputs for, the provision of transit services. Productivity is an element of efficiency, as are unit monetary costs since they are a rough surrogate for the quality of inputs into the system. In transit, the major inputs are labor, equipment, and energy.

Efficiency may be operationalized using measures for the equipment utilization of the system; the labor productivity of the system; and, as a measure of total inputs, the cost per unit of output. Figure 3 shows the relation between the goals underlying this paper's indication scheme, their operationalized definitions, and the performance indicators selected to represent them.

While energy is a major input to the production of transit services, the factors which effect it and means of evaluating it are not fully

[8] Comprehensive Planning Organization. Transit Operators Performance Audit Guide. San Diego, July, 1976, p. 42.

Figure 3

GOAL	OPERATIONAL DEFINITION	PERFORMANCE INDICATORS
EFFICIENCY		
	EQUIPMENT UTILIZATION	AVERAGE REVENUE VEHICLE HOURS PER VEHICLE
	LABOR PRODUCTIVITY	VEHICLE HOURS PER EMPLOYEE
	COST PER UNIT OF OUTPUT	OPERATING COST PER VEHICLE HOUR
EFFECTIVENESS		
	ACHIEVED PATRONAGE	PASSENGER TRIPS PER POPULATION SERVED
	ACCESSIBILITY	PERCENT POPULATION SERVED

understood. A measure of energy efficiency may be an important addition to the developed indicator system.

Effectiveness:

Effectiveness is concerned with the transit service which is actually provided: its accessibility to the area's residents and its correspondence to the transportation requirements of the particular area.

The quality of transit service,will not be considered in the evaluation of service effectiveness. Beyond reasonably timely service and basic comforts (the provision of seats and minimum heat in freezing weather), quality is a factor which changes with the climatic conditions, the demographic makeup, the trip characteristics, and even the geography of each area. The importance attached to the various aspects of service--such as frequency of stops, exposure to inclement weather, and availability of air-conditioning--are area specific; i.e., they cannot be predicted or prescribed for an area without knowledge of that particular area. For the purposes of this study it is assumed that "basic" transit service should be defined in terms of available mobility and not quality of service.

Where transit services are needed for the mobility of some sector of the population, the degree to which the service provided corresponds to the existing need will be indicated by the patronage achieved by the system. This correspondence can be evaluated through measures of service utilization such as passenger trips per population served.

Accessibility of the transit service to the residents of any area would ideally indicate the proportion of the population for whom the transit routes are within convenient distance of their origin and desired destination. Such an ideal measure would involve generation of considerable origin-destination data and demographic data which is not available in California. Therefore, this study operationalizes accessibility as the proportion of an area's population which resides within a prescribed distance of regularly scheduled transit service. It is a measure of accessible origins and not necessarily of destinations. However, the percentage of population served does provide a surrogate measure for the effectiveness of service.

Practical Considerations:

A prime consideration in selecting performance indicators should be that they rely upon generally available data elements or on elements which will be required by other reporting systems. The 1974 amendments to the Urban Mass Transportation Act specify that the Secretary of Transportation "...shall by January 10, 1977, develop, test, and prescribe a reporting system to accumulate public mass transportation financial and operating information by uniform categories and a uniform system of accounts and records."[9] Two reporting systems are being developed in response to this mandate: the Financial Accounting and Reporting Elements (FARE) system being developed by Arthur Andersen & Co., and the National Urban Transportation Reporting System being developed by UMTA.

While some indicators are methodologically inappropriate, there are other indicators which have been excluded because they cause inherent biases due to the effect of geography. Examples might be indicators utilizing vehicle-miles which introduce bias on the basis of congestion. Local

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[9] Urban Mass Transportation Act of 1964 (amended), Section 15(a).

conditions vary considerably and are usually beyond the control of the transit property. It is therefore inappropriate to suggest these as indicators for transit performance.

SELECTED INDICATORS

A review of transit literature discloses an extensive listing of potential performance measures. Methodological correctness and practical aspects, such as data availability, reduce this listing to a few appropriate measures (see listing of indicators in Appendix A). The following indicators have been selected as appropriate for evaluating and comparing transit properties and systems.

