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CONCEPTUAL PLANNING OF

LOCAL CIRCULATION AND FEEDER TRANSIT SYSTEMS

A Technical Report on Task 8.3
for the Alternative Transit Corridors
and Systems Technical Study

March 1974

Prepared for

Southern California Rapid Transit District

Prepared by

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and

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INTRODUCTION

The purpose of this study task was to prepare the conceptual framework to determine how public transit might (1) aid in improving circulation in urban centers and in lower-density communities, and (2) provide access to the future line-haul rapid transit system.

This task grew from public comments on the results of Phase II of the transit study. These comments suggested that too little attention had been given to access to the rapid transit system, and that the system itself was oriented around the central business district and did not adequately consider access to local centers and cross-corridor travel.

Therefore, a study task was undertaken to determine needs and alternative systems for transit circulation and feeder/distribution systems in prototypical communities. The output of this analysis then becomes prime input to the formulation of specific circulation and feeder/distribution systems to complement the defined Phase III Mass Rapid Transit Systems. This study task provides guidelines on selecting these local circulation and feeder/distribution systems, the calculation of system performance, and the estimation of patronage, and capital and operating costs. This report is not intended to solve specific community problems but rather to establish a methodology for application throughout the area. The methodological approach requires testing and validation.

The approach to this task included the following steps:

- Prototypical community areas were selected, including both high-activity centers and residential communities.
- Concurrently, techniques were developed to estimate patronage potential in these areas. (Regional transit patronage forecasting techniques are largely inapplicable at the community level.)

- Generic transit vehicle system operational concepts were reviewed to develop simplified unit costs and system operating characteristics.

- Next, alternative transit systems were laid out and quantified for selected prototypical communities. Tests for reasonableness of the results were conducted and the process revised as necessary.

- Finally, the process was set forth in a step-by-step manner for specific application. The result is a "sketch-planning" process for community transit systems.

CHAPTER I

PROTOTYPICAL COMMUNITIES

The selection of prototypical communities involved several considerations. It was desired that the communities span the range of conditions existing in the study area. Also, the number of communities was necessarily limited to a manageable number to take advantage of data availability. A dispersion was desired, both geographically and socially.

The selection process involved several steps. A trial run was undertaken to explore procedures. An initial selection of communities was reviewed by the Technical Advisory Committee. With their advice, the selection was modified and then reviewed by the SCAG Task Force. The final list was then presented to the RTD Board of Control for selection.

As an initial step, a community was defined as having a population between 30,000 and 140,000 persons, having a name or combination of names in common use by residents, and having recognized geographical and political boundaries.

Many factors were considered for use in classifying and selecting prototypical communities. These included income, auto registration. population density, distance from the central business district, distance from any proposed line-haul rapid transit systems, community age composition. trip generation, parking conditions, major attractor location, street configuration, and existing and proposed transit service. For high-activity centers, the relative location of the center and its activity mix were also important.

Use was made of planning data developed in Phase II. Included was information on population density, transit dependency, urban center location, employment density, political boundaries, and open space.

SELECTION PROCESS

The following steps were followed in the process of identifying and classifying communities:

- Three population density levels were mapped to cover the ranges of 0 to 12,800 persons per square mile; 12,800 to 19,200 persons per square mile; and over 19,200 persons per square mile based on 1990 projections.

- Areas of transit dependency were delineated, following the Phase II definition: a high percentage of young and old, low income, low auto ownership, and high unemployment.

- Designated urban centers were located. These centers were included and mapped in the Southern California Regional Development Guide (April 1972) and were identified in Concept Los Angeles as primary or secondary centers, depending on combined total population and employment.

- Area size was considered so that communities would fall within a population range of 30,000 to 140,000.

- Political boundaries were also considered so that communities would include whole jurisdictions where possible. Topographical features were also a factor.

- Through use of a series of map overlays illustrating the factors described above, general community boundaries were drawn for 38 communities as listed in Table I-1.

Many communities beyond the 38 listed can be identified in Los Angeles County. Most of the communities not listed in Table I-1, however, would fall in the far right-hand column (low population density/transit independent) or would contain small, scattered examples of higher densities and transit dependency.

The central business district was specifically excluded from consideration; this area, of course, has unique characteristics and is not representative of

TABLE I-1

COMMUNITIES IDENTIFIED FOR PROTOTYPICAL COMMUNITY SELECTION

	Population Density* Over 19,000		Population Density 13,000-19,000		Population Density Under 13,000	
Community	High Transit Dependency**	Low Transit Dependency	High Transit Dependency	Low Transit Dependency	High Transit Dependency	Low Transit Dependency
Primary Centers	West CBD Hollywood Long Beach			East Wilshire Mid-Wilshire Santa Monica Westwood	Pasadena Pomona	Van Nuys
Secondary Centers			Exposition Park Central	Inglewood Glendale	Watts	LAX Downey Canoga Park Torrance Lakewood San Pedro Covina Whittier
Others			East Los Angeles	Huntington Park	Compton	Vernon Commerce San Fernando Alhambra El Monte Burbank Reseda Northridge Chatsworth Norwalk Carson Hawthorne

* Persons per square mile.

** High percentage of old and young, low auto ownership, low income, unemployed.

any other in the region. Furthermore, it has already been studied in depth in Central City Los Angeles, 1972/1990 (April 1972).

During initial attempts to identify and select prototypical communities, the proximity of the community to proposed rapid transit lines was considered. This factor was ignored, however, in the final selection cycle since local circulation systems may be implemented prior to and independently of the line-haul rapid transit system. In addition, the configuration of that system is indefinite at this stage.

After the review cycles previously mentioned, the following communities were chosen as prototypical study areas: Hollywood, Westwood, Exposition, Pomona, Canoga Park, and Norwalk. These six were believed to adequately span the range of urban conditions in the RTD service area and, important to the study, to provide a basis for extrapolation of findings to other communities.

A summary of statistical abstracts for these communities is presented in Table C-5, Technical Memorandum "e" of this report. As can be seen, it is presently incomplete, particularly as regards the Los Angeles City "Centers." When the interview work results obtained by WMRT/K-S (Reference 23) is completed, this table will be completed by incorporating the available results.

CHAPTER II

CIRCULATION SYSTEMS

There are a host of technologies that have been proposed over the last several years or are presently in service. These can generally be characterized as:

- Manually controlled systems
- Automatically controlled systems.

The manually controlled systems include the bus operating in mixed traffic on existing street systems. The automatically controlled systems are operated on grade-separated guideways, usually elevated, that may be either demand-responsive or scheduled, depending on the desired application. For the purposes of this report, the various technologies have been grouped into the following generic classifications (see Table II-1):

- Manually controlled systems:
  - Conventional bus
  - Minibus (also used for dial-a-bus applications)

- Automatically controlled systems:
  - People-Mover Transit (PMT)
  - Personal Rapid Transit (PRT).

The selection of the most appropriate system depends on many factors such as technical feasibility, operational workability, environmental compatibility, institutional desires, ridership potential, transit dependency, planning factors, the capital investment required, and operating costs. An evaluation of all these factors will aid in the system selection of the most appropriate application in a particular community.

TABLE II-1

TRANSIT VEHICLE SYSTEMS

Functional Classification	Vehicle Type Classification
Manually Controlled	
Demand-Responsive Bus	Minibus Midibus (30 ft)
Conventional Bus	Midibus (30 ft) Transbus
Automatically Controlled	
Conventional Guideway	People-Mover Transit (PMT)
Demand-Responsive Guideway	Personal Rapid Transit (PRT)

SYSTEM DESCRIPTIONS AND CHARACTERISTICS

The following is a capsule description of the four generic systems; the characteristics of each are shown in Table II-2.

Conventional Bus: This is the most familiar transit vehicle in use today. Included in this group is the "midibus" which has operating characteristics similar to the standard bus except that it is shorter and consequently has a smaller capacity.

The bus has several advantages over fixed guideway systems in that it offers flexibility from the operational standpoint. Route changes are easily accommodated and additional buses can be added as the demand for public transportation increases. In recognition that the bus will continue to play a major role in the urban transportation scene, considerable advances are

TABLE II-2

CHARACTERISTICS OF TRANSIT SYSTEMS FOR INTRACOMMUNITY LOCAL CIRCULATION

Parameter	Unit	Vehicle System: Minibus	Midibus	40-Foot Bus	P-M	TERL	PRT
Maximum frequency of service possible during peak rush times	arrivals per minute	4	3	2	2	1.5	6
Minimum vehicle headways on route, between stations	seconds	15	20	30	30	45	5
Maximum system capacity, seated passengers/peak hour/direction	pass./hr /direction	5,000	6,000	7,000	8,000	10,000	3,000
Vehicle dimensions:							
Car width	feet	7 to 8	8 to 9	9 to 9.5	to 7	8.7	5
Car length		22 to 26	30 to 36	40	to 2[illegible]	30.6	8
Trainability of cars	cars/train	6 in minitrams	1	1.7 in superbus	1 to 6	1 to 9	1
Speeds:							
Normal cruise	mph	30	40	55	12 to 25	45	20
Top		40	50	70	30	55	60
Passenger capacity:							
Seated only	number of pass.	20	45	50	16 to 24	30	4
Seated and standing		30	55	70	32 to 48	50	4
Source of propulsion energy	–	Gasoline Propane Batteries Hybrid LNG	Gasoline Diesel Propane LNG Hybrid	Gasoline Diesel Trolley Wire Hybrid Propane LNG			
Vehicle support on guideway	–	Conventional automotive suspension			Steel wheels Elastomer tires Airfilm levitation Magnetic levitation	Rubber tires	Elastomer wheels Air cushion Maglev
Routing and operational flexibility	–	Most flexible	Flexible	Flexible	Fixed	Fixed	Some flexibility
Energy consumption	KWh/seat-mile	.45	.28	.28	.05	.06	.04
System installation staging	months to achieve	12	12	6	48	48	144
Safety	relative ranking	Highest	High	High	Intermediate	Low	Lowest
System availability	operational date	1974	1974	1975 (new)	1980	1980	1985

being made in this technology. Alternative power sources such as liquefied natural gas are being investigated; battery-powered buses are being demonstrated; the Urban Mass Transportation Administration is sponsoring the "Transbus" program to develop an improved bus, emphasizing such factors as control of air and noise pollution, comfort, provisions to accommodate the ambulatory handicapped, etc. Typical seating arrangements and examples of the conventional bus are shown in Figures II-1 to II-5.

Minibus: This vehicle is rapidly gaining more and more public acceptance. It has been effectively utilized in the Los Angeles Central Business District, as an airport shuttle service, for sight-seeing service, and more recently as a demand-responsive system as seen in the dial-a-bus applications. The vehicle is small (on the order of 24 feet in length), seating approximately 20 passengers, and usually powered by an internal combustion engine; however, alternative power sources are being utilized in some areas. Typical seating arrangements and an example of the minibus are shown in Figures II-4 and II-5.

People-Mover Transit (PMT): These are medium sized, electrically propelled vehicle systems operating under automatic controls with no operator, on a grade-separated guideway. The structures may either provide for two directional movements or for single direction movements in a loop configuration. Vehicles are operated singly or in trains depending upon the demand requirements. Systems presently in operation are supported on rubber tires; however, systems under consideration are supported on air cushions or magnetically levitated. Vehicle sizes range from 6 feet to 20 feet and seat from 8 (Morgantown) to 12 (Ford ACT) to as many as 30 passengers. Additional standing passengers can be comfortably accommodated. Stations may be either on-line or off-line and are usually spaced at intervals of 1/2- to 2/3-mile. With off-line stations, the system can operate in a schedule

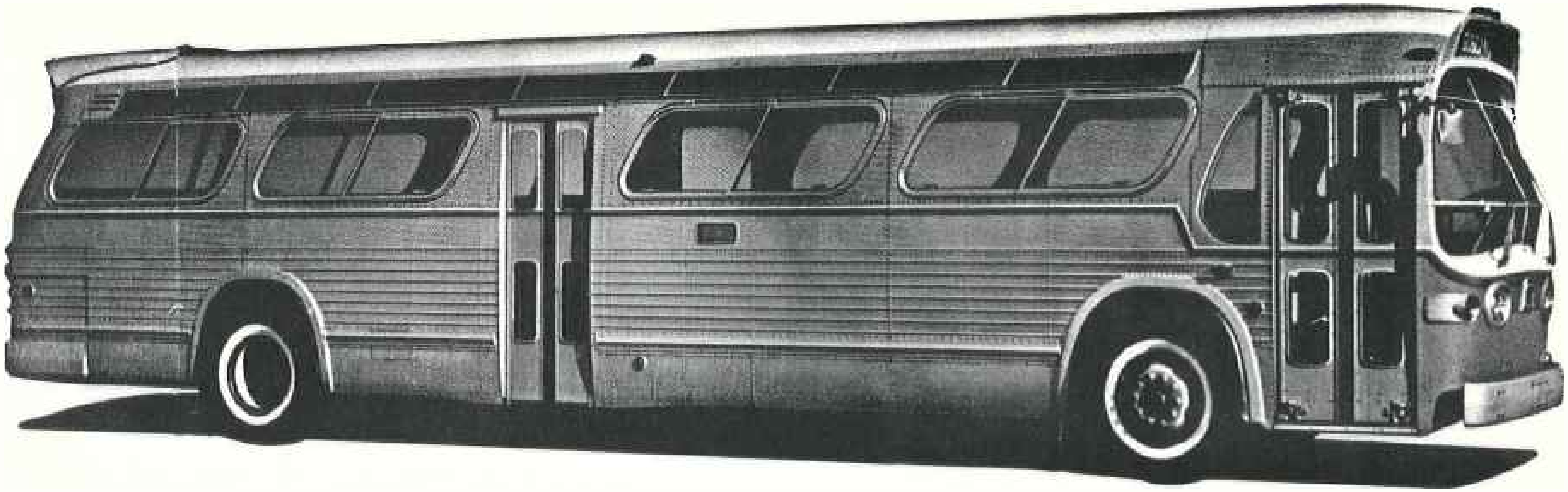
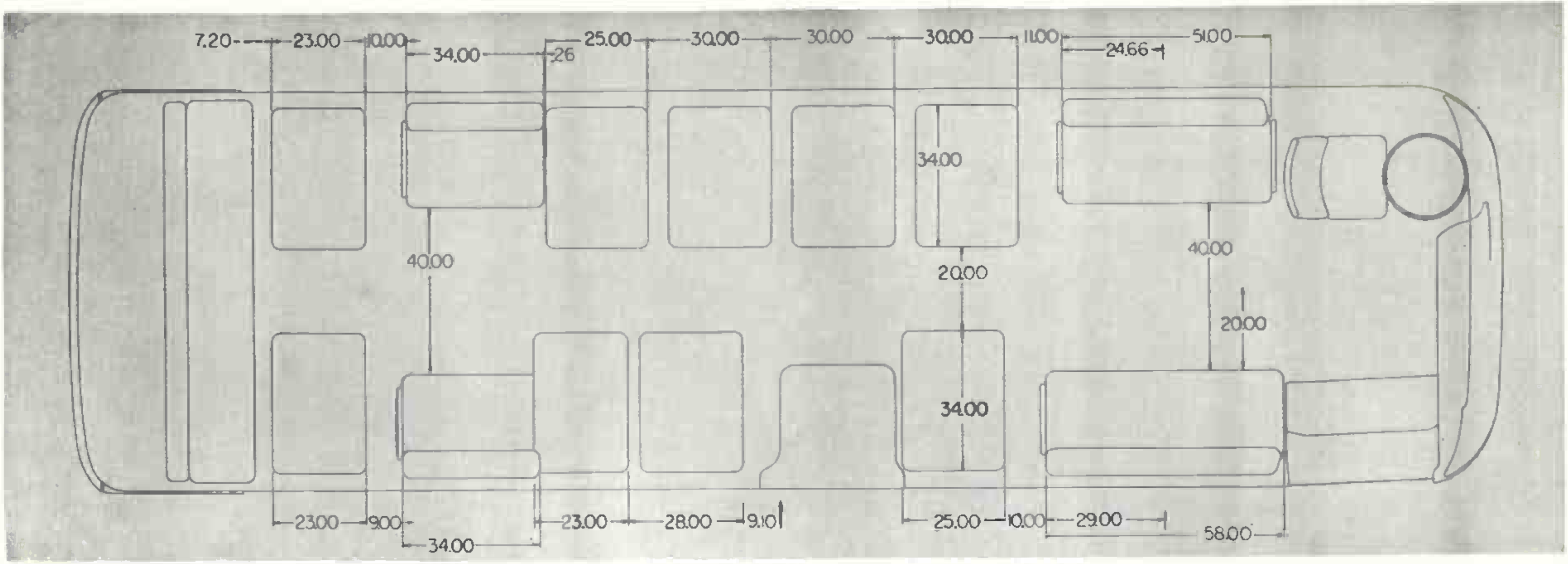
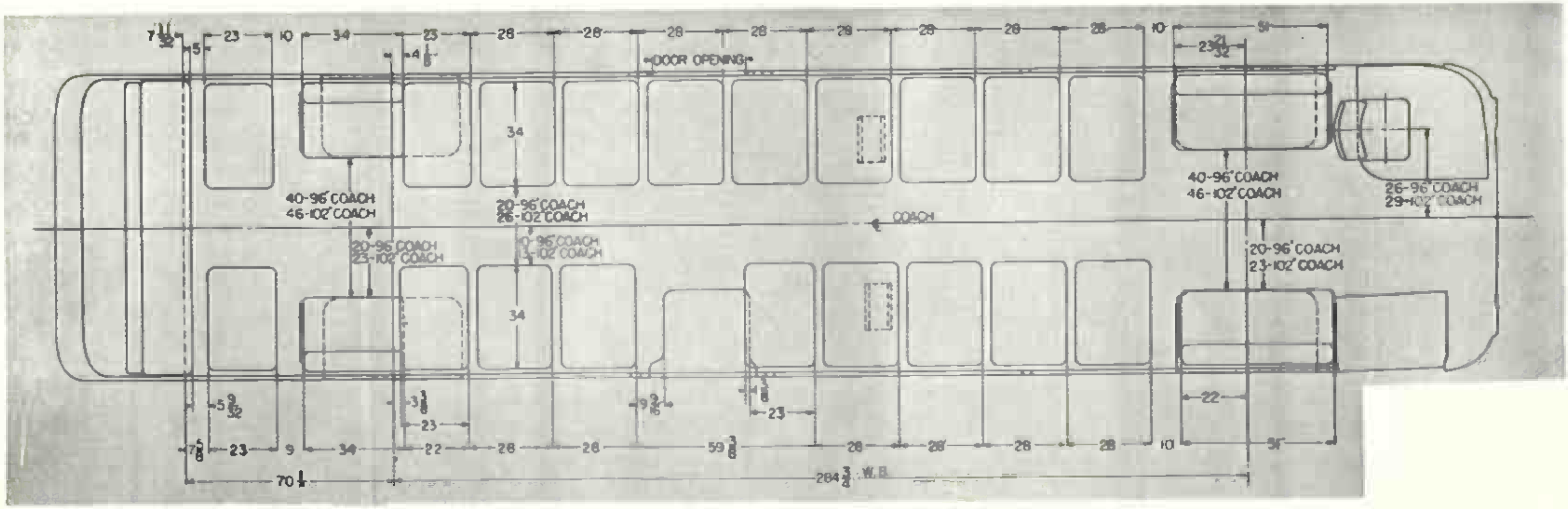


Figure II-1. 40-Foot Transit (TGH/M-5306A)



