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Small Cars in Neighborhoods

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Preface

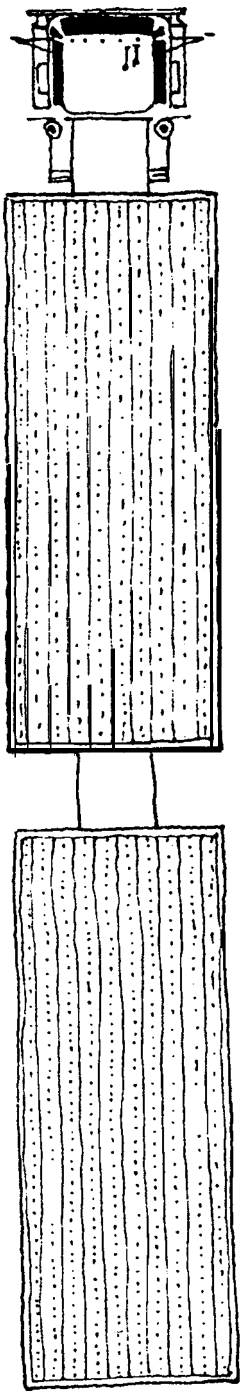
The work reported here began in the Summer of 1991 and it was essentially complete by June 1992. It was part of a several year effort to examine options for innovative, fuel efficient, and environmentally benign highway passenger vehicles. Such vehicles would be small, relatively inexpensive, and specialized to functions. Relatively small, they would have the potential to ease congestion problems. Although the possibility of such vehicles motivated the work, the main issue of concern is adjustments to road infrastructure. Adjustments might be necessary before individuals would purchase and use such vehicles. Alternatively, the purchase and use of small vehicles might mandate adjustments of road infrastructure.

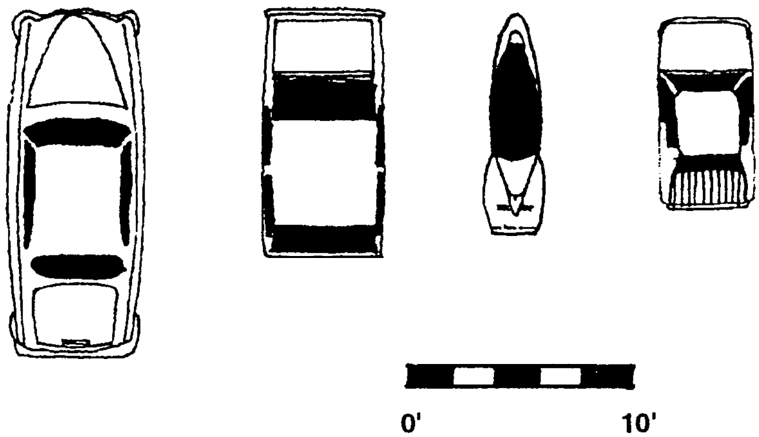
The implications of the adoption and use of a vehicle for neighborhood scale services was the focus of the work. Such a vehicle might improve mobility and also offer opportunities for improvements in neighborhood designs.

In the first sentence of this preface, the work was referred to as complete. That's true of the effort that yielded this report, but the subject is far from exhausted. An effort was made to analyze many of the topics that bear on small vehicle opportunities. Also, an effort was made to begin to characterize the neighborhood design opportunities that such vehicles might create. Those subjects are vast, and this work is a beginning at best.

Although this work was in every way a joint effort and involved a great deal of coordination, in should be noted that Professor Peter Bosselmann structured and created the designs presented in **Part 3** of the **Report,** assisted by Mr. Carl Maxey and Ms. A. Mitra. Ms. Danielle Cullinane prepared the subsection in **Part 2** on neighborhood/community development trends. The remaining parts of the **Report** were prepared by Professor William Garrison, with the section on vehicle curving based on some earlier work with Mr. Mark Pitstick. Mr. Kevin Gilson assisted in the layout design and production of the **Report** for publication.