Efficiency Indicators:

a) Average Revenue Vehicle Hours Per Vehicle. The ratio of total revenue vehicle hours of the transit property over the average revenue vehicles utilized by the property during the year. This measure provides an indication of the productive utilization of the average transit vehicle during the year. The component data elements are: Total Revenue Vehicle Hours: the total hours of revenue service provided by all transit vehicles of the subject property; and Average Revenue Vehicles: the average revenue vehicles in service during the year.

This indicator will highlight those properties which are heavily oriented toward commuter service as well as relative efficiency of equipment utilization. Modification of this indicator to utilize the elements of the FARE system of accounts may be achieved with a minimum of difficulty and will have the benefits of explicit definition of the elements and added ease of application.

b) Revenue Hours Per Employee. The ratio of total revenue vehicle hours over the total employees of the transit property. This indicator provides a measure of the labor productivity of the property. The component data elements of this indicator are: Total Revenue Vehicle Hours: the total hours of revenue service provided by all transit vehicles; and Total Employees: total of all employees of the transit property--operational and administrative. For part-time and contract employees this would be a sum of the proportion of time employed by the transit property.

Use of this indicator requires strict accounting of the use of contract services and shared employees, such as payroll personnel in a municipal operation who serve all aspects of the municipal government. This issue is not addressed adequately in the guidelines and structure of the FARE system as described in the Task IV Report of November, 1973.

Advantages of this indicator are that its data elements--other than contract and shared employees--are generally available or can be easily generated. It also takes into account the administrative personnel of the subject property in computing productivity, and it applies equally to large and small operations.

Disadvantages inherent in this indicator are that: 1) it will most likely produce an incorrect reading from a property which is either newly created or in the process of expansion since additional personnel are usually hired for planning, public relations, construction work, or in anticipation of increased volume; and 2) the indicator does not account for overtime worked by employees.

c) Operating Cost Per Revenue Hour. The ratio of total operating expenses over total revenue hours. This indicator provides an important measure of system efficiency: the cost of operating a transit vehicle per hour of revenue service. The component data elements are: Total Operating Expenses: includes transportation expenses, maintenance expenses, marketing expenses, fuel expense, and depreciation; and Total Revenue Vehicle Hours: the total hours of service provided by all transit vehicles of the property.

This indicator has the advantages of being applicable to all sizes and modes of service and utilizes data which is presently available. The inclusion of depreciation in Operating Expense facilitates comparability between transit modes: lower per rider operating costs in bus operations are offset by higher annual depreciation, while higher per-rider operating costs in rail-transit are partly offset by lower depreciation due to longer capital life. The use of this indicator would be greatly facilitated by the adoption of the FARE reporting system.

Effectiveness Indicators:

a) Passenger Trips Per Population Served. The ratio of total revenue passengers over the population of the coverage area. This indicator provides a measure of the penetration of transit into its potential market. The component data elements are: Total Revenue Passengers: total initial revenue passengers for a system during the subject year; and Population of the Coverage Area: the population within a specified distance of regularly scheduled transit service. For local bus service the specified distance shall be a quarter mile band width each side of the transit route. For express bus and/or rail transit service, the specified distance will be a quarter mile radius from the station or stop plus credit for local feeder bus service to and from the station or stop.

The advantage inherent in this indicator is that it encourages the transit property to search for routes which may be deleted without proportional reduction in patronage and for routes which may be added with higher than average patronage. At the same time, this measure is not intended to indicate quality of service and therefore does not consider frequency of service beyond requirements that service considered have headways less than an established standard.