29 Foot Transit (TDH-3301A) - 33 Passengers

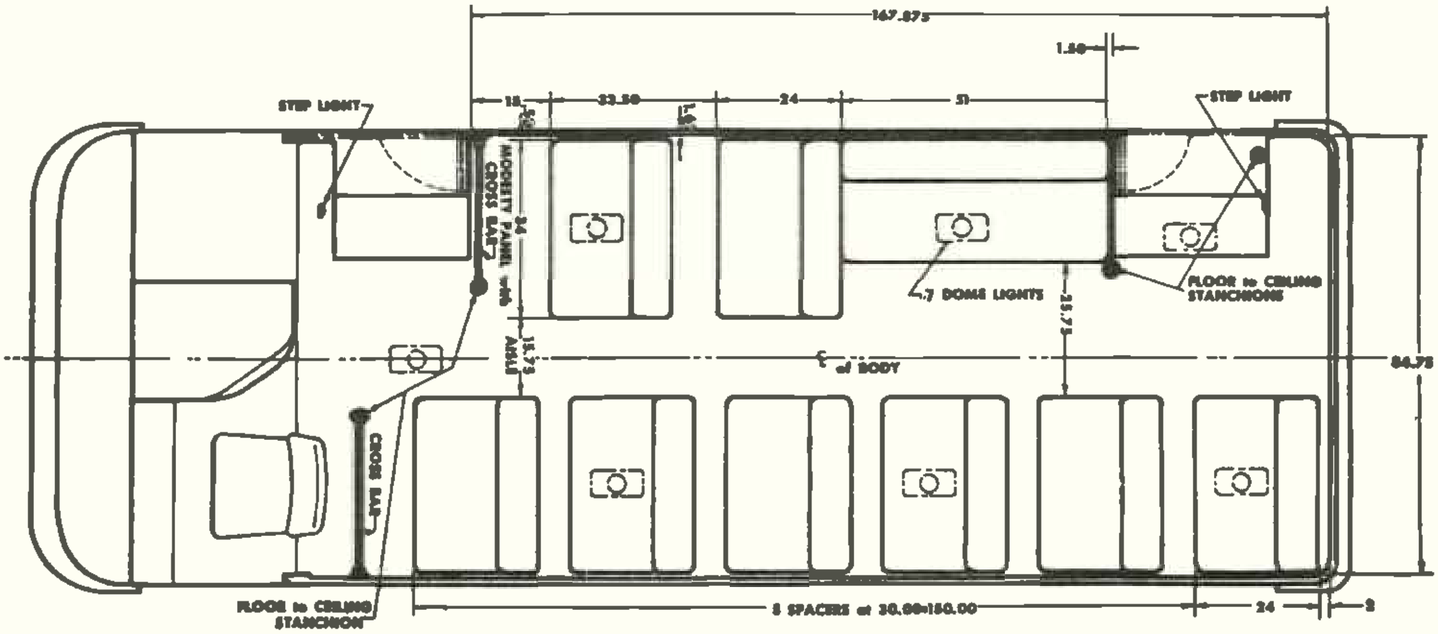


40 Foot Transit (TGH/M-5306A) - 53 Passengers

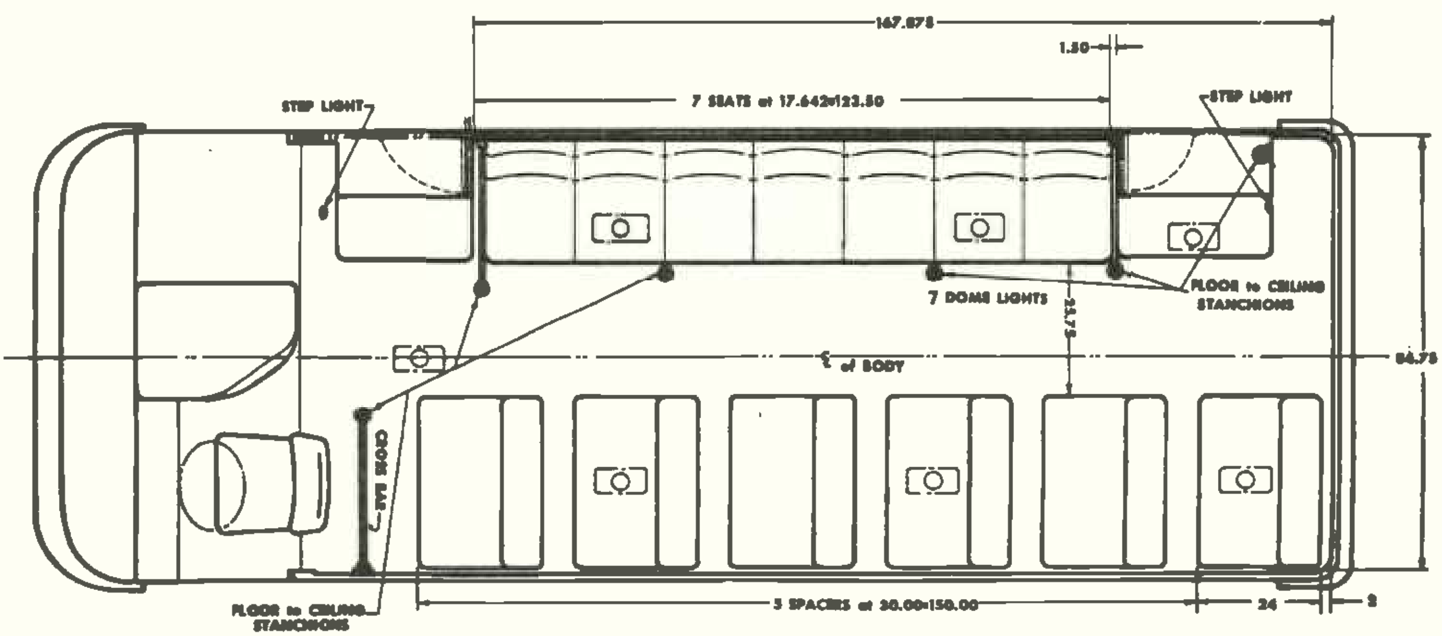
Figure II-2. GMC, 33- and 53-Passenger Seating Plans

Figure II-3. GMC 29-Foot Transit Bus (TDH-3301A)

Figure II-4. Flxette, The Flxible Co.



19 Passenger Transit, Standard Seating



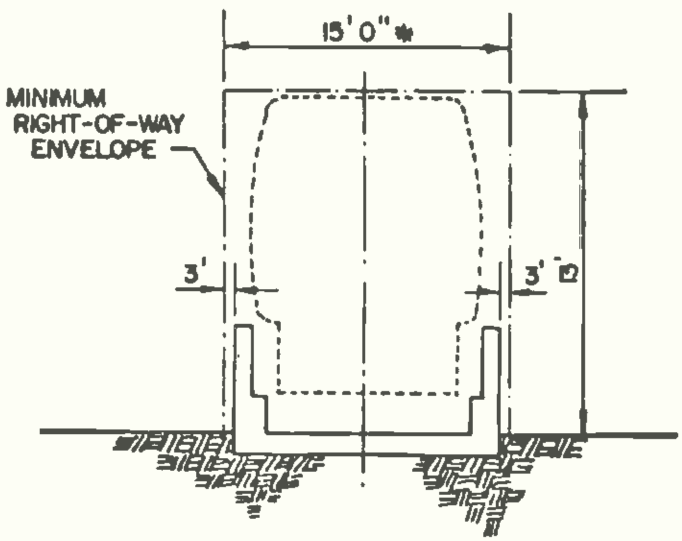
19 Passenger Transit, Partial Perimeter Seating

Figure II-5. **Flxette, 19 Passenger Transit Seating Plans** mode during peak periods or in a demand mode during the off-peak period, as in the proposed system for Denver. A typical one-way guideway is shown in Figure II-6.

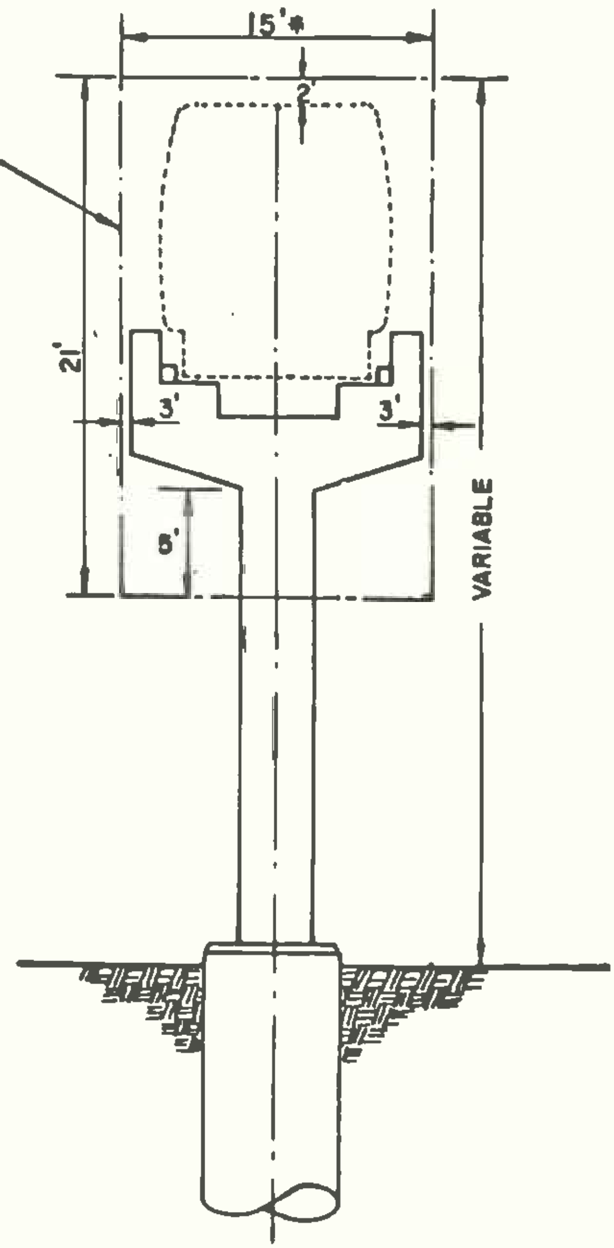
Personal Rapid Transit (PRT): As the name implies, PRT most nearly approaches the convenience, privacy, and comfort of the private automobile. It is a demand-responsive system with small 4- to 6-passenger-capacity vehicles that operate nonstop on a fixed guideway from the passenger's origin to destination.

The system provides a high level of service in its area of application. One-way elevated guideways form a grid pattern on approximately 1/2-mile spacing in all directions with stations located at similar intervals, so that boarding points to the system are within a reasonable walking distance. Stations are off-line. Vehicles are switched to the station siding, which permits other cars to continue past the station without stopping, thus providing the origin to destination nonstop service. During times of high demand (peak periods), the system can operate in a schedule mode, increasing the line volumes to move passengers to areas of employment within the community or to the regional transit system stations for longer trips.

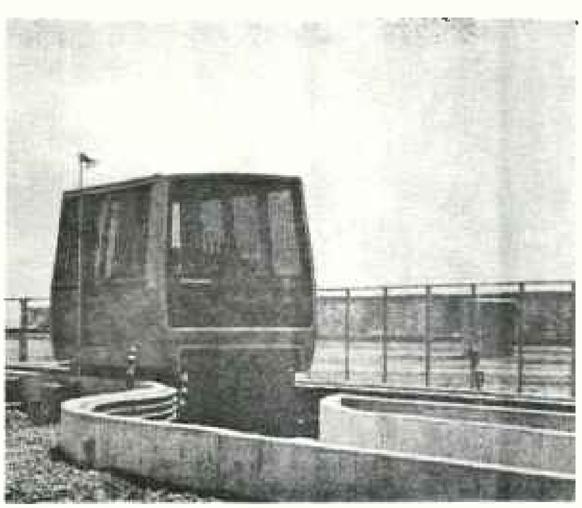
Because of the level of service provided by PRT systems, high ridership can be anticipated. PRT is capacity-limited, however, depending upon headways and the extent of the guideway configuration. Capacity is increased by adding guideways and/or decreasing headways. Headways normally range from 5 to 10 seconds. Advances are being made in the control system technologies, however, that permit headways of less than 1 second.
A schematic of a PRT system superimposed on downtown Los Angeles street is shown in Figure II-7.



AT-GRADE GUIDEWAY



ELEVATED GUIDEWAY



TRANSPO 72 Dashaveyor Installation

MANUFACTURER OR DEVELOPER:
BENDIX AEROSPACE DIVISION,
ANN ARBOR, MICHIGAN

SOURCE: MANUFACTURER'S DATA, 1972

Figure II-6.

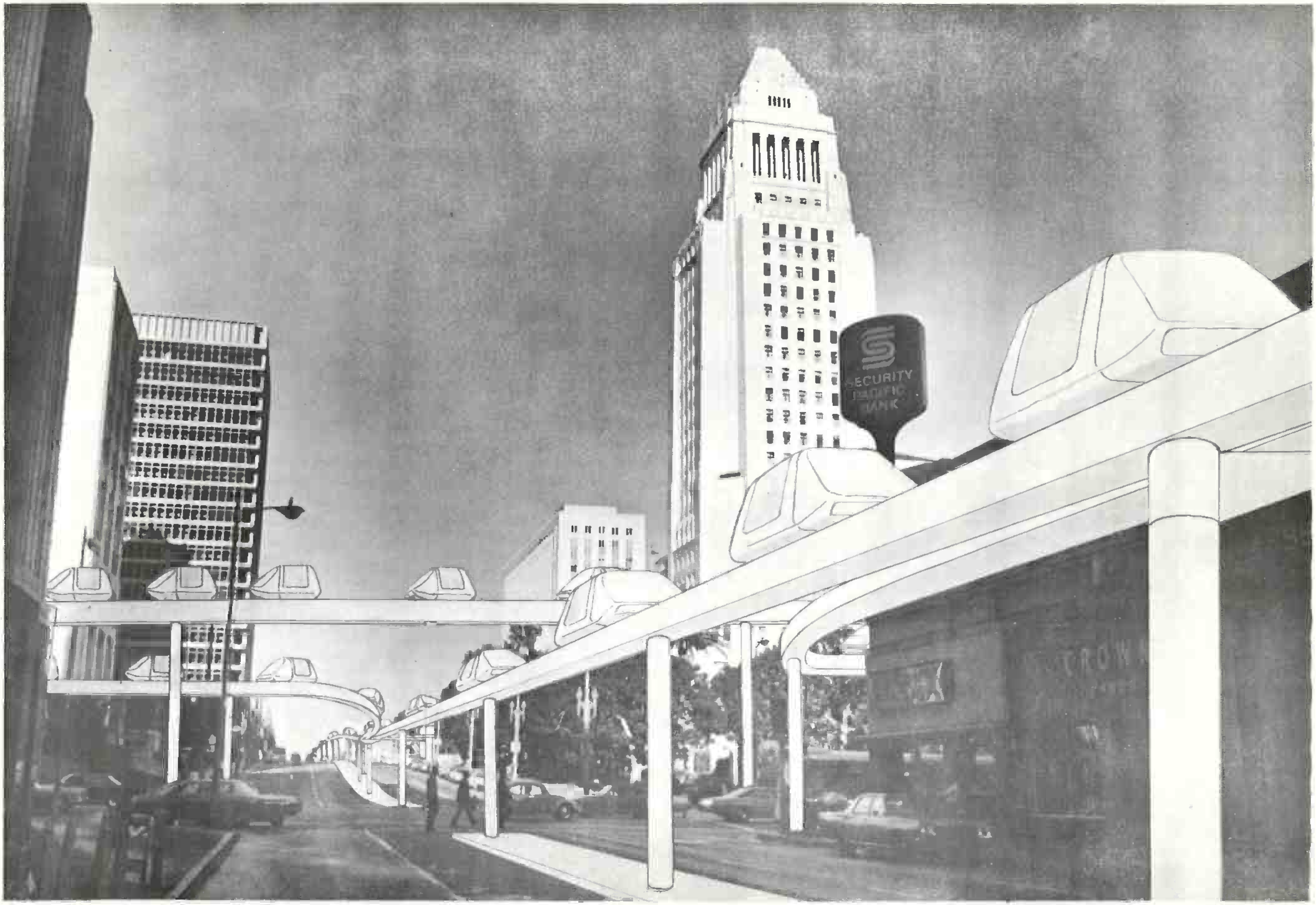


Figure II-7. Photomontage of downtown Los Angeles as it might appear with personal transit installed.

DEMAND-RESPONSE SYSTEMS

The concept of demand-responsive transit has caught the imagination of communities throughout the United States. These systems operate on a non-scheduled basis. Although interest in these systems has been great, useful experience in planning such systems is somewhat limited. Systems that fall into this category are the automatically controlled, fixed guideway PRT and the manually controlled dial-a-bus concept, with system characteristics as shown in Table II-3.

Dial-a-Bus: Dial-a-bus is generally defined as an option falling between conventional fixed-route, fixed-schedule bus service and taxi operation. Dial-a-bus is well suited to serving the elderly and the handicapped, although it is popular in feeder-type operations for suburban commuters as well. Many consider dial-a-bus expensive, and it seems less productive than conventional systems where densities are moderate to high. Nevertheless, it has been received enthusiastically because of its convenience and safety.

TABLE II-3

DEMAND-RESPONSIVE SYSTEM CHARACTERISTICS

System	Number of Seats	Average Waiting Time	Average Speed
Dial-a-Bus	20-30	12 min	Peak: 10 mph Base: 15 mph
PRT	4-6	1 min	20-30 mph

Analysis of existing systems provides several statistics that can be used (at least tentatively) to lay out demand-responsive systems in the prototypical communities. One of these statistics is indicated in Table II-4. Here, the service population per vehicle is listed for a variety of locations. As a guideline, one bus per 3,000 to 3,500 persons in the community appears adequate for initial system design.

Another statistic used to describe demand-responsive service concerns productivity, defined as the number of trips served per vehicle-hour. Existing dial-a-bus service shows productivity rates ranging from fewer than 3 to as many as 15 passenger-trips per vehicle-hour. Perhaps experience will allow future dial-a-bus systems to operate at higher levels of efficiency, possibly approaching 20 to 25 passenger-trips per vehicle-hour.

Current experience also seems to indicate that one dispatcher can process up to 50 calls hourly and can direct a bus fleet of six vehicles during the peak period and three vehicles during the base period. These are probably maximum figures for manual dispatching; assistance might be needed during peak periods. All of the data seem to suggest that the design of demand-responsive systems should be done in modules — conceivably units of six buses serving about 20,000 persons. For example, for a community population of 40,000, two modules would be used. Experience also seems to indicate that peak-hour service evolves into a subscription-type service owing to repeat trips during peak periods that can be arranged on a continuing daily basis. During base periods, the system can be operated in a completely demand-responsive mode.

An important principle seems to be emerging that transfer times can be reduced by using line-haul systems as a time clock for dial-a-bus. Scheduling of demand-responsive service can be built around scheduling of the line-haul service (whether at a mass transit station or on an arterial expressway). Consequently, it might be possible for passengers to move directly from their dial-a-bus (under shelter where necessary) to the line-haul transit vehicle with a minimum of transfer and waiting time.

TABLE II-4

EXISTING DEMAND-RESPONSIVE SYSTEM CHARACTERISTICS
(Dial-a-Bus)

Location	Service Population per Vehicle	Demands per Sq Mi	Productivity (Trips per Vehicle-Hour)
Ann Arbor	3,333	157	7.7
Batavia	3,460	96	6.7
Bay Ridges	2,740	345	11.3
Columbia	2,162	9	4.4
Haddonfield	1,454	52	2.6
Regina	2,250	435	15.0
La Habra	7,416	56*	6.7
La Mirada	5,583	54*	6.7

*Estimated

CHAPTER III

SYSTEM APPLICATION

This portion of the report on Task 8.3 is essentially a guide for use in developing community local circulation and feeder/distributions throughout the RTD service area. The steps taken in laying out transit systems within the community and in estimating patronage and costs on those systems are specified in the following paragraphs.