We found a great deal of interest in our topic and received many useful suggestions which we appreciate, especially suggestions by A. J. Sobey, D. Ashuckim, and C. Price. We owe particular thanks to Mr. William MacAdam of Trans 2 Corporation and Ms. Monica Sutter of Parsons Brinkerhoff Quade & Douglas, Inc. for permission to use figures they prepared.





Vehicles in the size and weight class discussed in this Report are shown on the upper right.

How can the advantages of smaller/lighter vehicles be realized without worsening the conflicts among vehicles of differing sizes and weights? That's one of the questions this Report begins to address.

Small Cars in Neighborhoods

ABSTRACT

Small vehicles might serve commuting and similar trips, neighborhood range trips, and trips to and from transit stations. They might improve transportation services and mobility by specializing vehicles and roads to functions. At the same time, their purchase and use should reduce congestion, pollution, and energy consumption. Focusing on neighborhood travel, this study first reviews the development of vehicles and roads suited to such travel. It then considers community development trends that might encourage or thwart the adoption and use of such vehicles. Demands for vehicles and travel patterns are then treated, followed by discussions of safety and regulation topics.

Turning to impacts on neighborhoods, designs illustrate how a new neighborhood might be created taking advantage of neighborhood car services and how an existing neighborhood might change as vehicle adoption and use increases.

The work reported was overview in character. The final Part of the Report suggests what needs to be do to further clarify the benefits and costs of neighborhood cars.

1. Introduction

Work discussed in this report explores improvements in the design of neighborhoods and improved travel mobility at the neighborhood scale. It is part of a larger continuing effort to examine the opportunities and problems that would accompany the appearance of increased numbers of small passenger vehicles in the vehicle fleet and uses of those vehicles. The topic is vast. It ranges from vehicle and road supply issues through questions about vehicle purchases and use to considerations of environmental enhancement. Institutional and regulatory issues loom large. As a new direction of work in a continuing effort, the work reported has an exploratory character. Coverage and perspective were its objectives. The work sought to stake out the parts of the puzzle and explore how the parts might fit together.

Although neighborhood designs and vehicles will receive much attention, the primary concerns of the work are the road infrastructure changes that might be needed to encourage the increased use of small vehicles and/or in response to increased uses of small vehicles. That's partly because roads have been designed and constructed to accommodate a mix of passenger and truck vehicles, and the appearance of passenger vehicles smaller than conventional ones in traffic streams would create perceived and/or real safety and other problems. Indeed, without changes in road infrastructure, the outlook for individuals' acquisition and use of radically changed vehicles seems small. If there are potential individual and social benefits from the use of such vehicles, they will not be captured.

Before further introducing the work to be reported, the small vehicle notion needs partial description. In mind are vehicles that weigh about 500 pounds (empty), are relatively inexpensive, and accommodate one to four persons. The reasons for our emphasis on small, relatively inexpensive vehicles will be treated in depth later in the discussion, as will safety and other vehicle related topics. One such vehicle would have range and acceleration characteristics suited to commuting and similar travel, a **commuter** vehicle. The vehicle emphasized in the present study is a **neighborhood** vehicle. Golf cart in size and performance, it would serve neighborhood scale travel needs and accommodate up to four persons on short trips. It might be used to access transit stations, bus stops, or park-and-ride lots and thus serve as a **station car.**

Behind the small vehicle notion is the possibility of the specialization of vehicles and roads to functions, in contrast to today's general purpose vehicles on mixed use facilities. Would tailoring vehicles and facilities to functions improve transportation services, ameliorate problems of energy use and environmental degradation, and create new social, economic, and environmental design opportunities? Aspects of those question are explored in this report.

Most of the work accomplished was neighborhood-scale design in character, and the designs to be presented later in the report are the major product of the work. One set of designs illustrates options for new communities, and another uses Emeryville, CA, to illustrate how an existing community might be modified if service by small neighborhood vehicles was adopted.