Disadvantages of this indicator are that Population of the Coverage Area is not computed by all properties (although it may soon be required as an element in data items required by UMTA under Section 15(a) of the Urban Mass Transportation Act), and that it is not applicable to demand-responsive and special purpose transit systems.

b) Percent Population Served. The ratio of the population of the coverage area over the population of the service area. This indicator provides a measure of the system's route coverage of residential areas and accessibility. Percent Population Served is the basic indicator of the level of service being provided by a transit system. The component data elements of this indicator are: Population of the Coverage Area: as described above under "Passenger Trips Per Population Served"; and Population of the Service Area: this is the population of the jurisdiction within which the transit property operates. For properties not operating within particular boundaries, this would be the population falling within a line drawn to connect the extreme points of the property's established routes.

The inherent difficulty with this indicator is that particular transit properties have problems in computing the populations of the service and coverage areas due to overlapping jurisdictions, frequent changes in routing, or simply insufficient administrative support to generate this information. Federal requirements will most likely mandate the collection of these data items by transit operators.

APPLYING THE INDICATORS

The five indicators were applied to major transit properties in the San Francisco Bay Region and other selected major operators in California. Data elements were obtained primarily from the Transportation Development Act Annual Report for FY 1974-75. The accuracy and meaning of these data elements may be debated. However, the basic trends and levels demonstrated in the computed statistics are essentially correct. Use of these statistical performance indicators for allocation or evaluation procedures would require more accurate and clearly defined data elements.

Applicability of the performance indicators varies with the transit mode because fixed-route buses, demand-responsive and variable-route buses, and fixed rail transit each have unique operating requirements. In addition, far more information is available on fixed-route bus systems than other modes; there is only one rail transit operator in California,[10] and the demand-responsive systems are too new to fairly assess performance.

Fixed-Route Buses:

Computed statistics for fixed-route operations appear in Figure 4 and correlation coefficients in Figure 5. The data elements used to produce these indicator values are enclosed as Appendix B. Standard deviation indicates the spread of values around the statistical mean value for each indicator. A high standard deviation signifies that indicator values are widely

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[10] The data elements for San Francisco Municipal System do not separate the bus operations, cablecar, street trolley, or streetcars. Therefore references to Muni are based on the aggregate statistics and it was classified as fixed-route bus for the purposes of this study. Commuter rail and intercity rail service was not subsidized by TDA funds in 1974-75.

Figure 4: COMPUTED STATISTICS FOR SELECTED OPERATORS (Estimated FY 1975-76)

Operator	Rev Veh Hours Per Vehicle	Veh Hours Per Employee	Oper Cost Per Veh Hour	Pass.Trips Per Pop. Served	Percent Pop. Served
1 A/C Transit	2431.2	1182.7	$ 20.95	44.6	1.00
2 GGBH&TD	1828.5	1013.6	31.15	101.2	.31
3 Long Beach	3433.5	1697.9	9.70	24.3	.95
4 Napa City	3666.7	1222.2	9.45	9.7	.50
5 OCTD	3436.9	1266.6	26.09	9.2	.59
6 SF Muni	2880.0	1000.0	23.12	167.7	1.00
7 San Mateo	2661.3	2022.6	14.27	9.5	.70
8 Santa Clara	3645.3	1303.5	21.19	36.5	.31
9 Santa Monica	*	*	*	30.6	.79
10 Santa Rosa	1984.3	2513.4	10.52	7.6	.90
11 SCRTD	3030.6	1161.0	15.92	42.5	.80
12 Vallejo	3066.0	1803.5	6.63	14.3	.95
13 Sacramento	2555.4	1088.6	15.65	17.2	.95
14 San Diego	2941.0	1257.3	20.27	37.5	.70
Mean Value	2889.3	1425.6	17.3	39.5	.75
Standard Deviation	587.6	452.8	7.3	44.3	.24

*Revenue Vehicle Hours are not compiled by Santa Monica Municipal Bus Lines

Figure 4: COMPUTED STATISTICS FOR SELECTED OPERATORS

Figure 5: CORRELATION COEFFICIENTS FOR FIXED-ROUTE OPERATORS

	Rev Veh Hours Per Vehicle	Veh Hours Per Employee	Oper Cost Per Veh Hour	Pass Trips Per Pop. Served	Percent Pop. Served
Rev Veh Hours Per Vehicle	1.00	-0.20	-0.26	-0.25	-0.17
Veh Hours Per Employee	-0.20	1.00	-0.61	-0.52	0.25
Oper Cost Per Veh Hour	-0.26	-0.61	1.00	0.57	-0.46
Pass Trips Per Pop. Served	-0.25	-0.52	0.57	1.00	0.03
Percent Pop. Served	-0.17	0.25	-0.46	0.03	1.00