The general process began with a second look at community boundaries. Then the various systems were laid out within the community, and patronage was estimated on these systems. Finally, system costs were calculated.

COMMUNITY BOUNDARIES

As a starting point, the initial outline of the community (from the selection process) was accepted. This initial configuration considered area size, population characteristics, and political boundaries. Detailed maps of the communities (primarily U.S.G.S. maps) were inspected for open areas, street discontinuities, and topographic features that might further define the community boundaries. The communities were field-checked for land use and general character.

The community configuration was also affected somewhat by probable station spacing as proposed in the Phase II MRT system, or by the location of freeway system interchanges, should the line-haul transit eventually take the form of express buses on freeways. Also considered was the 3 to 4-mile distance — found in a survey of BART users — which represented the service radius for bus access to the rail stations. Other factors that might prove useful in community definition in future applications include the districts for primary and secondary schools, the primary trade area of commercial centers, and the location of community organizations.

As a result of this review, it was concluded that community boundaries need not be over-emphasized as a factor because they are flexible as far as system layout is concerned. They become much more important in the detail planning, when the agency responsible for implementation is known.

SYSTEM ASSUMPTIONS

An initial assumption in delineating the systems in the communities was a required relatively high level of service if the system were to provide local community circulation. Therefore, the basic guideline of 1/2-mile route spacing was followed. (This is the industry standard which attempts to put transit service within 1/4-mile of each resident.)

Important in system layout is the fact that the system being designed for the community must serve three types of transit travel:

- Intracommunity local circulation
- Feeder/distribution service to future line-haul transit systems
- Intercommunity travel not occurring on the line-haul system.

This latter classification is important for several reasons. First, the basic configuration of various line-haul rapid transit systems prevents service of every intercommunity travel need. Second, because of transfers and the out-of-direction travel involved, there is a place in the regional transit system for surface transit lines which parallel rapid transit routes. A theoretical analysis of submodal split indicated that a parallel surface trasit line 1 mile or more away from a rapid transit route could be expected to attract from 70 to 100 percent of the travel from origin to destination immediately adjacent to the surface transit route. Third and perhaps most important, the community being served may not provide all social and economic services necessary for its residents. For example, community-service officials in the Norwalk area have stressed the importance of transit connections to adjacent communities (Downey, Bellflower, Artesia, and Hawaiian Gardens) so that Norwalk residents can have access to hospitals, schools, law enforcement agencies, training centers, libraries, courts, and social service agencies.

SYSTEM LAYOUT

A first step in designing systems within each community is to map existing surface transit routes. In close-in, relatively dense areas, existing RTD service often approximates a grid system. In all areas, the location of these surface transit routes may indicate the location for intercommunity non-rapid-transit surface transit connections.

The existing transit service generally provides a good basis upon which to lay out a comprehensive grid bus transit system with two-way routes on 1/2-mile spacing. This can result in a few modifications to present RTD routes with the addition of shuttle routes to provide the desired coverage. Such a system is easily expanded or reduced to match the most desirable community configuration.

<u>Conventional Bus:</u> The conventional grid system, laid out in the first step, then becomes a basis for laying out a radial bus system. For the radial system, one or more central nodes must be selected. This node should probably be located at the center of the community's activity. The locations of future rapid transit stations (which should be located to reinforce the commercial node) also help define the system nodes.

With the node selected, the radial system can be laid out by following the grid system as a guide but using two-way loops about 1/2-mile apart. The loops can be connected at the node to accommodate diagonal travel. For example, a loop serving the southwest portion of a community could be connected to the loop serving the northeast area.

More than one central node may be needed in some communities — especially with a bus-on-freeway line-haul system. As an alternative to two nodes, a shuttle system can be added between the community node and points of access to the freeway bus lines.

When the grid and radial bus systems for the six communities were laid out, it became obvious that little difference existed in the system length (in miles of route) between the two system types. This statistic (miles of route) is utilized in estimates of system performance and patronage. Therefore, in terms of estimating vehicle-miles and vehicle-hours of travel, it is not important which system is designated. However, there are advantages and disadvantages between the two layouts, depending upon conditions within each community; some of these advantages and disadvantages are discussed in Appendix A. For example, the radial layout fits well where the rapid transit system has a single station in the community. On the other hand, the grid-type system fits well into a bus-on-freeway line-haul system where each interchange is a potential point of access. Table III-1 lists the one-way route-miles for each of the six prototypical communities for the two types of conventional bus system layouts.

TABLE III-1

COMPARISON OF GRID AND RADIAL BUS SYSTEMS

	One-Way Route Miles	
Community	Grid	Radial
Pomona	128.4	114.0
Canoga Park	119.2	119.4
Norwalk	88.0	—
Exposition Park	74.2	82.0
Hollywood	45.8	44.4
Westwood	47.6	45.2

Personal Rapid Transit: The layout of the PRT vehicle system generally follows the grid bus system layout, except that one-way guideways are substituted for two-way bus routes. The process involves starting at two edges of the community and laying out the one-way network on 1/2-mile spacing until the community is covered. The one-way guideways are specified because of the complexity of interchange among two two-way guideways. Out-of-direction travel in the one-way system would be more than compensated for by the speed of the PRT and its short wait times as compared to a conventional bus system.

The layout of PRT systems showed that they fit well into either a single rapid transit station concept or a bus-on-freeway line-haul concept. Also, the system could be easily extended to nearby community centers or expanded into adjacent communities.

A particular problem with the PRT system is that of intercommunity non-rapid-transit service. Intercommunity ties could be made by PRT to PRT, PRT to local bus, or PRT to surface long-line bus routes at a route terminal on the periphery of the community or to a long-line route passing through the community.

People-Mover Transit: The layout of a people-mover system involved different principles from the three foregoing systems. The definition of the people-mover vehicle system includes a one-directional fixed guideway and relatively large vehicles (16 to 32 seats). In effect, it is a smaller version of the regional large-car mass rapid transit system. Such a system is not believed to be readily adapted to community-wide coverage. Therefore, it should be laid out around the denser nodes and corridors in the community.

Like the PRT, the people-mover could easily be extended to nearby centers or into adjacent communities. Otherwise, intercommunity travel must be accomplished by people-mover to people-mover transfers, people-mover to local bus transfers, or people-mover to long-line bus transfers.

One disadvantage of the people-mover system is that, because of its incomplete community coverage, it must be supplemented by bus service in some form. In the pilot communities, supplemental bus service was considered as conventional transit routes on arterials in areas not served by the people-mover or along routes connecting to adjacent communities.

Dial-a-Bus: Of course, the demand-responsive system could not be laid out in a "map" sense. It was assumed, however, that demand-responsive service could be implemented (by modules) in each community, providing coverage at least equal to that of a conventional bus system.

INTEGRATION

Each of the systems thus laid out were checked again against possible locations for rail rapid transit stations or freeway express bus access points. In some cases (particularly for the bus-on-freeway express system), some sort of shuttle connections might be necessary. Also, in outlying communities, it is possible that express buses using the freeways could move directly from the freeway onto arterials and into community central areas.

A final step in laying out the systems was to recheck the system layout with community boundaries. Both were modified where necessary to match the available data base, which was mainly oriented around LARTS analysis zones. A check was made at this time to ensure that adequate population had been included within each community.

As an example, the following Figures III-1, III-2, III-3, and III-4 illustrate the systems laid out for the Canoga Park community. Included is a radial

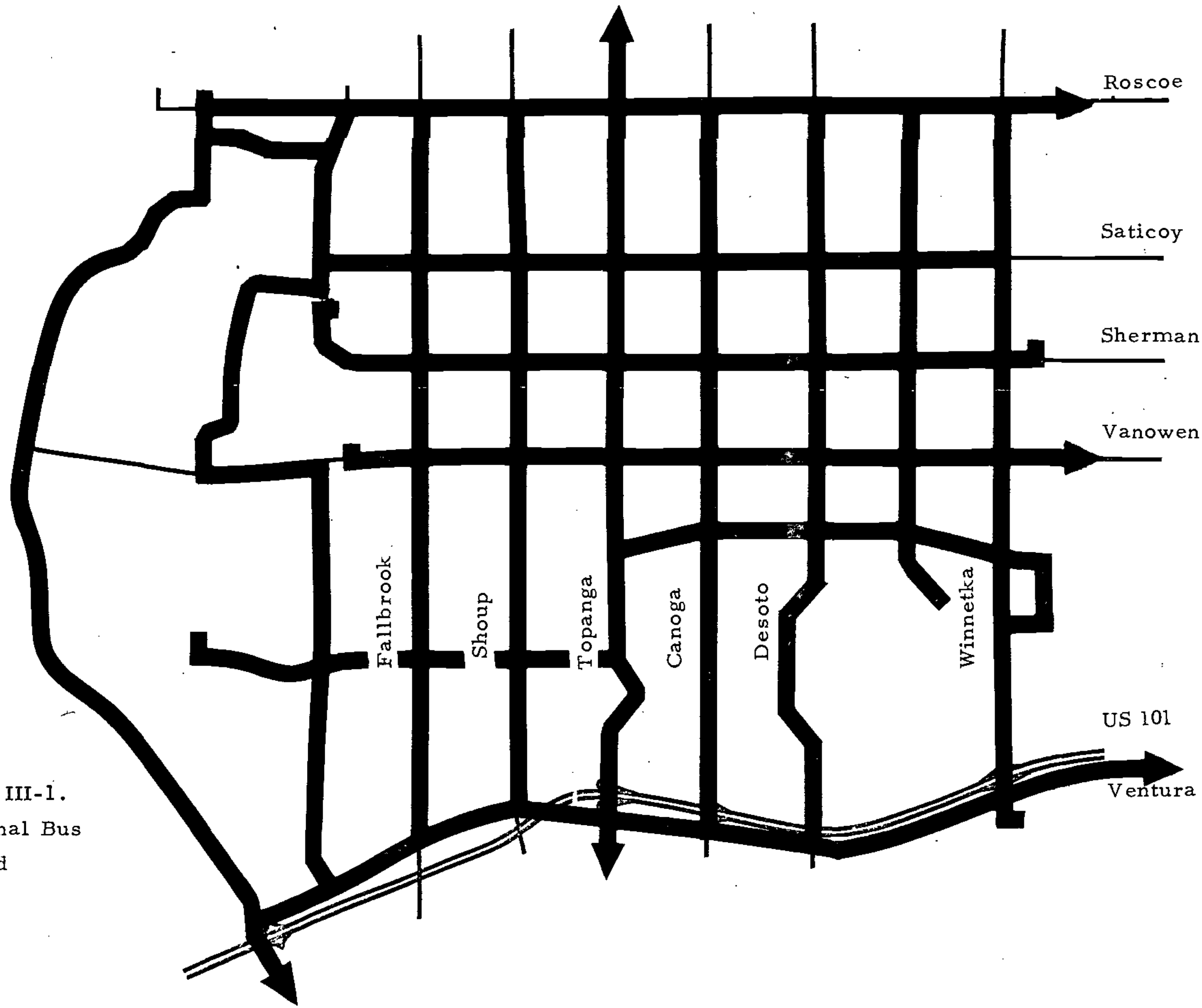


FIGURE III-1.
Conventional Bus
Grid

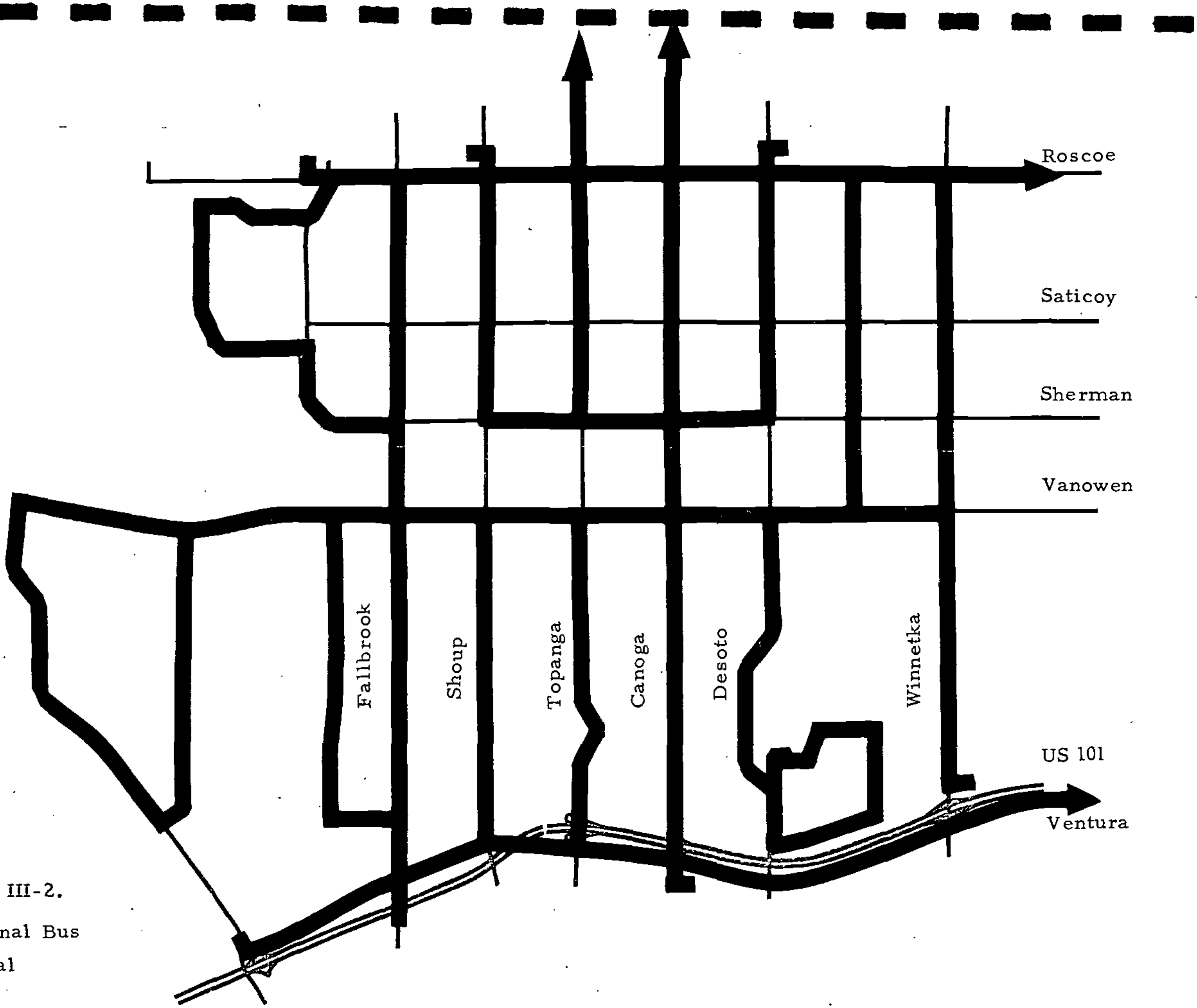


FIGURE III-2.