The designs serve a imagination stretchers, and imagination stretching is at two levels. Identifying the opportunities for changes in neighborhoods involves the arrangement of physical things--residences, roads, recreation spaces, etc.--in new ways, and the designs identify some of the arrangements that might be permitted by new forms of transportation services. But arranging things in new ways leaves many issues untreated, in particular, issues about costs and benefits, the sequencing of changes, and new problems that new arrangements might create. However, the designs provide a point of departure for dealing with such issues. Designs, then, provide images of the physical world and a point of departure for evaluating those images in social and economic terms.

To Set the Stage

To present the broad thinking that motivated and framed the exploratory work to be reported, several topics will now be briefly discussed.

Specializing the Highway System:

By comparing developments in selected non highway modes with the highway mode, the thinking underlying the ways the highway system might be further specialized to functions is partially presented in Figure 1. Production format (or technological changes) since the late 1800s are shown for some of the modes (air and pipelines are not shown). Two broad themes are apparent for the non highway modes: 1. the modes have increasingly specialized services to functions and 2. production formats have emerged that enable specialization and the matching of appropriate production formats to market sizes. For example, the railroads now provide freight services ranging from relatively high speed container or trailer on flat car movements to heavy haul coal trains. The railroads are exploring other options. For example, there is interest in a truck hauling train (the “Iron Highway”) that might offer successful intermodal services in corridors with a relatively small demand for services. Some rail routes are exclusively used for passenger services, and this is especially true in Europe and Japan. There have been, of course, market growth and shifts in market structure over the time period and these have interrelated with changes. Broadly, equipment, track structures, and operations protocols have been tailored to functions. Lesser scale technologies have emerged to support seeking specialization and appropriate scale: the ocean-rail-truck container, specialized cars, centralized traffic control, and electronic data interchange.

Inter-modal developments are not shown in Figure 1.1: passenger transfers to the walking or automobile modes at transit stations or stops on surface streets; rail, truck, and ship container interchanges; etc. More efficient and precisely controlled inter-modal relations are another trend.

The many purposes served by transportation and the difficulty of tailoring equipment, operations, and, especially, fixed facilities to functions make specialization difficult. Of the modes shown in Figure 1.1, perhaps the maritime services are already the most specialized, and rail services are specializing most rapidly at this time as rail right of way is selectively abandoned or improved to serve train movements of different types.

Although there are many types of vehicles, classes of roads, and uses, the automobile-highway system has not specialized to functions in the ways that other modes have specialized. It emerged from the precursor macadam or dirt road, horse drawn vehicle system during the first three decades of this Century. The general purpose passenger vehicle in almost its modem form was available in the 1930s, and by that time

Late 1800s	1950s	1980s	Future
Dirt Roads and Horse Drawn Wagons and Passenger Vehicles	Paved Roads, Autos Trucks and Busses	Increased Variety of Vehicles	Increased Specialization: Truck Facilities,. Commuter Facilities, Neighborhood Facilities. High Speed Intercity Routes
Rail Passenger and	Rail and Bus Transit		Specialized Transit Services, High Density Corridors, Low Density Services High Speed Intercity Passenger
Freight	Heavy Haul Freight Railways	Containers and Trailers on Freight Cars	Specialized Equipment and Services
Canal, River, and Coastal and Maritime	Large River and Coastal Tows Bulk and Neobulk Ports and Ships	Containerships and Ports	

Figure 1.1: Partial Sketch of the Evolution of Transportation Technologies and Services

the several varieties of trucks were available. The development of roads was also well under way by that time, including planning for a limited access interregional highway system. Especially because of federal interest in the interstate primary system and concentrating road building resources, the road system was divided into a hierarchy of primary, collector, and local roads by the 1930s. Additions of road types, such as the modern interstate, and urban and rural subdivisions have subsequently complicated the hierarchy.