Figure 5:CORRELATION COEFFICIENTS FOR FIXED-ROUTE OPERATORS

scattered around the statistical mean, whereas a low deviation implies a closer grouping of values. The correlation coefficient values demonstrate the degree to which paired indicator values vary together or inversely. The relationship between two indicators is interpreted as being stronger as the correlation coefficient approaches unity (+1 or -1).

A relatively low standard deviation is found in the values for Revenue Vehicle Hours Per Vehicle because of the rather uniform hours of service of each operation. Some noticeable deviation may be due to commuter-orientation of some properties, particularly GGBH&TD. Computation of correlation coefficients between the five indicators produce slightly negative correlations (-.17 to -.26) between Revenue Vehicle Hours Per Vehicle and the other four indicators. While it would be incorrect to attribute this result to a single cause, it may be inferred that high vehicle hours cannot alone define good transit service or produce high ridership. The negative correlation between this indicator and Operating Cost Per Vehicle Hour reflects the apportionment of costs among more vehicle hours, in that higher vehicle hour total will result in higher average hours per vehicle and lower per hour costs.

Vehicle Hours Per Employee--the measure of labor productivity--shows a high standard deviation, which again may be partially explained by the emphasis on commuter transit requirements. The lowest achieved scores--those of GGBH&TD, SF Muni, and Sacramento, followed closely by SCRTD and A/C Transit--are those of properties which provide significant levels of commuter service. Correlation coefficient values show a highly negative relation between Vehicle Hours Per Employee and Operating Cost Per Vehicle Hours (-.61), which is of greater significance than the correlation between

Revenue Vehicle Hours Per Vehicle and Operating Cost (-.26). This generally supports the accepted premise that operating costs are much more closely related to labor costs (and total employees) than to vehicle-hours.

Operating Cost Per Vehicle Hour shows considerable variation between properties, yet the most interesting aspects are its correlations with Passenger Trips Per Population Served and Percent Population Served. The significant positive correlation between Operating Cost and Passenger Trips Per Population Served (.57) may reflect the intensity of operations necessary to generate high patronage and the administrative structure which underlies effective operations. The significant negative correlation between Operating Cost and Percent Population Served (-.46) must be traced to several operations which are relatively recently established, like OCTD and Santa Clara, which have developed administrative structures--and hence overhead costs--in anticipation of projected growth of operations and patronage. As implied previously, the almost total commuter-orientation of GGBH&TD makes its comparison with more community-oriented services difficult. This is borne out by its high Operating Cost Per Vehicle Hour and extremely low Percent Population Served (.31).

The essentially zero correlation between Passenger Trips Per Population Served and the Percent Population Served (.03) warrants explanation. Two points arise from this correlation: first, the definition of accessibility underlying the Coverage Area may not adequately describe the population which is utilizing the transit service; and, second, the high service accessibility may not result in proportionately-high patronage. Accessibility as defined by the Coverage Area is an important and valuable measure, yet it does have limitations.

Some problems were encountered in the computation of the indicators. The population of the coverage area is not widely computed nor with a high degree of accuracy. The computation of Vehicle Hours Per Employee involved a moderate degree of difficulty due to the unavailability of accurate employment figures for the selected properties. The figures upon which the sample calculations are based, in most cases, do not include shared and contract labor or an accounting of overtime worked by regular employees. Operating Cost Per Vehicle Hour proved to be quite difficult to compute due to the differences in the accounting forms utilized by the various properties. Most of these problems will be resolved with the adoption of a common uniform accounting system and code of accounts (such as FARE) and a complementary reporting system emphasizing operating statistics such as the National Urban Transportation Reporting System.[11]

Demand-Responsive and Variable-Route Buses:

Demand-responsive systems provide a superior quality of transit service and require different indicators. Their coverage area--the area from which service is accessible--is in fact their entire service area; therefore, the indicator Percent Population Served serves no purpose. Further, their low ridership levels and low capacity vehicles make comparisons with fixed-route service undesirable.