Conventional Bus Radial

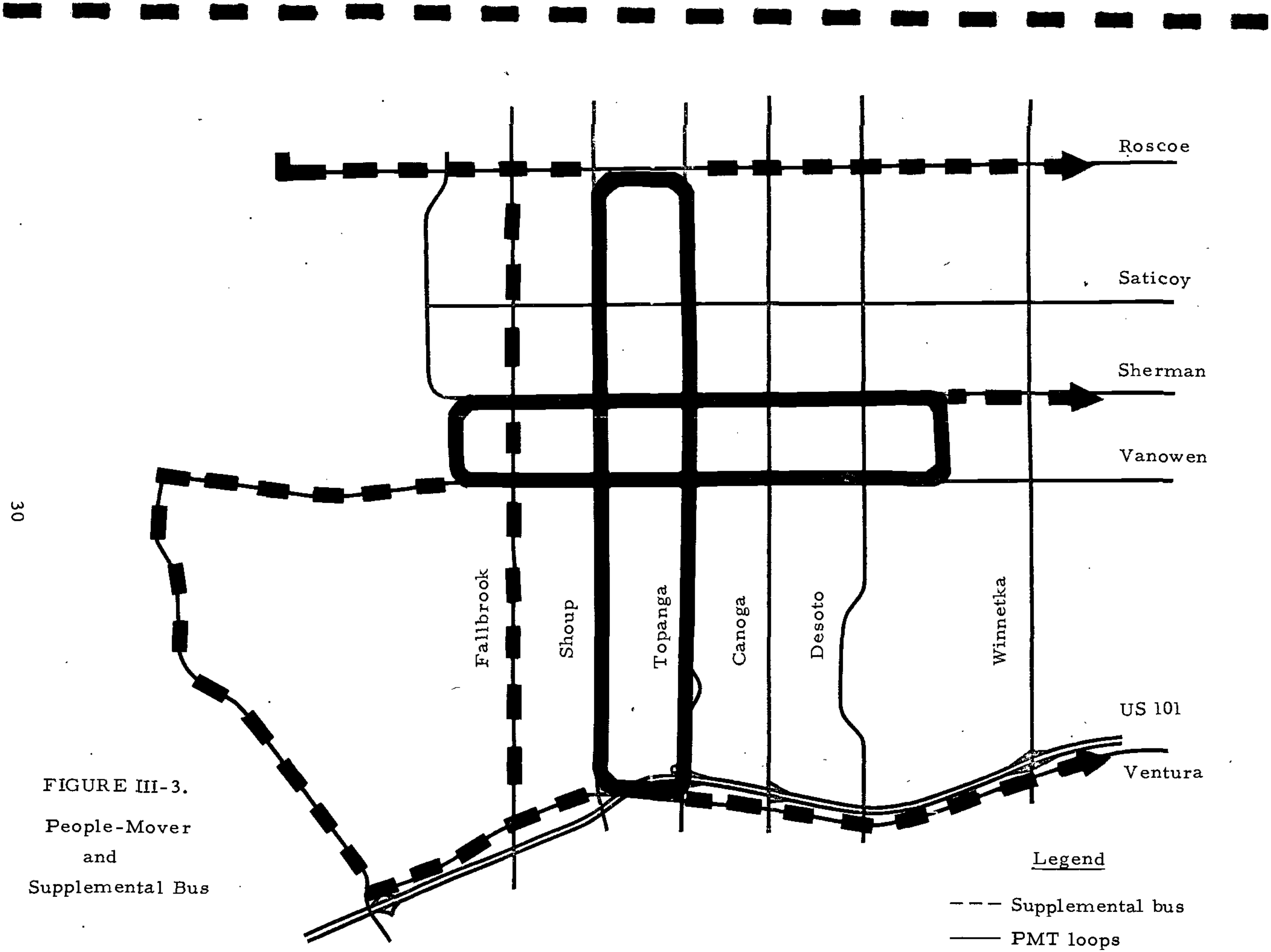


FIGURE III-3.
People-Mover
and
Supplemental Bus

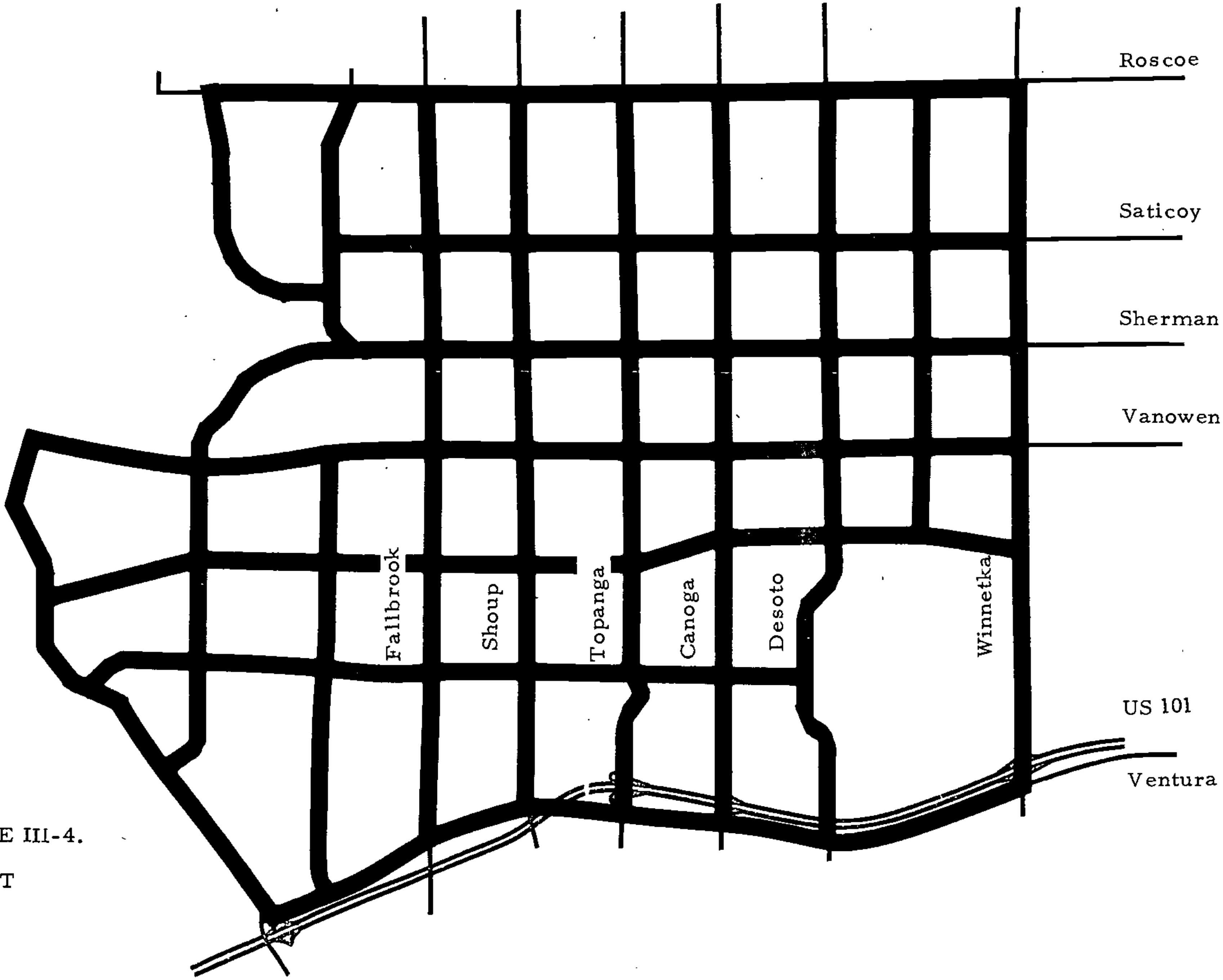


FIGURE III-4.
PRT

bus system for comparison, although it was not used in calculating system performance or patronage.

SYSTEM PERFORMANCE ESTIMATES

The first step in developing performance estimates for each system was to map them out on U.S.G.S. scale maps (1 foot = 2,000 feet). The systems were then measured and converted to one-way route-miles.

With the length of the system set and performance standards such as headway and average speed assumed, the system's daily vehicle-hours and vehicle-miles could be calculated using the formula shown in Table III-2. Note that the demand-responsive calculations follow a different procedure.

TABLE III-2
FORMULAS FOR SYSTEM PERFORMANCE CALCULATIONS

<u>Conventional Bus, People-Mover, & PRT:</u>

1. Number of vehicles $= \dfrac{\text{Frequency}}{\text{Speed}} \times \text{Miles of route}$

$$= \frac{\text{Vehicles}}{\text{Hour}} \times \frac{\text{Hours}}{\text{Mile}} \cdot \text{Miles of route*} = \frac{\text{Round Trip Time}}{\text{Headway}}$$

2. Daily vehicle-hours = (peak vehicles x 4 hours) + (base vehicles x 16 hours)

3. Daily vehicle-miles = (peak vehicle-hours · speed) + (base vehicle-hours · speed)

<u>Demand-Responsive Bus:</u>

1. Number of peak vehicles $= \dfrac{\text{Population}}{3{,}300}$ (for initial system design)

2. Daily vehicle-hours = (peak vehicles x 4 hours) + $\left(\dfrac{\text{peak vehicles}}{2} \times 16 \text{ hours}\right)$

3. Daily vehicle-miles = (peak vehicle-hours x speed) + (base vehicle-hours x speed)

* Round off to next higher number.

A 10 percent allowance was added to the conventional bus system for recovery of deadhead and turn-around time. The basic assumption in applying these formulas is that the system can be treated in concept as a single, long, one-way route. Note also that the calculations for the PRT system are done in a surrogate manner, assuming that all PRT vehicles are in motion at all times. In this way, a level of service could be calculated for the PRT that would be equivalent to the other systems (for use in patronage estimating), even though the PRT vehicles would be at rest unless actually serving a traveler.

Table III-3 shows a sample calculation for conventional bus in the Canoga Park community. Several points should be noted. First, the 1.1 factor used is the allowance for deadhead and other excess bus operation time. This factor probably is not applicable to PRT and people-mover. Also, the number of vehicles for demand-responsive bus is calculated as a ratio of population (in this study, one peak bus per 3,300), with base period buses about one-half of peak.

TABLE III-3

SAMPLE CALCULATIONS — CANOGA PARK

Conventional Bus:

Number of peak buses $= 4\left(\frac{\text{buses}}{\text{hour}}\right)\left(\frac{1}{10\text{ mph}}\right)(119.2\text{ miles}) = 47.7 \rightarrow 48$

Number of base buses $= 2\left(\frac{\text{buses}}{\text{hour}}\right)\left(\frac{1}{15}\right)(119.2\text{ miles}) = 15.5 \rightarrow 16$

Daily vehicle-hours = 1.1 (48 x 4 hours + 16 x 16 hours)

= 211 + 282 = 493

Daily vehicle-miles = (211 x 10 mph) + (282 x 15 mph)

= 2,110 + 4,230 = 6,340

Also important is the significance of the figures. Certainly, the number of vehicles must be rounded up to the next whole number. The generalities of the overall process would indicate that vehicle-miles and vehicle-hours should be rounded to three significant figures. It is obvious that these calculations can be combined to fewer steps. There are various ways of making the calculations lead to slightly different answers — owing to rounding off or not rounding off at each step.

The key point in this step is the basic assumed or measured values that are input to the equations. Speed is an assumption that can be varied, though probably not too greatly within each generic system type. Headways, on the other hand, along with the extent of the system (miles of routes) are the key variables under the control of the system planner. These quantities should be selected or developed to match the goals and objectives of the specific community.

SYSTEM PATRONAGE ESTIMATION

The patronage estimating procedure divides patronage into two categories: (1) local travel (including intracommunity and intercommunity, nonrapid travel), and (2) feeder/distribution travel to and from the rapid transit stations. The procedures used here are necessarily of a lower level of precision and sophistication than those used in forecasting regional travel and mode choice. Because of the virtual absence of proven techniques for modeling local travel, application has been made here of typical experience observed throughout the country. Estimates were made of local patronage on the candidate systems for the "near term" to represent implementation within 1 to 5 years — before the advent of a regional rapid transit system. "Long-range" estimates were made with both local patronage and feeder patronage included, and pertain to conditions forecast for 10 to 15 years from now.

For near-term patronage estimates, the following steps were taken:

A. Conventional Bus

1. Calculate the ratio of daily vehicle-miles per thousand persons (near-term population).

2. Using that ratio, enter the curves depicted in Figures III-5 and III-6 to estimate daily passengers per thousand population. (Figure III-6 shows an expanded scale for lower values.)

3. Multiply the ratio by near-term population.

B. Demand-Responsive Bus

1. Enter the curve in Figure III-7* with population density to select a productivity value (to the nearest whole number).

2. Multiply productivity by daily vehicle-hours to estimate daily patronage.

C. People-Mover

1. Using near-term population, calculate the ratio of daily vehicle-miles per thousand population.

2. Divide the ratio thus produced by the decimal fraction of area coverage by the people-mover system (since the total community may not be covered).

3. Estimate daily passengers per thousand persons, using the curves in Figures III-5 and III-6.

4. Multiply the resulting ratio by near-term population.

5. Multiply the results of Step 4 by the coverage ratio (see Step 2) and by an induced activity ratio of 1.56.

---

* This curve is derived from curves of productivity and demands per square mile; it assumes that demands are proportional to population. Figure III-7 is estimated beyond 15,000 density and 15 productivity, but assumes that dial-a-bus will become more efficient with more experience.

FIGURE III-5. LOCAL TRANSIT PATRONAGE ESTIMATION CURVE

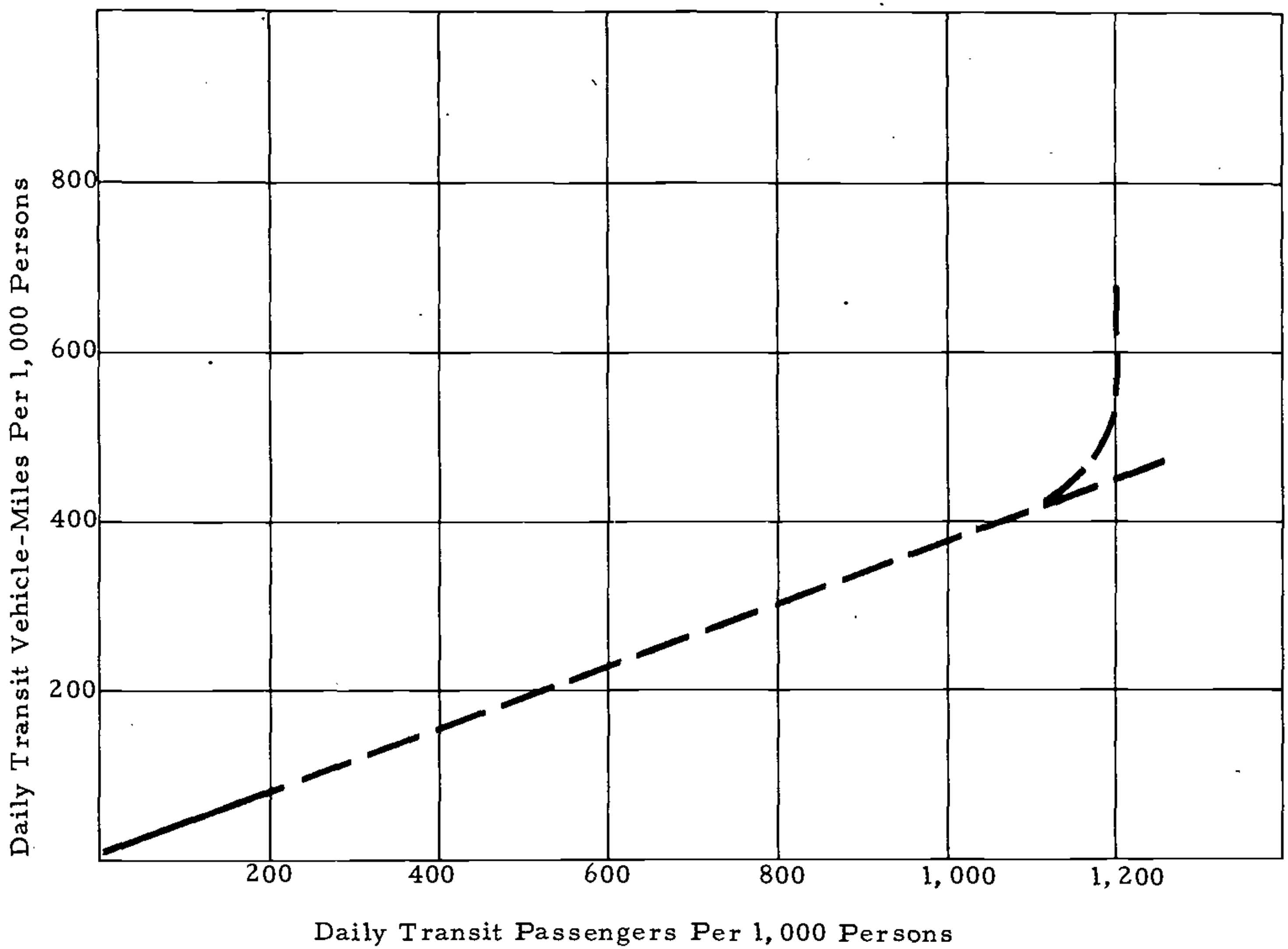


FIGURE III-6. LOCAL TRANSIT PATRONAGE ESTIMATION CURVE

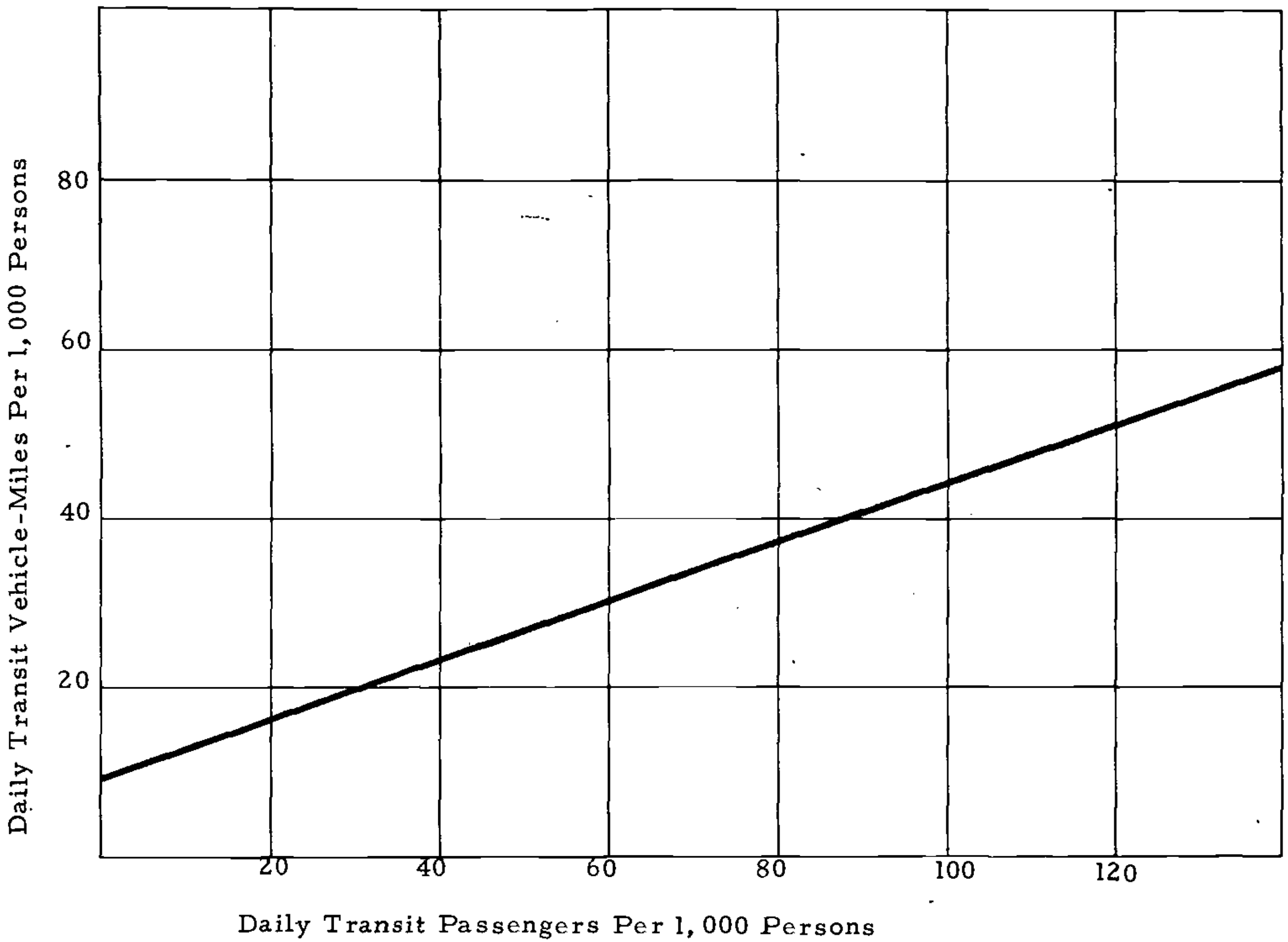
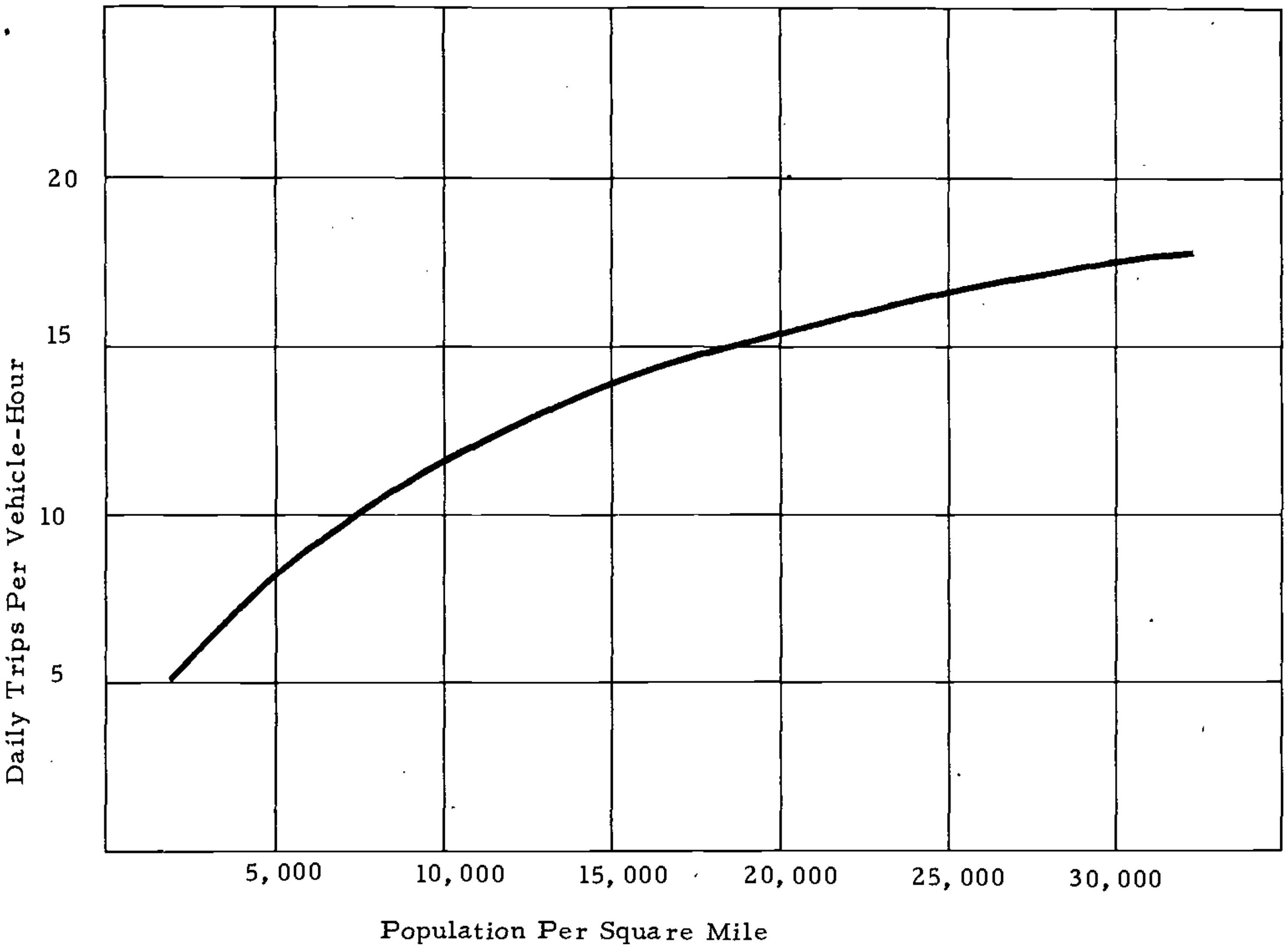


FIGURE III-7. DEMAND RESPONSIVE BUS PATRONAGE ESTIMATION CURVE



D. People-Mover Bus Supplement

1. Follow the same procedure as for People-Mover above, but delete the induced activity factor of 1.56.

E. PRT

1. Using near-term population, calculate daily vehicle-miles per thousand persons.

2. Enter the curve (Figure III-5 or III-6) with that ratio to estimate daily passengers per thousand persons.

3. Using the ratio produced in Step 2 and the near-term population, calculate daily transit trips for the community.

4. As a check, calculate the total potential intracommunity daily person-trips (using estimates of total community person-trip generation, trip length distribution curves, and an assumed capture ratio of 75 percent).