In considering how the auto-highway system might be increasingly specialized to functions and match the scale of production formats to functions, the ways road functions have been thought about in the past becomes an issue. As a general rule, the high in the hierarchy roads serve more traffic than low in the hierarchy roads: about 20 percent of the road mileage accommodates about 80 percent of the traffic. Also, the high in the hierarchy roads serve interstate and major intercity or intracity travel. Low in the hierarchy routes serve local purposes. The functions have a volume-of-traffic and geographic-area-served functional orientation rather than a functional orientation that emphasizes the purposes of facility use: going to work or to shop, hauling containers to ports, etc.

Road classification schemes oriented to passenger or freight movement purposes might assist in matching roads and vehicles to services. Vehicles might be matched to purposes. Most commuting is done in single passenger vehicles, so a small vehicle would serve; social and recreational trips are usually made with several passengers in the vehicle, a large car is needed; and, also considering trucks, many ways can be thought of to match vehicle size and other attributes to functions that recognize passenger or freight movement purposes. Ways can also be imagined to match road facilities to vehicles and the functions they serve. "The Future" suggestions for the auto-highway road system shown in Figure 1.1 have functional specialization in mind. The list of functions is endless, of course. The conjecture or hypothesis is that the neighborhood car-road system matches a number of functions, as would commuter cars and appropriate road facilities.

Two Tensions:

Today's roads are general purpose roads, most any vehicle and driver can go anywhere for any purpose. That accessible-to-all property of the road system is one of its fundamental strengths. Yet obtaining the advantages of specialization requires that roads be tailored to vehicle equipment and purposes, and this violates the advantages of the general purpose system. The issue is that achieving the advantages of specialization may erode accessible-to-all-everywhere attribute of the present system.

But specialization contains the solution to this issue, problem, conflict, or tension. Specialization will result in more efficient use of road space and free-up capacity for general purpose uses. Examples may help make this point.

> Suppose a lane is taken from a CBD access freeway for specialized use by commuter vehicles. Commuting is usually a one person per car matter, so small vehicles may be used. So the one lane might be divided into two, and a lane that was previously serving 2,000 vehicles per hour during the rush hours would now serve 4,000 vehicles. The remaining general purpose lanes would be advantaged because they would be serving 2,000 less cars per hour. Choke points where the freeway is accessed, on collector/distributor routes, and in and around parking facilities would also be advantaged.
>
> Suppose lanes are marked along the sides of suburban local streets for neighborhood cars and special access is developed for transit stations. That might eliminate some on-street parking. But there is usually excess capacity on local suburban streets and to avoid elimination of all parking on a single street, one way lanes could be marked on parallel streets. Small neighborhood cars would increase the capacity of transit parking lots, reduce parking requirements on suburban streets, and free up capacity for conventional cars in other ways. In addition, small neighborhood cars would enable revising street and parking arrangements and improving neighborhood quality.

The examples above are overly simplistic. Surely there would be situations where specialized and general purpose uses compete for road space, perhaps, especially when specialized facilities are new and vehicles have yet to make efficient use of them.

A second potential tension or conflict is organizational-financial in content. The historicquantity-of-traffic/geographic functional classifications have aided the establishment and smooth operation of design, government responsibility, and financing protocols. As the system is changed to respond to functions considered in a different fashion, these desirable features of historic functional classification may need to be altered. Again, the efficiency gains through specialization should aid in mitigating potential conflicts. More efficient use of facilities should ease facility requirements and funding problems.

Timely:

The mileage and capacity of highways is pretty much in place, and the market for vehicles and their use is saturated. In California there are more automobiles then there are drivers licenses; the average U.S. passenger vehicle is driven about 10,000 miles per year, and this has been true since the

1930s. Total vehicle miles of travel and the automobile population are increasing, of course, because of population increases. The resulting increasing congestion is not news to drivers in urban areas, and is well documented. (1) Redesigns to achieve specialization could provide one way to counter the stagnation of service improvements. They could be cost effective and could be made without increasing the land used for roads. Improved services and productivity enhancements could result from such specialization.