Indicator values for selected demand-responsive transit systems within California appear as Figures 6 and 7, with supporting data elements in Appendix B. Comparison of the mean values between fixed-route operations

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[11]The National Urban Transportation Reporting System is a joint effort of UMTA and FHWA to comply with the requirements of Section 15(a) of the Urban Mass Transportation Act (amended). Section 15(a) requires the Secretary of DOT to develop, test and prescribe a public mass transportation reporting system.

Figure 6: COMPUTED STATISTICS FOR SELECTED DEMAND-RESPONSIVE SYSTEMS (Estimated FY 1975-76)

Operator	Rev Veh Hours Per Vehicle	Veh Hours Per Employee	Oper Cost Per Veh Hour	Pass. Trips Per Pop. Served
1 Davis	1920.0	960.0	$ 6.87	.31
2 Fairfield	2800.0	1750.0	9.33	2.50
3 Healdsburg	3187.5	3187.5	2.30	2.10
4 Hemet	1976.0	1317.3	21.85	1.50
5 Hollister	2800.0	2800.0	6.12	2.90
6 La Mesa	3133.3	2088.9	8.22	2.30
7 Merced	1650.0	1200.0	8.80	3.10
Mean Value	2183.4	1663.0	7.94	1.80
Standard Deviation	1058.0	1028.1	6.50	1.20

Note: Several well known demand-responsive systems within California have not been included in the above table as they do not qualify for TDA funds and statistics are therefore not readily available.

Figure 7: CORRELATION COEFFICIENTS FOR DEMAND-RESPONSIVE SYSTEMS

	Rev Veh Hours Per Vehicle	Veh Hours Per Employee	Oper Cost Per Veh Hour	Pass Trips Per Pop. Served
Rev Veh Hours Per Vehicle	1.00	0.90	0.18	0.65
Veh Hours Per Employee	0.90	1.00	-0.04	0.67
Oper Cost Per Veh Hour	0.18	-0.04	1.00	0.20
Pass Trips Per Pop. Served	0.65	0.67	0.20	1.00

Figure 7: CORRELATION COEFFICIENTS FOR DEMAND-RESPONSIVE SYSTEMS

(Figure 4) and demand-responsive operations shows the difficulty of comparing the two modes.

The indicator values computed for demand-responsive systems show a much higher degree of deviation overall than those for the fixed-route operators. This may be attributed to the non-uniform conditions surrounding their operation: some operate full days, others only middays during the week; some rely upon part-time labor, others on full-time employees; some utilize small or medium-size buses, others utilize taxis and small vans.

More interesting are the correlations between the computed indicators. Between Revenue Vehicle Hours Per Vehicle and Vehicle Hours Per Employee there was found to be a strongly positive correlation (.90), as compared to a coefficient of -.20 for the same two indicators among fixed-route operators. This difference may be attributed to the fact that demand-responsive systems are not generally oriented to serve commuter needs, and therefore do not suffer the tremendous excess of capacity which plagues many fixed-route operations during off-peak periods. A contributing factor might be that administrative staffs are generally smaller or contracted to outside management firms and therefore not considered in this evaluation.

Vehicle Hours Per Employee had an essentially zero correlation with Operating Cost Per Vehicle Hour (-.04) as opposed to a significant negative correlation among fixed-route operators (-.61). This suggests that unionization is not extremely strong among the operations analyzed, and that labor costs do not constitute quite as high a proportion of total expenses as in fixed-route operations.

Finally, Passenger Trips Per Population Served had significant positive correlations with both Revenue Vehicle Hours Per Vehicle and Vehicle Hours Per Employee. These two correlations tend to indicate that demand-responsive services are generally on the upward slope of their productivity curve: that an extra hour of service will produce proportionate patronage increases.