5. Select the lower of the figures produced in Steps 2 and 4.

The 1.56 factor is calculated from trip purpose data and represents new transit trips or trips diverted from auto by a level of transit service not often experienced today. (Specifically, it is the factor by which transit work trips would be multiplied to make transit trip purpose distribution the same as auto trip purpose distribution.) The factor is also applicable to PRT, but the basic curve overestimates PRT usage, and the factor usually is not needed. In fact, the PRT estimates from the curve exceeded the probable total of short, community-oriented trips. That is why an alternative process was used for this mode.

Key variables are the "induced travel" factor of 1.56 and, for PRT, the process of estimating intracommunity trips from trip-length data and the assumed "capture rate." If better data are available, they should be used.

The procedures above will produce an estimate of near-term daily transit passenger trips for the community. The methodology cannot be considered calibrated and tested, but it should give a general order of magnitude of the community response to the level of service provided by the alternative transit systems. Future validation of the approach is required.

Since the curves in Figures III-5 and III-6 were developed from data on existing transit systems, it probably should not be applied directly to long-range (1985 or 1990) conditions. Therefore, to estimate local transit trips for the long range for each of the systems, multiply the near-term local transit trips by the ratio of long-range to near-term population.

To these long-range estimates of local trips must be added the incremental feeder/distributor trips for future rapid transit. It was concluded that these trips could not be estimated independently by community but must be developed on a region-wide basis to accurately reflect changes in level of transit service on the longer, regional trips. Therefore, the feeder/distributor volume within the local community should be abstracted from the best available assignment of rapid transit trips. For this particular analysis, the "R2" network assignment was utilized. (In future applications of this procedure to community system design, the best and most appropriate transit assignment should be used.)

The feeder trip data utilized were the station volumes. These volumes were produced in the assignment in terms of productions and attractions (rather than origin and destinations). Also utilized were the total community transit productions and attractions regardless of transit submode, whether or not they were assigned to a rapid transit station.

Also utilized from the assignment were the link volumes on network links leading to the stations. These data were utilized to split the station volumes by direction (using the ratio of assigned volumes on feeder links) in those cases where a station was on the periphery of the community.

If better methods of estimating feeder volumes are available, they should be utilized. One such method would be a special analysis of the transit assignment to indicate the zones served by a station and the volume of feeder trips to each of those zones.

Once the community feeder volume was established, the community transit system feeder patronage was estimated as follows:

1. Station volumes were multiplied by 0.68, the share of new transit riders on the rapid transit system.

2. Trips attracted to the station were multiplied by a percentage representing transit access mode to the station. Access mode information developed in Phase II (plus data from BART experience) was utilized to make an assumption that 50 percent of the station production trips would be via local transit (with the exception of Hollywood, where the percentage was 65 percent). For PRT, the transit mode use percentage was assumed at 90 percent. For people-mover, the coverage ratio must also be applied.

The total of long-range local trips plus long-range feeder trips is the total long-range daily patronage on the local system.

Key variables in the hands of the analyst are the feeder volume estimates by station, the assumed directional split (where applicable), the share representing new transit riders ("old" riders should already be in the local travel estimate), and the modal split of trip production and attraction. As always, the analyst must use the best and most appropriate data that can be obtained.

Appendix B illustrates the detailed calculations necessary to determine both near-term and long-range patronage.

The patronage estimating process described in this chapter can be considered as "sketch planning" for local transit. By its nature, sketch planning is intended to provide overall order-of-magnitude results using general factors, guidelines, and rules-of-thumb. The results of sketch planning form a basis for decisions about the general direction of the next steps in planning a transit system. A wide variety of alternatives can be considered at a rather coarse level of detail.

Because of the generalities of sketch planning, and because of the mechanization of the processes, it is important to follow the estimation of system statistics with checks to ensure that final results are in tune with the real world. Appendix C presents some of these tests of reasonableness.

SYSTEM COST ESTIMATES

The actual cost, for any point in time, to provide circulation and distribution/collection transit service to local communities in the Los Angeles Basin is a highly variable parameter. Much depends upon the specific hardware selected and upon the fiscal policies and constraints imposed by both the

Federal Government and the local area. Fixed-guideway system costs, for example, are heavily dependent upon new construction, and as such have shown significant increases over the past few years. Unlike buses, these systems are not in widespread use and have not yet achieved economic offsets through standardization and mass production. Many of the newer systems have had limited or no service applications, making operating statistics speculative at best.

However, for comparative purposes it is reasonable to use the most current information available to estimate the order-of-magnitude capital and operating costs required for different types and levels of service to a given area. The methodology presented herein will allow individual communities to evaluate the comparative monetary implications of alternative transportation policies and to simplify the preplanning selection of alternative systems.

The cost statistics presented have been gathered over the past 3 years from a variety of sources, and consequently represent the composite estimates of the most current cost data. Specific hardware systems have been grouped into the four generic categories, analyzed, and a representative capital cost average determined. In a like manner, operating costs were developed from a range of values experienced by transit system operators. In the case of conventional bus, current Los Angeles bus lines providing local circulation service were used as a base. Capital and operating costs were developed separately due to the variation between the ratios of these costs to total costs for the four generic systems.

<u>Capital Costs</u>: Capital costs are all costs which are required to purchase vehicles, construct guideways, stations, and the maintenance facilities necessary to place a system into service. No costs were included for right-of-way acquisition or utilities relocation, as these are highly variable.

Costs for the automated people-mover and PRT systems were based on the assumption that the guideway and support structures would be elevated throughout the route's entire length. Average per mile costs were developed for the various elements of the fixed guideway system and converted to total costs by multiplying by the total mileage in each prototypical community. The assumptions leading to the capital costs for each of the four systems is discussed below. The user of this manual is advised to alter any or all of these assumptions either at his discretion or if he is possessed of more current data.

A. Bus Systems

1. Conventional Bus Systems

Conventional bus costs were based on current industry-wide averages of vehicles in the 30- to 50-foot class. The fleet mix was assumed to be approximately two-thirds larger vehicles and one third in the 30- to 40-foot size. An average cost was then established as $45,000 per vehicle. No other capital costs were assumed for a conventional bus operation such as maintenance and bus storage facilities.

2. Dial-a-Bus System

Buses were also used as the base for capital cost estimates for dial-a-bus systems. Because of the nature of this operation, smaller vehicles were assumed. An average cost of $25,000 per vehicle including the cost of dispatching equipment was used. As with the conventional bus operation no capital costs were derived for maintenance and storage; these were assumed to be absorbed by the existing facilities.

B. Fixed Guideway System

1. People-Mover Systems

People-mover system capital costs were broken down into rolling stock and fixed facility categories. The latter group consisted of five separate elements which vary between types of fixed guideway systems. For people-mover, these included the following components and cost estimates for each mile of single guideway:

People-Mover System Component	Per Mile Cost*
Guideway and Support System	$4,000,000
Stations (two/mile average), @ $500,000 each	1,000,000
Electrification	500,000
Command and Control System	300,000
Maintenance Facilities and Contingencies	800,000
Total Fixed Facility Costs	$6,600,000/mile

In addition to these, rolling stock costs were estimated to be $100,000 per vehicle.

2. PRT Systems

An elevated guideway structure with its component elements were also assumed for PRT. Its vehicles being small and lighter than people-mover, the PRT guideway, stations, and vehicle costs are less. However, being more extensive in coverage, PRT systems require more capital outlay to construct. They also require a more complex command and control system. The items shown for people-mover capital costs are listed below for PRT systems:

*Subject to change and finalization during Task 8.5.2.

PRT System Component	Per Mile Cost*
Guideway and Support System	$2,000,000
Stations (three/mile) @ $300,000 ea.	900,000
Electrification	500,000
Command and Control System	600,000
Maintenance Facilities and Contingencies	800,000
Total Fixed Facility Costs	$4,800,000/mile

PRT vehicle costs were assumed to be $25,000 per vehicle.

Table III-4 summarizes the unit capital cost estimates for each of the generic systems chosen for analysis. These figures were used as a base to multiply by the appropriate system mileage and fleet in each of the six prototypical communities.

Operating Costs: Operating costs are those which are necessary to operate and maintain the system. They are normally reported on an annual basis, and include such costs as payrolls, insurance, power and fuel, maintenance of roadway, right-of-way, and equipment, plus overhead. The estimates used herein are based in part on the experience of existing operating agencies and on the experience developed by the consultant in similar analyses for such cities as San Francisco, Honolulu, Baltimore, Atlanta, Pittsburgh, Los Angeles, and others.

A. Bus Systems

1. Conventional Bus Systems

Operating cost data was provided by the SCRTD. Their current system-wide experiences average $1.35 per bus mile. However, local circulation lines tend to run at higher rates due to their

*Subject to change and finalization during Task 8.5.2.

TABLE III-4

ESTIMATED CAPITAL COSTS — GENERIC SYSTEMS*

Fixed Facility	Capital Costs
People-Mover — Single Guideway	
Guideway and Support System	$4,000,000/mile
Stations (two/mile average) @ $500,000 ea	1,000,000/mile
Electrification	500,000/mile
Command and Control System	300,000/mile
Maintenance Facilities and Contingencies	800,000/mile
Total	$6,600,000/mile
PRT — Single Guideway	
Guideway and Support System	$2,000,000/mile
Stations (three/mile) @ $300,000 ea	900,000/mile
Electrification	500,000/mile
Command and Control System	600,000/mile
Maintenance Facilities and Contingencies	800,000/mile
Total	$4,800,000/mile

Rolling Stock	Capital Costs
Dial-a-Bus	
20- to 30-Ft Vehicles @ $25,000 ea	$ 25,000/vehicle
Conventional Bus	
30- to 50-Ft Vehicle @ $45,000 ea	$ 45,000/vehicle
People-Mover Vehicles	
32-Passenger @ $100,000 ea	$ 100,000/vehicle
PRT Vehicles	
6-Passenger @ $25,000 ea	$ 25,000/vehicle

*Subject to change and finalization during task 8.5.2.

lower average operating speeds. Typical local bus lines were investigated to derive more refined costs: Table III-5 summarizes current SCRTD costs for local circulation systems in selected areas. Based on these analyses it was decided to use a figure of $1.75 per bus mile for the high activity centers of Hollywood and Westwood, and $1.50 per bus mile in the other four pilot areas.

TABLE III-5

CURRENT LOS ANGELES BUS OPERATING COSTS

Bus Line	Number of Buses	Headway	Cost/Mile
Fairfax Ave. (Hollywood)	12	15 min. peak 15 min. base	$1.72
Kern Ave. (East L.A.)	9	10 min. peak 10 min. base	$1.68
Exposition Park	-	15 min. peak 20 min. base	$1.44
Pasadena	6	15 min. peak 20 min. base	$1.49
Minibus (CBD)	-	10 min. peak 10 min. base	$1.92

Source: Southern California Rapid Transit District

2. Dial-a-Bus System

The major operating costs for a dial-a-bus operation are essentially the same as those for conventional buses. Smaller vehicles do not substantially decrease the per-mile operating costs, as can be seen from the downtown minibus costs shown in the previous table. There are however, additional costs associated with dispatching these vehicles. Averages from operations in other cities are on the order of 25 percent of the total operating costs for dispatching. Therefore, the conventional bus costs were increased accordingly and a figure of $2.20 per bus mile was used in Hollywood and Westwood, while the remaining areas were assigned a value of $1.90 per bus mile.

B. Fixed Guideway Systems

1. People-Mover Systems

Operating costs for the people-mover systems are considerably more detailed than bus statistics since there are physical plants which must be maintained. Transit operating properties with fixed guideway operations normally report these costs broken down into six accounts. This analysis has followed the same procedure. These accounts are discussed in a general description in the following paragraphs.

a. Maintenance of Way and Structures

This activity deals with the maintenance and repair of the running surface (rail or concrete), ballast, structures, retaining walls, etc. The organization consists of two groups: (1) men to repair and maintain the guideway and its components and (2) men to repair the buildings and other facilities.

The guideway crew consists of: (1) men for daily inspections; (2) workers who maintain and repair the power distribution and control system; and (3) workers to perform general labor and to operate guideway equipment. The structures crew includes mechanics and electricians and technicians for the maintenance and repair of power systems, station equipment, etc. These men, along with the structural maintenance crew, would make all repairs to the buildings and elevated structures. The estimate of annual cost for this item is: $3 per linear foot of single guideway, or $15,840 per mile.

b. Maintenance of Equipment

The main functions of the maintenance of equipment personnel are periodic car inspections, car repairs, car sweeping, and car washing. The annual cost of this department is: $.06 per car-mile.

c. Power Costs

Power costs are based on rate information from the Department of Water and Power in Los Angeles. Using a rate schedule which considers both total consumption and past demand a value of $0.02 kilowatt hour was developed. This value takes into consideration higher costs of fossil fuels. Power consumption for the system included propulsion, air conditioning, lighting, and control equipment. Using an industry standard of 0.247 kwh/ton-mile and assuming a 26,000-pound loaded vehicle, power costs were derived as follows:

$0.02/kwh x 0.247 kwh/ton-mile x 13.0 tons = $0.0642/ car-mile

d. Provisions of Services

The provision of services is concerned with operating the yards, cleaning the stations, preparing the schedules, and supplying the stations with attendants. This cost is a function of many operations and was developed using linear regression techniques which resulted in the following empirical equation:

Provision of Services = A(38,100) + B(9.09) + C(.073) + D(9,312) where A = number of stations, B = train hours, C = train miles of operation, and D = miles of system.

e. Injuries and Damages

Injury and damage costs are estimated at $50,000 for administration of a self-insurance program, with variable cost for claim settlements of 0.25 cents for each passenger trip.

f. Administrative and General

The Administrative and General Department is responsible for accounting, public relations, purchasing and stores, and legal and claim functions. Administrative and general expenses were based on 2 cents per passenger trip.

2. PRT Systems

Operating costs were developed for PRT systems in the same categories as those for the people-mover. However, the characteristics of the two systems are different and the parameters and multiplying coefficients within each group were changed. PRT estimating values are listed below.

a. Maintenance of Way and Structures

The activities in this category are the same, but the guideway and support structures have been scaled down for smaller vehicles requiring less maintenance. Therefore, PRT estimates are: $2.00 per linear foot of single guideway, or $10,560/mile

b. Maintenance and Equipment

PRT vehicles are intrinsically more complex than people-mover vehicles and would require higher maintenance costs. The average figure selected for PRT was $0.08 per car mile.

c. Power Costs

Unit costs for powering PRT vehicles were the same as for the people-mover, but the vehicle is lighter. Therefore, the following value was used:

$$0.247 \text{ kwh/ton-mile} \times \$0.02/\text{kwh} \times 5 \text{ tons/car} = \$0.0247/\text{car mile}$$

d. Provision of Services

The ubiquitous nature of the PRT operation produces economies of scale in providing services. Personnel requirements do not increase in linear proportion to those of other fixed guideway systems for order-of-magnitude increases in vehicle miles and hours of operation. To reflect these savings, the coefficients in the empirical equation were reduced to the following values:

$$9,500\ (A) + 2.25 \times (B) + 0.018\ (C) + 2,328\ (D),$$

where again: A = number of stations; B = annual vehicle hours; C = annual vehicle miles; and D = track miles.

e. Injuries and Damages

Injury and damage costs are the same as those experienced for the people-mover, or $50,000 for administration of a self-insurance program with a variable cost for claim settlements of $0.0025 for each passenger trip.

f. Administrative and General

Cost savings were again realized by the economies of scale, making the administrative and general costs $0.01 per passenger trip.

Equivalent Annual Costs: In order to obtain a common base of comparing costs of alternative systems, all costs were converted to a uniform equivalent annual cost. An annual interest rate of 6 percent was used as an assumed cost of capital. Escalation was not considered, so that all values given are in constant 1973 dollars.

Fixed facility construction costs were amortized over a 50-year period. Fixed guideway vehicle systems were assumed to have a life of 25 years. Buses were assumed to have a life of 15 years. No salvage value was assumed for either the fixed facilities or the rolling stock. Converting all costs to a uniform equivalent cost provides a measure of comparability when divided by the annual ridership to determine the annual cost per passenger. This is an economic evaluation of comparative system costs and is not necessarily the only criterion used in system selection. Other factors such as planning objectives, institutional desires, cost-benefit analyses, etc. should be considered. Moreover, the cited comparison suffers from the severe limitation that levels-of-service for each alternative equipment solution are not comparable.

SAMPLE COST CALCULATIONS

Having determined the patronage generated and operating statistics of each of the generic modes, comparative costs are derived by an arithmetical exercise using the capital and operating cost values developed above. As with the patronage example, the community of Canoga Park was selected to detail the procedures in estimating system costs.

Capital Costs: Estimating capital costs is a two-step process. Initially the unit costs for vehicles and guideway mileage given under the previous section of this report are multiplied by the appropriate parameters in the area under study for each of the generic modes. These results are then converted to an equivalent annual cost for comparison with annual operating costs.

These calculations are performed in Tables III-6 and III-7 for the near-term and long-range conditions in Canoga Park. These tables indicate that bus capital costs are considerably lower than either of the fixed guideway systems, as expected. However, these costs do not stand alone and must be added to operating costs to determine total outlays.

Operating Costs: As input to the operating case analysis, daily operating statistics had to be converted to annual data. The rationale for this was developed by assuming that full operation would be achieved on normal weekdays calculated as follows:

52 weeks x 5 days = 260 days minus 10 holidays
= 250 days of full operation

Operations on the 52 Saturdays were assumed to take place at two-thirds the normal rate or 2/3 x 52 days = 34 days. Sunday and holiday operations were further assumed to take place at one-half the norm or 1/2 x (52 + 10) days = 31 days. This gave a total of 315 annual equivalent days.

Daily operating statistics obtained in the patronage analysis were then multiplied by 315 to convert them to annual data. Table III-8 summarizes these estimates in Canoga Park for each generic system for both near-term and long-range conditions. It should be noted that the supplemental bus statistics shown are to provide coverage in Canoga Park areas not served by the fixed guideway people-mover, and are thus additive to this generic system.

The detailed calculations to determine annual operating costs are given in Tables III-9 and III-10 for the near-term and long-range conditions. All the previous assumptions outlined are indicated in these tables at their appropriate point of application and no further explanation is necessary.