Policy decisions have a substantial impact upon the performance and character of variable-route systems. Whether the system is oriented to provide general transit service or special purpose service and whether the system is prevented from directly competing with fixed-route operators represent policy questions limiting the service potential of the variable-route system. Further, the selection of transit vehicle places definite limits on the riders which the system can accommodate.

Fixed Rail Transit:

As with demand-responsive systems, fixed rail must be compared with similar systems due to the character of the mode: labor intensity is much lower, and the definitions of both the coverage area and service area for fixed rail are inherently different.

The definition of coverage area for fixed rail systems encounters quite different problems from those with demand-responsive systems: here the problem is determining the method by which credit will be given for feeder-bus service into fixed rail stations. Park and ride facilities also introduce some complexity into the calculations, yet credit for such facilities can be computed using parking space totals and average vehicle occupancies. The definition of the service area, however, becomes a significant problem with fixed rail because it draws its users from a wide area which is not adequately defined by geographic distance from the system. For these reasons, both Percent Population Served and Passenger Trips Per Population Served are not applicable for fixed rail transit systems. Statistics were not computed for California's single fixed rail operation (BART) due to these problems and the absence of another property for comparison purposes.

USE OF PERFORMANCE INDICATORS

Performance indicators provide the basis for the comparison of transit properties. There is now no widely accepted way in which transit systems can be ranked against each other in terms of efficiency or effectiveness--indeed no way in which different routes within the same system can be statistically compared. Comparisons have historically been on the basis of total patronage, total vehicles in operation, or total budget. The necessity of implementing a scheme by which properties may be ranked and compared with regard to efficiency and effectiveness is founded in the limited availability of funds with which to address the enormous problems facing transit--problems which can only become more pressing in the next decade.

Utilization of performance indicators in the allocation of scarce funds at all governmental levels will not absolve elected and appointed officials from hard decisions regarding funding, but will provide a statistical basis to assist in those decisions. Statistical indicators, given the difficulties inherent in their data elements and the attitude of the industry toward their acceptability, should not be the exclusive basis for the allocation of transit funding.

Performance indicators also facilitate the development and imposition of performance standards in the transit field. This is the logical step from simple comparison, and would allow the specification of minimum service levels and service criteria. Transit service contracts would also benefit from the ability to specify performance levels and minimum standards to be met by the contractor.

One implementation of performance indicators might be a two-tier system of financial assistance. The first tier--a subsidy intended to provide support of a basic level of transit service--would provide a population-based subsidy to operators achieving a specified threshold level of accessibility (Percent Population Served). Such a threshold level would require gradual introduction to lessen its impact on assistance levels.

A second tier of the financial assistance scheme would be that of providing for incentive subsidies. These subsidies would be designed to reward improvement of performance relative either to the previous year's performance or relative to some established standard or industry average. Passenger Trips Per Population Served, Revenue Vehicle Hours Per Vehicle, Vehicle Hours Per Employee, and Operating Cost Per Vehicle Hour all could be utilized in this fashion. Not only could this subsidy be a positive incentive, but it could also be designed to result in a loss of subsidy (or a portion of the subsidy) for negative changes in performance indicators.

New Transit Properties:

Application of performance indicators to newly created or expanding transit properties presents special difficulties. Newly created and expanding systems cannot be expected to achieve the same performance levels required of established systems, and must therefore be provided with financial support exclusive of their achieved indicator values. Such systems are labor-intensive in anticipation of developing ridership and suffer a lag between the imposition of transit service and the growth of ridership. Financial assistance must therefore be provided either following a modified indicator-allocation scheme or on some other basis with the full indicator-scheme becoming phased in over a reasonable period of time.

An allocation scheme founded on performance indicators would permit the encouragement of desired transit policies through the selection of indicators to be used and the weight given to each in the allocation formula. It would also facilitate public knowledge of the criteria upon which funds are allocated annually and force government and transit agencies to specify the objectives to be achieved by transit.