TABLE III-6

CANOGA PARK CAPITAL COST CALCULATIONS
NEAR TERM
($000)

Generic Mode	Unit Costs	x	Guideway Miles or Vehicles	=	Total Cost	x	Capital Recovery Factor	=	Annual Costs
Conventional Bus	45.0		48		2,160		0.1030		222.5
Dial-a-Bus	25.0		33		825		0.1030		85.0
People-Mover:									
Fixed Facilities	6,600.0		15.0		99,000		0.0634		6,281.0
Fixed Facilities Vehicles	100.0		8		800		0.0782		62.6
Buses	45.0		14		630		0.1030		64.9
Total P-M					100,430				6,408.5
PRT:									
Fixed Facilities	4,800.0		62.5		300,000		0.0634		19,033.3
Vehicles	25.0		243		6,075		0.0782		475.2
Total PRT					306,075				19,508.5

TABLE III-7

CANOGA PARK CAPITAL COST CALCULATIONS
LONG RANGE
($000)

Generic Mode	Unit Costs	x	Guideway Miles or Vehicles	=	Total Cost	x	Capital Recovery Factor	=	Annual Costs
Conventional Bus	45.0		48		2,160		0.1030		222.5
Dial-a-Bus	25.0		44		1,100		0.1030		113.5
People-Mover:									
Fixed Facilities	6,600.0		15.0		99,000		0.0634		6,281.0
Fixed Facilities Vehicles	100.0		10		1,000		0.0782		78.2
Buses	45.0		14		630		0.1030		64.9
Total P-M					100,630				6,424.1
PRT:									
Fixed Facilities	4,800.0		62.5		300,000		0.0634		19,033.3
Vehicles	25.0		318		7,950		0.9782		621.9
Total PRT					307,950				19,655.2

TABLE III-8

ANNUAL OPERATING STATISTICS
CANOGA PARK

Mode	Operating Data		
	Vehicle Miles	Vehicle Hours	Passengers
Short Term:			
Conventional Bus	1,995,840	155,300	4,854,150
Dial-a-Bus	1,762,110	137,340	1,373,400
People-Mover	1,260,000	50,400	4,904,500
Supplemental Bus (P-M)	609,840	47,250	1,243,940
PRT	38,272,500	1,530,900	24,645,600
Long Term:			
Conventional Bus	1,995,840	155,300	6,689,030
Dial-a-Bus	2,315,880	180,500	2,164,050
People-Mover	1,587,600	63,630	6,668,550
Supplemental Bus (P-M)	609,840	47,250	1,615,950
PRT	50,085,000	2,003,400	32,543,910

Sample Calculation:

315 days/yr x 6,336 vehicle miles/day = 1,995,840 vehicles miles/yr

TABLE III-9

ANNUAL OPERATING COSTS
CANOGA PARK
NEAR TERM

	Cost per Year
Conventional Bus	
1,995,840 miles/yr x $1.50/mile	$2,993,760
Dial-a-Bus	
1,762,110 miles/yr x $1.90/mile	$3,348,010
People-Mover	
Maintenance of Way & Structures: $15,840/mile x 15.0 miles	$ 237,600
Maintenance of Equipment: $0.06/mile x 1,260,000 miles	75,600
Power: $0.0642/mile x 1,260,000 miles	80,900
Provision of Services: 38,100 x 30 stations + 9.09 x 50,400 hrs + 0.073 x 1,260,000 miles + 9,312 x 15.0 track miles	1,832,800
Injuries and Damages: $50,000 + $0.0025/passenger x 4,904,550 passengers	62,300
Administrative and General: $0.02/passenger x 4,904,550 passengers	98,100
Supplemental Bus @ $1.50/mile x 609,840 miles	914,760
Total People-Mover	$3,302.060
PRT	
Maintenance of Way & Structures: $10,560/mile x 62.5 miles	$ 660,000
Maintenance of Equipment: $0.08/mile x 38,272,500 miles	3,061,800
Power: $0.0247/mile x 38,272,500 miles	945,330
Provision of Services: 9,500 x 188 stations + 2.25 x 1,530,900 hrs + 0.018 x 38,272,500 miles + 2,328 x 62.5 track miles	6,064,930
Injuries and Damages: $50,000 + $0.0025/passenger x 24,645,600 passengers	111,600
Administrative and General: $0.01/passenger x 24,645,600 passengers	246,460
Total PRT	$11,090,120

TABLE III-10

ANNUAL OPERATING COSTS
CANOGA PARK
LONG RANGE

	Cost per Year
Conventional Bus	
1,995,840 miles/yr x $1.50/mile	$ 2,993,760
Dial-a-Bus	
2,315,880 miles/yr x $1.90/mile	$ 4,400,200
People-Mover	
Maintenance of Way & Structures: $15,840/mile x 15.0 miles	$ 237,600
Maintenance of Equipment: $0.06/mile x 1,587,600 miles	95,260
Power: $0.0642/mile x 1,587,600 miles	101,920
Provision of Services: 38,100 x 30 stations + 9.09 x 63,630 hrs + 0.073 x 1,587,600 miles + 9,312 x 15.0 track miles	1,976,980
Injuries and Damages: $50,000 + $0.0025/passenger x 6,668,550 passengers	66,670
Administrative and General: $0.02/passenger x 6,668,550 passengers	133,370
Supplemental Bus @ $1.50/mile x 609,840 miles	914,760
Total People-Mover	$ 3,459,890
PRT	
Maintenance of Way & Structures: $10,560/mile x 62.5 miles	$ 660,000
Maintenance of Equipment: $0.08/mile x 50,085,000 miles	4,006,800
Power: $0.0247/mile x 50,085,000 miles	1,237,100
Provision of Services: 9,500 x 188 stations + 2.25 x 2,003,400 hrs + 0.018 x 50,085,000 miles + 2,328 x 62.5 track miles	7,340,680
Injuries and Damages: $50,000 + $0.0025/passenger x 32,543,910 passengers	131,360
Administrative and General: $0.01/passenger x 32,543,910 passengers	325,440
Total PRT	$13,701,380

Summaries of the estimated total annual operating costs in Canoga Park for each mode are as follows:

Near Term

Conventional Bus	$ 2,993,760
Dial-a-Bus	3,348,010
People-Mover*	3,302,060
PRT	11,090,120

Long Range

Conventional Bus	$ 2,993,760
Dial-a-Bus	4,400,200
People-Mover*	3,459,890
PRT	13,701,380

The conventional bus is the least expensive to operate, followed by the mixture of bus and people-mover systems. Dial-a-bus closely follows these two and is trailed by PRT which, owing to the extensive coverage and frequency of service it provides, has relatively higher operating costs.

Equivalent Annual Costs: Since both capital and operating costs are on a common base, they can be added to produce total annual costs. This calculation is performed in Table III-11. As expected, fixed guideway costs are considerably higher than bus operations. PRT costs are on the order of 10 times that of conventional buses. However, there is another statistic which warrants consideration: also shown in Table III-11 is the cost per passenger mile to provide the different kinds of local circulation service. Considering the large number of passengers served, PRT provides cheaper per-passenger costs than either dial-a-bus or people-mover and is only twice as expensive as conventional bus in providing a much higher level of service.

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*Includes supplemental bus costs

TABLE III-11

CANOGA PARK EQUIVALENT ANNUAL COSTS
($000)

Costs	Conventional Bus	Dial-a-Bus	People-Mover	PRT
	Mode			
Near Term:				
Capital Costs	$ 222.5	$ 85.0	$6,412.5	$19,508.5
Operating Costs	2,993.8	3,348.0	3,302.1	11,090.1
Total Costs	$3,216.3	$3,433.0	$9,714.6	$30,598.6
Cost per Passenger**	$0.66	$2.50	$1.58	$1.24
Long Range:				
Capital Costs	$ 227.5	$ 113.3	$6,424.1	$12,655.2
Operating Costs	2,993.8	4,400.2	3,459.9	13,701.4
Total Costs	$3,216.3	$4,513.5	$9,984.0	$33,356.6
Cost per Passenger**	$0.48	$2.09	$1.21	$1.02

* Includes Supplemental Bus Costs

** Cost per passenger expressed in dollars.

SUMMARY

The procedures described in this chapter can be applied for the estimation of system performance, patronage, and costs of community transit systems throughout the RTD service area. Many assumptions are made, however, and assumed values should be replaced with better data where improved information is available. It must be stressed again that the patronage and cost estimates give general order-of-magnitude information and should be carefully reviewed in the implementation planning within each community.

The data resulting from these processes should form an adequate starting point for detailed planning of systems within communities. The data developed can then form the basis for policy decisions about the type and extent of such community transit systems.

Furthermore, combinations of systems have not been specifically analyzed in this study, with the exception of the supplemental bus in the people-mover systems.

Although demand-responsive transit would appear to have its most reasonable application in low-density areas, it is conceivable that demand-responsive transit can be used to supplement conventional fixed-route/fixed-schedule transit for certain types of travel and certain periods of the day in locations where vehicle inventories and driver training will allow such dual service. Also, other "para transit" concepts have been gaining increasing attention lately as a result of the gasoline shortage. Such concepts would fit in between private auto travel and conventional bus travel, and would include short-term and daily auto rental, taxi, jitney, carpool, vanpool, and subscription bus as well as the demand-responsive bus analyzed in this task.

APPENDICES

APPENDIX A

GRID AND RADIAL BUS SYSTEMS

There are two basic bus route layout patterns: grid and radial.

The grid system is traditional and has several advantages. It lends itself to multiple focal points such as feeding a regional bus-on-freeway where each point of freeway access is a potential point of rapid transit travel. The grid system also can be easily expanded into adjacent communities, and eases the problem of intercommunity nonregional rapid transit travel. Such a system appears best for diffused, noncentralized travel areas such as the Norwalk area.

However, the grid system has one serious disadvantage: since it does not emphasize any single focal point (such as a single rapid transit station), it requires transfers for all diagonal movements.

The radial system, on the other hand, focuses on a single point — thus maximizing its availability. It permits travel that is diagonal across the community (oriented to the focal point) without requiring a transfer. In a very real way, the radial system layout for a community is similar to the orientation of citywide bus systems around the central business district. The radial system could be selected for the community for the same reasons that radial systems are developed citywide.

The radial system does have its disadvantages: it does not lend itself to multiple nodes; neither does it lend itself to intercommunity movements or connections with adjacent systems. It is more self-contained within the community and requires superimposition of intercommunity service. The radial system may also impose travel in-direction and transfer for nonradial movements.

OTHER BUS LAYOUT PRINCIPLES

Several general points should be emphasized. First, any one-way bus route loops should be small. Buses should in general go both directions on most route segments.

Headway frequencies of one hour or more greatly discourage bus use whereas higher frequencies attract increasing usage. Headways probably should not exceed 15 to 20 minutes during peak periods and 30 to 40 minutes during the base period. In areas where longer headways are indicated, demand-responsive service is probably better.

Bus routes should be as straight and as "predictable" as possible. They should lend themselves to brief and meaningful signing so that the system can be easily understood by the uninformed user.

APPENDIX B

SAMPLE PATRONAGE CALCULATIONS

Table B-1 illustrates the near-term patronage calculation for Canoga Park, and Table B-2 shows the long-term estimate wherein feeder volumes are added to local.

The "directional" factor is used to reduce total station feeder volumes to that portion heading toward the community under study, if such correction is needed. The second factor – the ratio of station P's* and A's* to total community P's and A's – is to check whether or not the station is serving more than the community. Ratios of 0.75 or less look about right, but this depends on the relative location of the community and the station.

Table B-3 illustrates the long-range feeder volume estimates for the six prototypical communities. This table follows the calculation up to (but not including) the 0.68 "new transit trip" factor and the access mode split. Note in this table how the directional factor is applied, and how the station volume in Westwood exceeded the total community transit trip generation (the "transit-shed" was larger than the community). The assumed 0.75 is no more than an assumption and should be replaced with better data if available.

Tables B-4 through B-8 show the results of the patronage estimates. Noteworthy is the large impact of feeder travel in Hollywood. In fact, the first "reasonableness" check (see Appendix C) showed such high peak-period bus occupancy that the long-range fleet size was doubled. This was assumed to have the effect of halving headways and doubling vehicle miles. Patronage was thereby recycled, with the resulting increase of 40 percent for the local component.

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*P = Trips Produced in the local community.
A = Trips Attracted to the community (e.g., employment).

TABLE B-1

PATRONAGE ESTIMATION FOR CANOGA PARK
NEAR-TERM LOCAL TRIPS

1. Conventional Bus:

   A. $\frac{6,336 \text{ vehicle-miles}}{108.5}$ = 58.4 vehicle miles/1,000 persons

   B. Curve produces 142 passengers/1,000 persons

   C. (142)(108.5) = 15,407

2. Demand-Responsive Bus:

   A. 6,300 persons/sq mi produces (from the curve) 10 trips per vehicle-hour

   B. (10)(436 vehicle-hours) = 4,360 daily passengers

3. People-Mover:

   A. $\frac{4,000 \text{ vehicle-miles}}{108.5}$ = 36.9 vehicle-miles/1,000 persons

   B. $\frac{36.9}{0.46 \text{ coverage}}$ = 80.2 adjusted vehicle-miles/1,000 persons

   C. Curve produces 200 passengers/1,000 persons

   D. (108.5)(200) = 21,700

   E. (21,700)(0.46)(1.56) = 15,572 daily passengers

4. PRT:

   A. $\frac{75,000 \text{ vehicle-miles}}{108.5}$ = 691.2 vehicle-miles/1,000 persons

   B. Curve produces 1,200 passengers/1,000 persons

   C. (1,200)(108.5) = 130,800

   D. (336,500 total person trips)(0.305 under 4.0 miles)(0.75) = 78,240

   E. Use 78,240 because alternate (130,800) is more travel than all person trips under 4 miles

TABLE B-2

PATRONAGE ESTIMATION FOR CANOGA PARK
LONG-TERM LOCAL AND FEEDER TRIPS

Local Trips:

Conventional Bus	15,407 x 1.30 =	20,033
Demand-Responsive Bus	4,360	5,668
People-Mover	15,570	20,240
PRT	78,240	101,710

Feeder Trips:

1. Station P + A — 1,479 + 1,142 = 2,621
2. Directional Correction — 1.00 (station is in center of community)
3. Corrected P + A — 1,479 + 1,142 = 2,621
4. Total Community P + A — 7,370
5. Ratio Step 3 to Step 4 — 0.36
6. Revised Ratio — 1.00
   (Since only 36% of community P's and A's use the station, a reasonable figure.)
7. Final station P + A — 1,479 + 1,142 = 2,621
8. By mode:

Conventional and Demand-Responsive Bus:

(1,479 P's)(0.68 new trips)(0.90 via bus) = 699
(1,142 A's)(0.68 new trips)(0.50 via bus) = 503
1,202

People-Mover:

(1,479 P's)(0.68 new trips)(0.90 via P-M) = 699
(1,142 A's)(0.68 new trips)(0.50 via P-M)(0.46 coverage) = 231
930

PRT:

(1,479 P's)(0.68 new trips)(0.90 via PRT) = 699
(1,142 A's)(0.68 new trips)(0.90 via PRT) = 905
1,604

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* P = Trips Produced in the local community (residents' travel).
A = Trips Attracted to the local community (e.g., employment).

TABLE B-3

FEEDER VOLUME ESTIMATION
(Daily Passengers)

Item	Canoga Park	Westwood	Hollywood	Exposition Park	Pomona	Norwalk
Station P*	1,479	10,695	18,710	1,992	3,042	1,770
Station A*	1,142	18,926	19,829	13,427	2,605	990
Directional Correction Factor	1.00	**	1.00	0.87	0.86	0.75
Modified P	1,479	9,468	18,710	1,733	2,616	1,328
Modified A	1,142	15,653	19,829	11,681	2,240	742
Sum	2,621	25,121	38,539	13,414	4,856	2,070
Community Total P + A	7,370	24,580	92,218	43,118	9,908	10,581
Ratio	0.36	1.02	0.42	0.31	0.49	0.20
Revised Ratio	–	0.75	–	–	–	–
Final P	1,479	7,101	18,710	1,733	2,616	1,328
Final A	1,142	11,740	19,829	11,681	2,240	742

* P = Trips Produced in the prototypical community (e.g., residents' travel).
A = Trips Attracted to the prototypical community (e.g., employment).

** 1.00 for rail station; 0.35 for freeway stations.

TABLE B-4

PATRONAGE ESTIMATES — CONVENTIONAL BUS
(Daily Trips)

Community	Local Trips	Feeder Trips	Total Trips
Near Term:			
Pomona	16,606		
Canoga Park	15,407		
Norwalk	11,291		
Exposition Park	8,687		
Hollywood	5,427		
Westwood	6,723		
Long Range:			
Pomona	22,756	2,077	24,833
Canoga Park	20,033	1,202	21,235
Norwalk	12,000	906	12,986
Exposition Park	8,957	7,742	16,693
Hollywood	20,140	20,407	40,547
Westwood	10,819	9,602	20,421

TABLE B-5

PATRONAGE ESTIMATES — DEMAND-RESPONSIVE BUS
(Daily Trips)

Community	Local Trips	Feeder Trips	Total Trips
Near Term:			
Pomona	3,204		
Canoga Park	4,360		
Norwalk	4,440		
Exposition Park	5,726		
Hollywood	4,016		
Westwood	1,272		
Long Range:			
Pomona	4,389	2,077	6,466
Canoga Park	5,668	1,202	6,870
Norwalk	4,751	906	5,657
Exposition Park	5,895	7,742	13,637
Hollywood	5,707	20,407	26,114
Westwood	2,048	9,602	11,650

TABLE B-6

PATRONAGE ESTIMATES – PEOPLE-MOVER
(Daily Trips)

Community	Local Trips	Feeder Trips	Total Trips
Near Term:			
Pomona	23,575		
Canoga Park	15,570		
Norwalk	15,635		
Exposition Park	18,747		
Hollywood	11,033		
Westwood	6,458		
Long Range:			
Pomona	32,300	1,940	34,240
Canoga Park	20,240	930	21,170
Norwalk	16,730	889	17,419
Exposition Park	19,310	7,642	26,952
Hollywood	18,425	16,021	34,446
Westwood	10,400	8,178	18,578

TABLE B-7

PATRONAGE ESTIMATES – PEOPLE-MOVER BUS SUPPLEMENT
(Daily Trips)

Community	Local Trips	Feeder Trips	Total Trips
Near Term:			
Pomona	1,678		
Canoga Park	3,949		
Norwalk	2,846		
Exposition Park	2,073		
Hollywood	2,231		
Westwood	1,725		
Long Range:			
Pomona	2,300		
Canoga Park	5,130		
Norwalk	3,040		
Exposition Park	2,135		
Hollywood	3,720		
Westwood	2,780		

TABLE B-8

PATRONAGE ESTIMATES — PRT
(Daily Trips)

Community	Local Trips	Feeder Trips	Total Trips
Near Term:			
Pomona	45,420		
Canoga Park	78,240		
Norwalk	42,760		
Exposition Park	30,670		
Hollywood	24,070		
Westwood	10,470		
Long Range:			
Pomona	62,220	2,972	65,192
Canoga Park	101,710	1,604	103,314
Norwalk	45,750	1,267	47,017
Exposition Park	31,590	8,748	40,338
Hollywood	40,190	23,589	63,779
Westwood	16,850	11,534	28,384

APPENDIX C

TESTS OF REASONABLENESS

As a check on the reasonableness of the various system statistics calculated via the procedures detailed in this study, a number of statistics can be calculated with the data developed to this point. Factors such as vehicle-hours per vehicle or others will be useful if a comparison with actual experience can be made. Two factors that have been calculated in this study are the daily passenger per vehicle-mile ratio, and the estimated peak-hour vehicle loading.