RECOMMENDATIONS

Research into the allocation of financial assistance to transit, and particularly the allocation of that assistance within California, has attempted to demonstrate the policy implications and technical problems. The effects produced by the present allocation scheme may not be those intended by the officials responsible for transportation policy or the citizens in general, for the present scheme does not encourage efficient and effective service.

Additional research on performance indicators and their use is warranted. Research to date has only begun the efforts required to bring an effective, easily implemented, and concise scheme of performance indicators into being.

The selection of the five indicators utilized in this work is not final. In continuing this work, effort must be directed toward cataloging the various indicators and statistics which have been used within the transit industry over the years and those which have been suggested in other research efforts. The search for reliable, easily understood performance indicators must continue. New indicators must be evaluated as to their role: their advantages and disadvantages must be understood and the most promising indicators chosen for trial application. In this manner the procedures for evaluating transit performance will be refined.

Indicators which have demonstrated significant potential in their application here may be further enhanced by additional research. Vehicle Hours Per Employee, for example, may be improved by changing the unit of computation from "employee" to "employee hour." Use of hours would facilitate accounting for overtime incurred by regular employees, shared employees, and contract labor.

Further research must also address the issue of applicability of indicator schemes to the different modes of transit: fixed-route buses, demand-responsive and variable-route buses, and fixed rail transit. Where necessary, modified indicator schemes should be designed and tested.

Implicit in the research recommended above is basic investigation into the issue of comparability of data elements and the procedures by which comparable data elements can be defined and generated. In addition, research must consider the methods by which governmental entities can conduct periodic audits to verify the accuracy of the data upon which allocation decisions are based.

Finally, further research should recommend alternative uses of the selected indicators and evaluate the strategies for implementing such performance indicator schemes.

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APPENDIX A: Performance Indicators

	Methodologically Correct	Data Generally Available	Inherent Bias
Efficiency Measures:			
Transit Unit Costs:			
1. Operating Expense Per Passenger	no	yes	no
2. Operating Expense Per VMT	yes	yes	yes
3. Maintenance Cost Per VMT	yes	yes	yes
4. Operating Expense Per Bus Hour	yes	yes	no
5. Labor Cost Per Seat Mile	yes	yes	yes
6. Operating Expense Per Vehicle	yes	yes	no
7. Operating Expense Per Pass-Mile Carried	no	no	yes
8. Passenger-Miles Per Unit of Fuel	no	no	yes
9. Energy Consumed Per VMT	yes	yes	yes
10. Energy Consumed Per Pass-Mile Carried	no	no	yes
11. Energy Consumed Per Passenger Carried	no	yes	no
Labor Productivity:			
12. Vehicle Miles Per Employee	yes	yes	yes
13. Passenger Trips Per Employee	no	yes	no
14. Total Platform Hours/ Pay Hours	yes	no	no
15. Passenger Miles Per Employee	no	no	yes
16. Vehicle Miles Per Employee	yes	yes	no
17. Passengers Per Employee Hour	no	no	no
Equipment Utilization:			
18. Vehicle Miles Per Vehicle	yes	yes	yes
19. Passenger Trips Per Vehicle	no	yes	no
20. Revenue Passengers Per Vehicle	no	yes	no
21. Average Revenue Hours Per Vehicle Per Day	yes	no	no
22. Average Revenue Miles Per Vehicle Per Day	yes	no	yes

	Methodologically Correct	Data Generally Available	Inherent Bias
23. Scheduled Veh Hours/ Available Veh Hours	yes	no	no
24. Passengers Per Seat Mile	no	no	yes
Labor Utilization:			
25. Total Employee Hours Per VMT	yes	no	yes
26. Total Employee Hours Per Passenger Carried	no	no	no
27. Total Employee Hours Per Pass. Mile Carried	no	no	yes
<u>Effectiveness Measures:</u>			
Accessibility:			
28. Percent Population Served	yes	no	no
29. Percent Transit Dependent Served	yes	no	no
30. Percent Employment Served	yes	no	no
Service Utilization:			
31. Passenger Trips Per Population Served	yes	no	no
32. Per Capita Passenger Miles	yes	yes	yes
33. Passengers Per Route Mile	yes	yes	yes
34. Passenger Trips Per Vehicle Mile	yes	yes	yes
35. Passenger Trips Per Seat Mile	yes	no	yes
36. Passengers Per Sq. Mile of Service Area	yes	yes	yes
37. Passengers Per Vehicle Per Hour	yes	yes	no
38. Passenger Miles Per Scheduled Vehicle Mile	yes	no	no
39. Seat Miles Utilized/ Seat Miles Available	yes	no	no
Quality:			
40. System Reliability (% trips on time)	yes	no	no