Determining passengers per vehicle-mile is a straightforward procedure. For Canoga Park, the calculation for the near-term situation is

$$\frac{15,407 \text{ passengers}}{6,336 \text{ vehicle-miles}} = 2.4$$

For comparison, some values found today in the RTD operation are:

Hollywood	5.2
CBD Minibus	4.1
Pasadena	3.3
San Pedro	1.8
Pomona	1.0

Generally, the process should give conservative results in the near term, although the analyst may wish to modify patronage estimates to obtain a different result. In the long term, the addition of the feeder trips increases the ratio.

Another factor that gives a test of realism is peak-hour vehicle loading. The daily average of persons per vehicle can be calculated:

$$\frac{\text{Passenger-miles}}{\text{Vehicle-miles}}$$

Passenger-miles is developed by assuming an average trip length (such as 2.5 miles in Canoga Park). To convert daily average to peak, multiply by 2.0 for buses and 2.5 for other modes. The result for bus in Canoga Park is:

$$\frac{(15,407)(2.5)(2.0)}{6,336} = 12.2$$

This means that the average loading during the peak hour throughout the community is 12 to 13 persons. At the peak-load point during the peak hour, the occupancy may be twice this amount (24 to 25 persons).

If the peak-load point occupancy exceeds seating capacity, the fleet size is probably inadequate and must be increased. This does not imply that there will be no standees. Rather, seating capacity is used as a benchmark for the average peak-load point so that individual buses in heavy corridors will not be excessively loaded.

If it is necessary to increase fleet size, vehicle-miles and vehicle-hours are increased in proportion. Patronage is probably not affected for guideway modes where headways are already assumed to be short and additional vehicles add capacity through "training." For conventional buses, however, patronage may increase. If fleet-size increase shortens headways, the patronage estimate probably should be recycled. If, on the other hand, buses are doubled-up on the same headway (perhaps during the peak only, to meet feeder loads), no change in patronage is indicated.

Table C-1 shows results of the reasonableness checks. For illustrative purposes, the values shown are before final adjustments.

TABLE C-1

PATRONAGE CHECKS

Type System	Community	Near Term: Local Only — Daily Passengers per Vehicle-Miles	Near Term: Local Only — Peak Passengers per Vehicle	Long Range: Local Plus Feeder — Daily Passengers per Vehicle-Miles	Long Range: Local Plus Feeder — Peak Passengers per Vehicle
Bus	Pomona	2.4	12.2	3.7	18.4
	Canoga Park	2.4	12.2	3.4	16.8
	Norwalk	2.4	10.0	2.7	11.4
	Exposition Park	2.2	10.2	4.2	18.4
	Hollywood	2.2	9.4	8.4	35.2
	Westwood	2.5	7.6	7.6	22.8
Dial-a-Bus	Pomona	0.7	3.6		
	Canoga Park	0.8	4.0		
	Norwalk	0.8	4.0		
	Exposition Park	1.1	5.0		
	Hollywood	1.2	4.2		
	Westwood	0.9	2.8		
People-Mover	Pomona	3.9	24.5	5.7	35.8
	Canoga Park	3.9	24.3	5.3	33.0
	Norwalk	3.9	20.5	4.4	23.0
	Exposition Park	3.8	21.5	5.4	31.0
	Hollywood	3.7	19.3	11.5	60.3
	Westwood	4.3	18.3	12.4	46.5
PRT	Pomona	0.7	4.0	0.9	6.0
	Canoga Park	1.0	6.5	1.4	8.5
	Norwalk	1.2	6.3	1.3	6.8
	Exposition Park	0.7	4.0	0.9	5.3
	Hollywood	0.8	4.3	2.2	11.4
	Westwood	0.6	2.0	1.5	5.8

First, "long-range" conventional bus peak-hour passengers per vehicle in Hollywood is a high 35.2. This is not alarming in relation to a 50-seat capacity. However, the value is an average for all buses during the hour and does not reflect what might happen at — for example — the rapid transit station where feeder volumes have the heaviest impact. If we follow the assumption that the peak-load point is twice this value (and if it should not exceed 50), the fleet must again be increased — this time by 40 percent. Rather than recycle patronage again, it is assumed that fleet augmentation would occur only in the peak and in the form of additional sections to bus routes.

A similar adjustment occurred for people-mover in the long range and for PRT in both long range and near term. People-mover fleets were increased to reduce average peak occupancy to 26, and PRT's were adjusted to a 4.0 occupancy. Patronage was not modified (although costs increased).

Even at 4.0 average occupancy, the PRT might not meet peak load requirements at a single feeder station. Each car should be full in order to serve a large station adequately.

The near-term passengers per vehicle-mile look reasonable at between 2.0 and 3.0. However, present RTD service in Pomona (for example) is at a rate of 1.0 passengers per vehicle-mile. This may represent a practical maximum in such an area.

It is interesting to note that a ratio of 1.0 is near dial-a-bus rates. If community-wide conventional service does not perform up to estimates, a shift to demand-response operation may be desirable. Although costs might increase, service would be improved.

APPENDIX D

EXAMPLE CALCULATION OF ANNUAL OPERATING COSTS:

HOLLYWOOD
WESTWOOD
EXPOSITION PARK
POMONA
NORWALK

TABLE D-1

ANNUAL OPERATING COSTS
HOLLYWOOD
NEAR TERM

	Cost per Year
Conventional Bus	
762,300 miles/yr x $1.75/mile	$1,334,000
Dial-a-Bus	
1,014,300 miles/yr x $2.20/mile	$2,231,500
People-Mover	
Maintenance of Way & Structures: $15,840/mile x 12.4 miles	$ 196,400
Maintenance of Equipment: $0.06/mile x 945,000 miles	56,700
Power: $0.0642/mile x 945,000 miles	60,700
Provision of Services: 38,100 x 25 stations + 9.09 x 37,800 hrs + 0.073 x 945,000 miles + 9,312 x 12.4 track miles	1,480,600
Injuries and Damages: $50,000 + $0.0025/passenger x 3,475,400 passengers	58,700
Administrative and General: $0.02/passenger x 3,745,500 passengers	69,500
Supplemental Bus @ $1.75/mile x 360,360 miles	630,600
Total People-Mover	$2,553,200
PRT	
Maintenance of Way & Structures: $10,560/mile x 24.0 miles	$ 253,400
Maintenance of Equipment: $0.08/mile x 9,765,000 miles	781,200
Power: $0.0247/mile x 9,765,000 miles	241,200
Provision of Services: 9,500 x 72 stations + 2.25 x 390,600 hrs + 0.018 x 9,765,000 miles + 2,328 x 24.0 track miles	1,794,500
Injuries and Damages: $50,000 + $0.0025/passenger x 7,582,050 passengers	69,000
Administrative and General: $0.01/passenger x 7,582,050 passengers	75,800
Total PRT	$3,215,100

TABLE D-2

ANNUAL OPERATING COSTS
HOLLYWOOD
LONG RANGE

	Cost per Year
Conventional Bus	
1,524,600 miles/yr x $1.75/mile	$ 2,668,000
Dial-a-Bus	
4,797,135 miles/yr x $2.20/mile	$10,553,700
People-Mover	
Maintenance of Way & Structures: $15,840/mile x 12.4 miles	$ 196,400
Maintenance of Equipment: $0.06/mile x 2,182,950 miles	131,000
Power: $0.0642/mile x 2,182,950 miles	140,100
Provision of Services: 38,100 x 25 stations + 9.09 x 87,255 hrs + 0.073 x 2,182,950 miles + 9,312 x 12.4 track miles	2,020,500
Injuries and Damages: $50,000 + $0.0025/passenger x 10,850,490 passengers	77,100
Administrative and General: $0.02/passenger x 10,850,490 passengers	217,000
Supplemental Bus @ $1.75/mile x 360,360 miles	630,600
Total People-Mover	$ 3,412,700
PRT	
Maintenance of Way & Structures: $10,560/mile x 24.0 miles	$ 253,400
Maintenance of Equipment: $0.08/mile x 26,208,000 miles	2,096,600
Power: $0.0247/mile x 26,208,000 miles	647,300
Provision of Services: 9,500 x 72 stations + 2.25 x 1,048,635 hrs + 0.018 x 26,208,000 miles + 2,328 x 24.0 track miles	3,571,000
Injuries and Damages: $50,000 + $0.0025/passenger x 20,090,385 passengers	100,200
Administrative and General: $0.01/passenger x 20,090,385 passengers	200,900
Total PRT	$ 6,869,400

TABLE D-3

ANNUAL OPERATING COSTS
WESTWOOD
NEAR TERM

	Cost per Year
Conventional Bus	
845,460 miles/yr x $1.75/mile	$1,479,600
Dial-a-Bus	
428,400 miles/yr x $2.20/mile	$ 942,500
People-Mover	
Maintenance of Way & Structures: $15,840/mile x 4.4 miles	$ 69,700
Maintenance of Equipment: $0.06/mile x 472,500 miles	28,400
Power: $0.0642/mile x 472,500 miles	30,300
Provision of Services: 38,100 x 9 stations + 9.09 x 18,900 hrs + 0.073 x 472,500 miles + 9,312 x 4.4 track miles	590,200
Injuries and Damages: $50,000 + $0.0025/passenger x 2,034,270 passengers	55,100
Administrative and General: $0.02/passenger x 2,034,270 passengers	40,700
Supplemental Bus @ $1.75/mile x 249,480 miles	436,600
Total People-Mover	$1,251,000
PRT	
Maintenance of Way & Structures: $10,560/mile x 15.1 miles	$ 159,500
Maintenance of Equipment: $0.08/mile x 5,827,500 miles	466,200
Power: $0.0247/mile x 5,827,500 miles	143,900
Provision of Services: 9,500 x 45 stations + 2.25 x 233,100 hrs + 0.018 x 5,827,500 miles + 2,328 x 15.1 track miles	1,092,000
Injuries and Damages: $50,000 + $0.0025/passenger x 3,298,050 passengers	58,200
Administrative and General: $0.01/passenger x 3,298,050 passengers	33,000
Total PRT	$1,952,800

TABLE D-4

ANNUAL OPERATING COSTS
WESTWOOD
LONG RANGE

	Cost per Year
Conventional Bus	
845,460 miles/yr x $1.75/mile	$1,479,600
Dial-a-Bus	
2,142,000 miles/yr x $2.20/mile	$4,712,400
People-Mover	
Maintenance of Way & Structures: $15,840/mile x 4.4 miles	$ 69,700
Maintenance of Equipment: $0.06/mile x 841,050 miles	50,500
Power: $0.0642/mile x 841,050 miles	54,000
Provision of Services: 38,100 x 9 stations + 9.09 x 33,705 hrs + 0.073 x 841,050 miles + 9,312 x 4.4 track miles	751,600
Injuries and Damages: $50,000 + $0.0025/passenger x 5,852,070 passengers	64,600
Administrative and General: $0.02/passenger x 5,852,070 passengers	117,000
Supplemental Bus @ $1.75/mile x 249,480 miles	436,600
Total People-Mover	$1,544,000
PRT	
Maintenance of Way & Structures: $10,560/mile x 15.1 miles	$ 159,500
Maintenance of Equipment: $0.08/mile x 8,442,000 miles	675,400
Power: $0.0247/mile x 8,442,000 miles	208,500
Provision of Services: 9,500 x 45 stations + 2.25 x 337,995 hrs + 0.018 x 8,442,000 miles + 2,328 x 15.1 track miles	1,375,100
Injuries and Damages: $50,000 + $0.0025/passenger x 8,940,960 passengers	22,400
Administrative and General: $0.01/passenger x 8,940,960 passengers	89,400
Total PRT	$2,530,300

TABLE D-5

ANNUAL OPERATING COSTS
EXPOSITION PARK
NEAR TERM

	Cost per Year
Conventional Bus	
1,247,400 miles/yr x $1.50/mile	$1,871,100
Dial-a-Bus	
1,652,805 miles/yr x $1.90/mile	$3,140,300
People-Mover	
Maintenance of Way & Structures: $15,840/mile x 20.3 miles	$ 321,600
Maintenance of Equipment: $0.06/mile x 1,575,000 miles	94,500
Power: $0.0642/mile x 1,575,000 miles	101,100
Provision of Services: 38,100 x 41 stations + 9.09 x 63,000 hrs + 0.073 x 1,575,000 miles + 9,312 x 20.3 track miles	2,438,800
Injuries and Damages: $50,000 + $0.0025/passenger x 5,905,305 passengers	64,800
Administrative and General: $0.02/passenger x 5,905,305 passengers	118,100
Supplemental Bus @ $1.50/mile x 374,220 miles	561,300
Total People-Mover	$3,700,200
PRT	
Maintenance of Way & Structures: $10,560/mile x 36.4 miles	$ 384,400
Maintenance of Equipment: $0.08/mile x 13,860,000 miles	1,108,800
Power: $0.0247/mile x 13,860,000 miles	342,300
Provision of Services: 9,500 x 109 stations + 2.25 x 554,400 hrs + 0.018 x 13,860,000 miles + 2,328 x 36.4 track miles	2,617,100
Injuries and Damages: $50,000 + $0.0025/passenger x 9,661,050 passengers	74,200
Administrative and General: $0.01/passenger x 9,661,050 passengers	96,600
Total PRT	$4,623,400

TABLE D-6

ANNUAL OPERATING COSTS
EXPOSITION PARK
LONG RANGE

	Cost per Year
Conventional Bus	
1,247,400 miles/yr x $1.50/mile	$1,871,100
Dial-a-Bus	
2,505,825 miles/yr x $1.90/mile	$4,761,100
People-Mover	
Maintenance of Way & Structures: $15,840/mile x 20.3 miles	$ 321,600
Maintenance of Equipment: $0.06/mile x 1,874,250 miles	112,500
Power: $0.0642/mile x 1,874,250 miles	120,300
Provision of Services: 38,100 x 41 stations + 9.09 x 74,970 hrs + 0.073 x 1,874,250 miles + 9,312 x 20.3 track miles	2,569,400
Injuries and Damages: $50,000 + $0.0025/passenger x 8,489,880 passengers	71,200
Administrative and General: $0.02/passenger x 8,489,880 passengers	169,800
Supplemental Bus @ $1.50/mile x 374,220 miles	561,300
Total People-Mover	$3,926,100
PRT	
Maintenance of Way & Structures: $10,560/mile x 36.4 miles	$ 384,400
Maintenance of Equipment: $0.08/mile x 18,301,500 miles	1,464,100
Power: $0.0247/mile x 18,301,500 miles	452,000
Provision of Services: 9,500 x 109 stations + 2.25 x 731,745 hrs + 0.018 x 18,301,500 miles + 2,328 x 36.4 track miles	3,096,100
Injuries and Damages: $50,000 + $0.0025/passenger x 12,706,470 passengers	81,800
Administrative and General: $0.01/passenger x 12,706,470 passengers	127,100
Total PRT	$5,605,500

TABLE D-7

ANNUAL OPERATING COSTS
POMONA
NEAR TERM

	Cost per Year
Conventional Bus	
2,134,440 miles/yr x $1.50/mile	$3,201,660
Dial-a-Bus	
1,438,605 miles/yr x $1.90/mile	$2,733,350
People-Mover	
Maintenance of Way & Structures: $15,840/mile x 23.8 miles	$ 376,990
Maintenance of Equipment: $0.06/mile x 1,890,000 miles	113,400
Power: $0.0642/mile x 1,890,000 miles	121,340
Provision of Services: 38,100 x 48 stations + 9.09 x 75,600 hrs + 0.073 x 1,890,000 miles + 9,312 x 23.8 track miles	2,875,540
Injuries and Damages: $50,000 + $0.0025/passenger x 7,426,125 passengers	68,570
Administrative and General: $0.02/passenger x 7,426,125 passengers	148,520
Supplemental Bus @ $1.50/mile x 235,620 miles	353,430
Total People-Mover	$4,057,790
PRT	
Maintenance of Way & Structures: $10,560/mile x 57.1 miles	$ 602,980
Maintenance of Equipment: $0.08/mile x 21,735,000 miles	1,738,800
Power: $0.0247/mile x 21,735,000 miles	536,850
Provision of Services: 9,500 x 171 stations + 2.25 x 869,400 hrs + 0.018 x 21,735,000 miles + 2,328 x 57.1 track miles	4,104,810
Injuries and Damages: $50,000 + $0.0025/passenger x 14,307,300 passengers	85,770
Administrative and General: $0.01/passenger x 14,307,300 passengers	143,070
Total PRT	$7,212,280

TABLE D-8

ANNUAL OPERATING COSTS
POMONA
LONG RANGE

	Cost per Year
<u>Conventional Bus</u>	
2,135,700 miles/yr x $1.50/mile	$3,203,550
<u>Dial-a-Bus</u>	
2,009,700 miles/yr x $1.90/mile	$3,818,430
<u>People-Mover</u>	
Maintenance of Way & Structures: $15,840/mile x 23.8 miles	$ 376,990
Maintenance of Equipment: $0.06/mile x 2,589,300 miles	155,360
Power: $0.0642/mile x 2,589,300 miles	166,230
Provision of Services: 38,100 x 48 stations + 9.09 x 103,950 hrs + 0.073 x 2,589,300 miles + 9,312 x 23.8 track miles	3,189,360
Injuries and Damages: $50,000 + $0.0025/passenger x 10,785,600 passengers	76,970
Administrative and General: $0.02/passenger x 10,785,600 passengers	215,710
Supplemental Bus @ $1.50/mile x 235,620 miles	353,430
Total People-Mover	$4,534,050
<u>PRT</u>	
Maintenance of Way & Structures: $10,560/mile x 57.1 miles	$ 602,980
Maintenance of Equipment: $0.08/mile x 32,602,500 miles	2,608,200
Power: $0.0247/mile x 32,602,500 miles	805,280
Provision of Services: 9,500 x 171 stations + 2.25 x 869,400 hrs + 0.018 x 32,602,500 miles + 2,328 x 57.1 track miles	4,300,430
Injuries and Damages: $50,000 + $0.0025/passenger x 20,534,850 passengers	101,340
Administrative and General: $0.01/passenger x 20,534,850 passengers	205,350
Total PRT	$8,623,580

TABLE D-9

ANNUAL OPERATING COSTS
NORWALK
NEAR TERM

	Cost per Year
Conventional Bus	
1,496,880 miles/yr x $1.50/mile	$2,245,320
Dial-a-Bus	
1,495,305 miles/yr x $1.90/mile	$2,841,080
People-Mover	
Maintenance of Way & Structures: $15,840/mile x 16.0 miles	$ 253,440
Maintenance of Equipment: $0.06/mile x 1,260,000 miles	75,600
Power: $0.0642/mile x 1,260,000 miles	80,890
Provision of Services: 38,100 x 32 stations + 9.09 x 50,400 hrs + 0.073 x 1,260,000 miles + 9,312 x 16.0 track miles	1,918,310
Injuries and Damages: $50,000 + $0.0025/passenger x 4,925,025 passengers	62,310
Administrative and General: $0.02/passenger x 4,925,025 passengers	98,500
Supplemental Bus @ $1.50/mile x 471,240 miles	706,860
Total People-Mover	$3,195,910
PRT	
Maintenance of Way & Structures: $10,560/mile x 30.2 miles	$ 318,910
Maintenance of Equipment: $0.08/mile x 18,049,500 miles	1,443,960
Power: $0.0247/mile x 18,049,500 miles	445,820
Provision of Services: 9,500 x 91 stations + 2.25 x 724,500 hrs + 0.018 x 18,049,500 miles + 2,328 x 30.2 track miles	2,889,830
Injuries and Damages: $50,000 + $0.0025/passenger x 13,469,400 passengers	83,680
Administrative and General: $0.01/passenger x 13,469,400 passengers	134,690
Total PRT	$5,316,890

TABLE D-10

ANNUAL OPERATING COSTS
NORWALK
LONG RANGE

	Cost per Year
Conventional Bus	
1,496,880 miles/yr x $1.50/mile	$2,245,320
Dial-a-Bus	
1,430,730 miles/yr x $1.90/mile	$2,841,080
People-Mover	
Maintenance of Way & Structures: $15,840/mile x 16.0 miles	$ 253,440
Maintenance of Equipment: $0.06/mile x 1,260,000 miles	75,600
Power: $0.0642/mile x 1,260.000 miles	80,890
Provision of Services: 38,100 x 32 stations + 9.09 x 50,400 hrs + 0.073 x 1,260,000 miles + 9,312 x 16.0 track miles	1,918,310
Injuries and Damages: $50,000 + $0.0025/passenger x 5,486,985 passengers	63,720
Administrative and General: $0.02/passenger x 5,486,985 passengers	109,740
Supplemental Bus @ $1.50/mile x 471,240 miles	706,860
Total People-Mover	$3,208,560
PRT	
Maintenance of Way & Structures: $10,560/mile x 30.2 miles	$ 318,910
Maintenance of Equipment: $0.08/mile x 19,561,500 miles	1,564,920
Power: $0.0247/mile x 19,561,500 miles	483,170
Provision of Services: 9,500 x 91 stations + 2.25 x 781,200 hrs + 0.018 x 19,561,500 miles + 2,328 x 30.2 track miles	3,044,620
Injuries and Damages: $50,000 + $0.0025/passenger x 14,810,355 passengers	87,030
Administrative and General: $0.01/passenger x 14,810,355 passengers	148,100
Total PRT	$5,646,750

APPENDIX E

COST SUMMARIES FOR PROTOTYPICAL COMMUNITIES

TABLE E-1

TOTAL CAPITAL COST COMPARISONS BY COMMUNITY
NEAR TERM
($000)

Prototypical Community	Conventional Bus		Dial-a-Bus		People-Mover*		PRT	
	Total Costs	Annualized Costs	Total Costs	Annualized Costs	Total Costs	Annualized Costs	Total Costs	Annualized Costs
Hollywood	855	88.1	475	48.9	82,800	5,276.3	116,750	7,430.1
Westwood	855	88.1	200	20.6	29,610	1,893.6	73,405	4,670.8
Exposition Park	1,350	139.1	775	79.8	135,385	8,620.2	176,920	11,257.1
Canoga Park	2,160	222.5	825	85.0	100,430	6,412.5	306,075	19,508.5
Pomona	2,340	241.0	675	69.5	158,505	10,082.9	277,530	17,658.7
Norwalk	1,620	166.9	675	69.5	106,850	6,809.0	147,835	9,421.8

*Includes supplemental buses.