	Methodologically Correct	Data Generally Available	Inherent Bias
41. Available Seat Miles Per Sq. Mile of Service Area	yes	no	no
42. Route Miles Per Sq. Mile of Service Area	yes	yes	yes
43. Veh Miles Per Sq Mile of Service Area Per Capita	yes	yes	yes
44. Vehicle Miles Per Capita	yes	yes	yes
45. Percent Service Area Served (area)	yes	yes	no
46. Veh Seat Capacity/ Population of Service Area	yes	yes	no
47. Directness of Service (% transfers)	yes	no	no
48. Route Miles Per 1000 Persons in Service Area	yes	yes	yes
49. Vehicle Miles Per Route Mile	yes	yes	no

OPERATING AND FINANCIAL STATISTICS, SELECTED OPERATORS (Estimated FY 1975-76)

Operator	Population Coverage Area	Service Area	Patronage	Employees	Total Rev Vehicles	Rev Veh Hours	Operating Expense
1 A/C Transit	1,178,000	1,178,000	52,500,000	1,850	900	2,188,074	$45,830,857
2 GGBH&TD	113,240	365,290	11,457,000	451	250	457,114	14,237,506
3 Long Beach	475,000	500,000@	11,555,730	273	135	463,523	4,495,460
4 Napa City	22,725	45,450	220,000	9	3	11,000	104,000
5 OCTD	977,902	1,646,300	8,990,000	483	178	611,771	15,960,909
6 SF Muni	715,674	715,674	120,000,000	2,880	1000	2,880,000	66,589,545
7 San Mateo	385,000	550,000	3,667,900	100**	76	202,262	2,886,837
8 Santa Clara	356,500	1,150,000	13,000,000	660	236	860,300	18,226,000
9 Santa Monica	395,000	500,000	12,100,000	181	102	--*	3,111,285
10 Santa Rosa	55,530	61,700	420,000	15	19	37,701	396,646
11 SCRTD	5,501,261	6,889,076	234,000,000	6,150	2,356	7,140,000	113,700,000
12 Vallejo	68,780	72,400	985,322	34	20	61,320	406,805
13 Sacramento	760,000	800,000	13,108,182	500	213	544,296	8,519,700
14 San Diego	770,000	1,100,000	28,847,000	821	351	1,032,276	20,922,399

@Estimate by Long Beach City Transportation Management Department

**Estimate based on patronage figures

*Revenue Vehicle Hours are not compiled by Santa Monica Municipal Bus Lines

APPENDIX C: Financial and Operating Statistics For Selected Demand-Responsive Systems (Estimated FY 1975-76)

OPERATING AND FINANCIAL STATISTICS, SELECTED DEMAND-RESPONSIVE SYSTEMS (Estimated FY 1975-76)

Operator	Service Area Population	Patronage	Total Employees	Total Revenue Vehicles	Revenue Veh Hours	Operating Expense
1 Davis	32,000	10,000	2	1	1,920	$ 13,186
2 Fairfield	48,650	120,000	8	5	14,000	130,600
3 Healdsburg	6,200	13,000	2	2	6,375	14,660
4 Hemet	16,200	24,000	3	2	3,952	86,356
5 Hollister	17,000	50,000	3	3	8,400	51,400
6 La Mesa	43,000	100,000	9	6	18,800	154,500
7 Merced	28,000	86,000	11	8	13,200	116,109