TABLE E-2

TOTAL CAPITAL COST COMPARISONS BY COMMUNITY
LONG RANGE
($000)

Prototypical Community	Conventional Bus Total Costs	Conventional Bus Annualized Costs	Dial-a-Bus Total Costs	Dial-a-Bus Annualized Costs	People-Mover Total Costs	People-Mover Annualized Costs	PRT Total Costs	PRT Annualized Costs
Hollywood	1,710	176.1	2,250	231.8	83,600	5,338.9	119,375	7,635.4
Westwood	855	88.1	1,025	105.6	29,810	1,917.1	73,830	4,704.0
Exposition Park	1,350	139.1	1,175	121.0	135,585	8,635.9	177,645	11,313.8
Canoga Park	2,160	222.5	1,100	113.3	100,630	6,424.1	307,950	19,655.2
Pomona	2,340	241.0	950	97.9	159,005	10,122.0	279,255	17,793.6
Norwalk	1,620	166.9	675	69.5	106,850	6,809.0	148,060	9,439.4

*Includes supplemental buses.

TABLE E-3

ANNUAL OPERATING COST SUMMARIES
NEAR TERM
($000)

Prototypical Community	Conventional Bus	Dial-a-Bus	People-Mover	PRT
Hollywood	1,334.0	2,231.5	2,553.2	3,215.1
Westwood	1,479.6	942.5	1,251.0	1,952.8
Exposition Park	1,871.1	3,140.3	3,700.2	4,623.4
Canagoa Park	2,993.8	3,348.0	3,302.1	11,090.1
Pomona	3,201.7	2,773.4	4,057.8	7,212.3
Norwalk	2,245.3	2,841.1	3,195.9	5,316.9

TABLE E-4

ANNUAL OPERATING COST SUMMARIES
LONG RANGE
($000)

Prototypical Community	Conventional Bus	Dial-a-Bus	People-Mover	PRT
Hollywood	2,668.0	10,553.7	3,412.7	6,869.4
Westwood	1,479.6	4,712.4	1,544.0	2,530.3
Exposition Park	1,871.1	4,761.1	3,926.1	3,605.5
Canoga Park	2,993.8	4,400.2	3,459.9	13,701.4
Pomona	8,203.6	3,818.4	4,534.0	8,623.6
Norwalk	2,245.3	2,841.1	3,208.6	5,646.8

TABLE E-5

EQUIVALENT ANNUAL CAPITAL AND OPERATING COSTS
NEAR TERM
($000)

Prototypical Community	Conventional Bus	Dial-a-Bus	People-Mover	PRT
Hollywood	1,422.1	2,280.4	7,829.5	10,645.2
Westwood	1,567.7	963.1	3,144.6	6,623.6
Exposition Park	2,010.2	3,220.1	12,320.4	15,880.5
Canoga Park	3,216.3	3,433.0	9,714.6	30,598.6
Pomona	3,442.7	2,842.9	14,140.7	24,871.0
Norwalk	2,412.2	2,910.6	10,004.9	14,738.7

TABLE E-6

EQUIVALENT ANNUAL CAPITAL AND OPERATING COSTS
LONG RANGE
($000)

Prototypical Community	Conventional Bus	Dial-a-Bus	People-Mover	PRT
Hollywood	2,844.1	10,785.5	8,751.6	14,504.8
Westwood	1,567.7	4,818.0	3,461.1	7,234.3
Exposition Park	2,010.2	4,882.1	12,562.0	16,919.3
Canoga Park	3,216.3	4,513.5	9,884.0	33,356.6
Pomona	3,444.6	3,916.3	14,656.0	26,417.2
Norwalk	2,412.2	2,910.6	10,017.6	15,086.2

TABLE E-7

COST PER PASSENGER TRIP COMPARISONS
NEAR TERM

Prototypical Community	Conventional Bus	Dial-a-Bus	People-Mover	PRT
Hollywood	0.83	1.80	1.87	1.40
Westwood	0.74	2.40	1.22	2.01
Exposition Park	0.73	1.79	1.88	1.64
Canoga Park	0.66	2.50	1.58	1.24
Pomona	0.66	2.82	1.78	1.74
Norwalk	0.68	2.08	1.72	1.09

TABLE E-8

COST PER PASSENGER TRIP COMPARISONS
LONG RANGE

Prototypical Community	Conventional Bus	Dial-a-Bus	People-Mover	PRT
Hollywood	0.22	1.31	0.73	0.72
Westwood	0.24	1.31	0.51	0.81
Exposition Park	0.38	1.14	1.37	1.33
Canoga Park	0.48	2.09	1.19	1.02
Pomona	0.44	1.92	1.27	1.29
Norwalk	0.59	1.63	1.55	1.02

APPENDIX F

AREAWIDE EXTRAPOLATION

There is no question that the best method for extrapolating prototypical community study results throughout the region is to follow the procedures developed in this "handbook." When alternative transit vehicle systems were laid out for the prototypical communities, it was found that the systems were easily expanded or contracted to fit whatever community definition was desirable. There is considerable flexibility in this process, and therefore a rigid definition of community boundaries becomes important only in terms of system implementation. The most reasonable approach to determining areawide community transit needs would be to lay out appropriate systems within each community and then, for the total area, summarize characteristics such as cost and patronage.

On the other hand, it might be useful to have a method to directly extrapolate prototypical community data. There are several ways to expand the results of studies of the six prototypical communities throughout the RTD service area. One method would be to continue the processes followed in selecting the six prototypical communities, to complete the identification and classification of communities throughout the study area. Figure F-1 shows results of such a process, where the general configuration of 68 communities (plus the central business district) is illustrated. Table F-1 is an expansion of Table I-1 to show the addition of other communities; Table F-1 includes 49 communities. There are 19 others that are not listed but which fall into the lowest-density category (see Technical Memorandum "c").

Another approach could be to use the relationship between community population and employment and areawide data to expand community transit system statistics in a gross manner. Table F-2 shows statistics for the

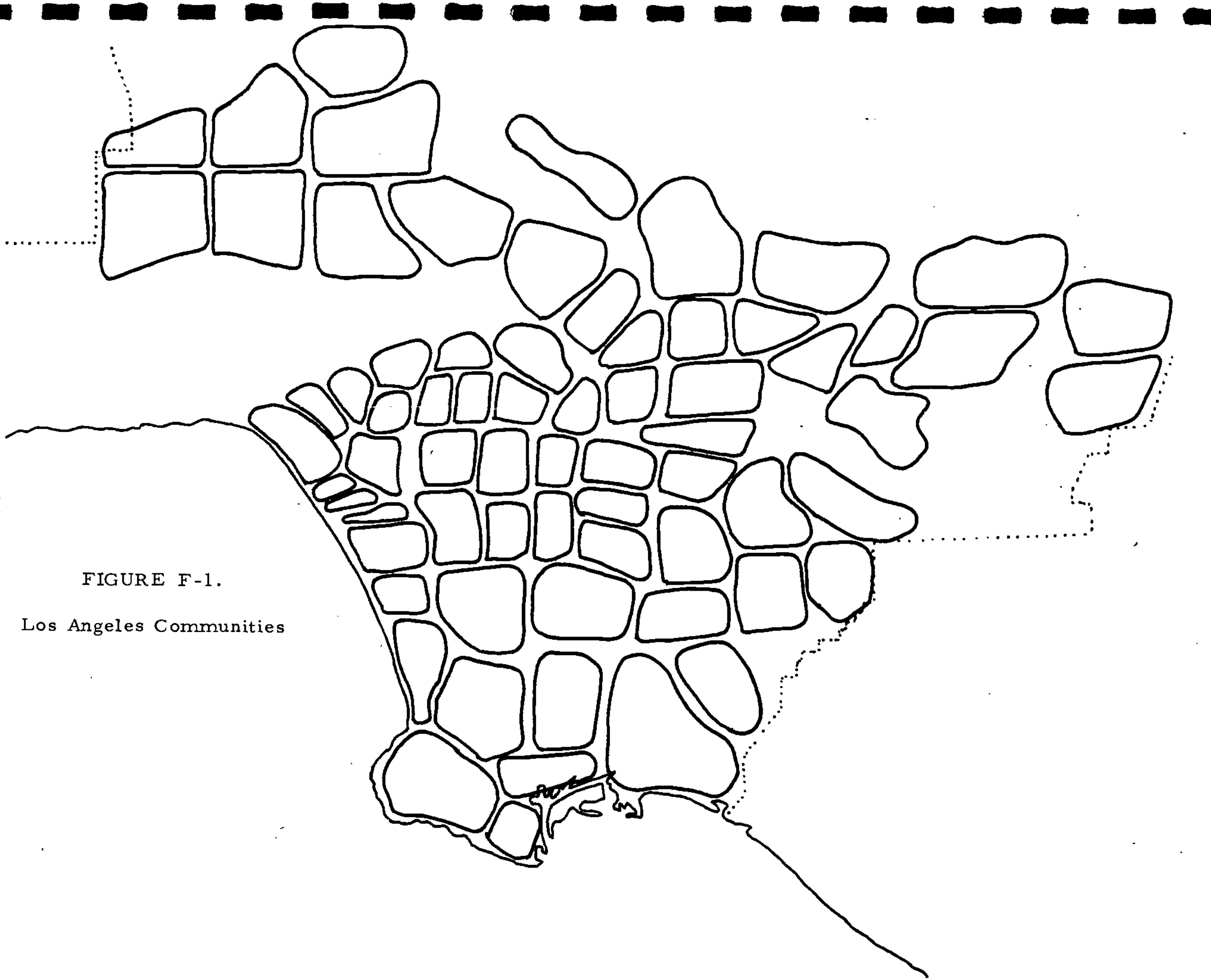

FIGURE F-1.

Los Angeles Communities

TABLE F-1

COMMUNITIES IDENTIFIED IN LOS ANGELES COUNTY*

Community	Population Density** Over 19,000		Population Density 13,000-19,000		Population Density Under 13,000	
	High Transit Dependency***	Low Transit Dependency	High Transit Dependency	Low Transit Dependency	High Transit Dependency	Low Transit Dependency
Primary Centers	West CBD Hollywood Long Beach			Beverly Hills East Wilshire Mid Wilshire Santa Monica Westwood	Pasadena Pomona	Van Nuys Century City
Secondary Centers			Exposition Park Central	Inglewood Glendale	Watts	LAX Downey Canoga Park Torrance Lakewood San Pedro Crenshaw Covina Whittier
Others		Silver Lake	Venice Manchester East Los Angeles	Huntington Park West Los Angeles Culver City Beaches Montebello South Gate	Compton	Vernon Commerce San Fernando Alhambra El Monte Burbank Reseda Northridge Chatsworth Norwalk Carson Hawthorne and 19 others

*See also, Technical Memorandum "c" of this report.

**Persons per square mile

***High percentage of old and young, low auto ownership, low income, unemployed.

TABLE F-2

PROTOTYPICAL COMMUNITIES CHARACTERISTICS

Community	Area (acres)	Population		Population Density		1990 Employment
		1970	1990	Per Sq Mi	Per Acre	
Canoga Park	14,447	108,538	141,283	6,260	9.8	66,381
Pomona	14,400	87,384	120,053	6,195	9.7	84,531
Norwalk	6,397	91,827	97,888	9,789	15.3	27,543
Exposition Park	4,308	102,226	105,590	15,684	24.5	26,880
Hollywood	2,460	60,349	100,680	21,745	34.0	89,719
Westwood	2,722	24,936	40,060	9,426	14.7	41,712

prototypical communities, and Table F-3 shows similar data for the entire RTD service area. Figure F-2 shows how the prototypical communities fit into the population density distribution for the region.

Trial extrapolations are illustrated in Table F-4, where various expansion factors are listed. If the simple number of communities in each class of Table F-1 is used, the expansion factors are as listed in the first row of Table F-4.

More elaborate procedures are shown in rows 2 and 4, where ratios of population by density category and population plus employment by density category are listed. Rows 3 and 5 show expansion factors by land gross area (and also by density category).

Overall, the factors are not dissimilar. In expanding the number of conventional transit system buses to a region-wide estimate, the various approaches give these results:

1. Factor = number of communities by class: 2,313 buses
2. Factor = ratio of population by density class: 2,938 buses
3. Factor = ratio of area by density class: 3,086 buses
4. Factor = ratio of population plus employment: 2,814 buses
5. Factor = ratio of area by density class: 2,954 buses

The results are similar except the first. The basic question is, of course, is the process valid at all? For the number of buses, the need for short headways (and more buses) on lines converging on downtown would seem to indicate that simple expansion is too low as an estimator of regional needs.

FIGURE F-2. DISTRIBUTION OF POPULATION DENSITY

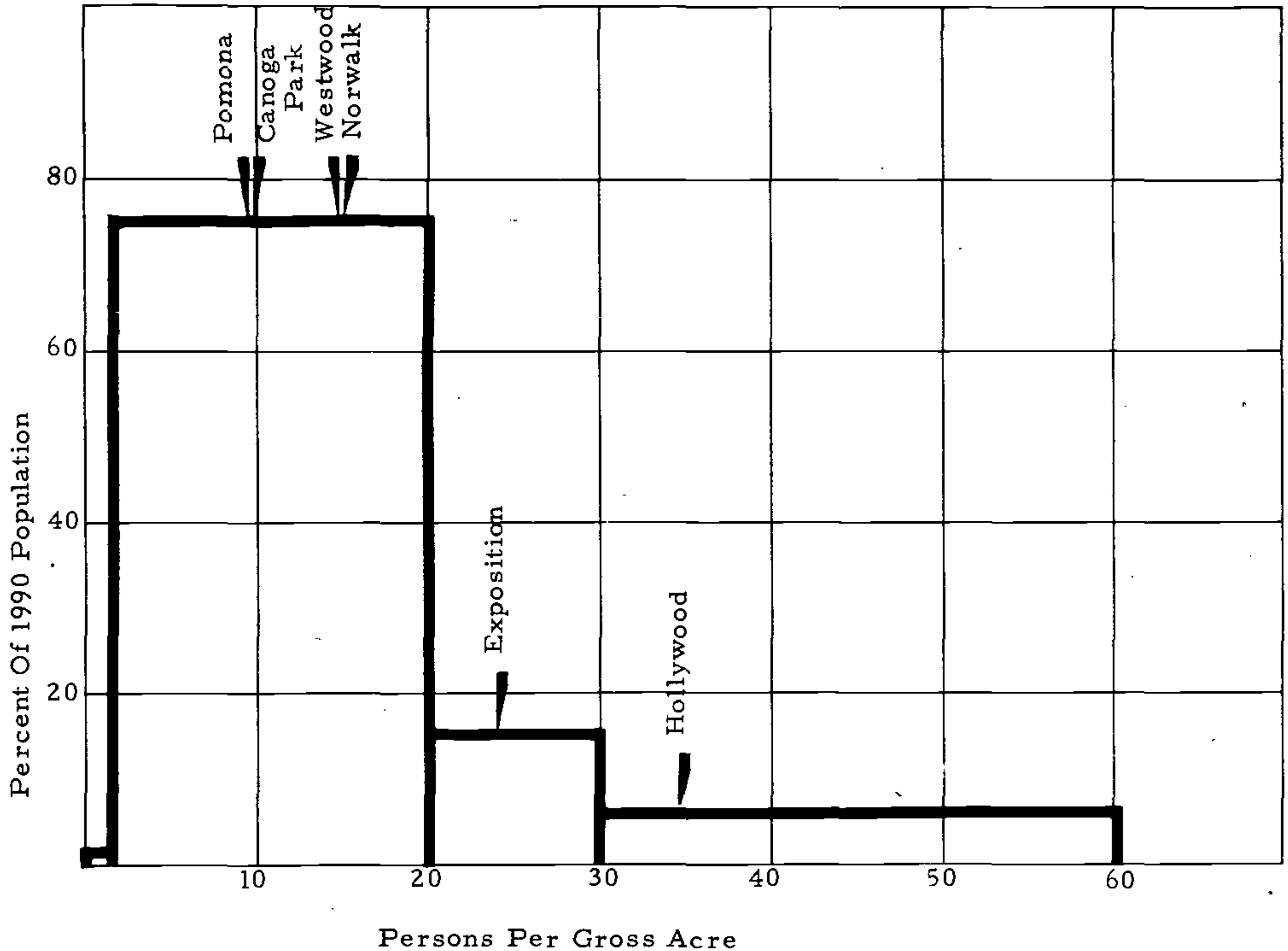

TABLE F-3 STUDY AREA CHARACTERISTICS				
Area	Population	Population Density Range (persons/acre)	1990 Employment	Number of Zones
57,690 acs	46,987	0.0-1.5	241,291	19
606,165	6,341,688	1.5-20.0	2,846,125	546
52,183	1,237,602	20.0-30.0	470,817	97
17,332	641,356	Over 30.0	348,707	42

TABLE F-4.

GROSS EXPANSION FACTORS

	Canoga Park	Pomona	Norwalk	Westwood	Exposition	Hollywood
Similar Areas	10	4	32	13	5	4
Population Density			15.9		11.7	6.4
Area by Pop. Density Categories			16.9		12.1	5.9
Population Plus Employment Density		17.1			8.0	5.2
Area by Pop. & Empl. Density		18.2			7.4	5.9