In addition, ecological and energy concerns press for changes in the highway system, and meeting these concerns could be simplified as the highway system is redesigned into more specialized formats. If redesign yields small vehicles and reduced roadway requirements or more efficient truck transport of freight, for example, these would aid in reducing energy use and emissions. Reductions in congestion as some traffic shifted to specialized facilities would also reduce energy use and emissions.

Synchronization:

The paragraphs above treat adjusting the highway system to counter today's problems. The treatment was broad, but not sufficiently broad to reflect the roots of problems and the types of solutions needed. The word synchronization perhaps captures the situation. Roads, similar to other large infrastructure investments, are supplied in light of the needs of the times and projections of needs over a forecasting period. The urban interstate, for example, was to serve travel needs for 20 years and to be supplemented by investment in other facilities. Time has gone by; supplemental investment was skimpy. It is no wonder that congestion is a problem in many places.

Once in place, road infrastructure does not adjust easily to changes in its environments. Changes occur and are reflected in such things as land uses, increased diversity in occupations, demands for living space, population shifts, and life styles. At the same time, perceptions and priorities change. The road infrastructure is out of synchronization with these changes. Opposition to further investment in yesterday's road infrastructure is a result.

In this frame, the problem is that of synchronizing infrastructure improvements with social changes. Infrastructure must play catch-up, and life is played out on an obsolete infrastructure stage, so to speak. The problem is to create road (and other infrastructure) designs so that facilities can better track on social change. It is proposed that the specialization of transportation services provides one way to do that.

Although not stressed in this report, it should be mentioned that new designs would provide new markets for technology. That's timely.

Neighborhood Vehicle:

This report explores the notion that neighborhood cars and associated road facilities and uses would represent a viable market niche as the automobile-highway system is specialized to functions. The objective of the work to be reported is to improve the definition of the market niche and the vehicles and road facilities that might serve the market niche. The work also gave attention to possible barriers to the evolution of services and benefit and cost topics. There are potential mobility benefits (lower cost, increased access to vehicles) and benefits resulting from improvements in neighborhood environments.

To partially flesh out the neighborhood car notion or hypothesis, a simple scenario-like description suggesting how neighborhood vehicles might be introduced and used will now be given. The description will suggest topics to be treated later in the report and it serves to identify the ideas and questions the researchers bring to the work reported.

Suppose a well defined neighborhood, such as a gated retirement community, undertook marking lanes for neighborhood vehicles on existing streets, providing access to the doors of residencies using path like roads, providing fringe parking for larger passenger vehicles, and improving access by small vehicles to adjacent shopping centers, churches, and other trip ends of community residents. A new community might be designed for the start with facilities of this type. This is an easy supposition to make because there are already a number of communities where golf carts or vehicles of similar size and performance characteristics are in use. It is imagined that the purchase and use of small vehicles would increase if roads better accomodated them.

Suppose the mobility advantages of small vehicles and their use continue to drive their purchase and suppose techniques are worked out to provide road facilities to match increased use. Also suppose that as small vehicles are increasingly used, more and more opportunities for improved neighborhood designs are seen and implemented. This might be as simple as reducing road width in front of residencies and using the freed space for gardens or play spaces. Street space could be left to accommodate the occasional passage of larger vehicles or, perhaps, those vehicles could access the back entrances of residencies. As small vehicle use increases, store or shopping center owners might create special access lanes and parking arrangements.

Manufacturers have attempted to produce and market small vehicles in the past and only a few have been successful. But encouraged as the market is energized by road and neighborhood design improvements, those manufacturers and new ones begin to tailor vehicles to neighborhood markets. Many of the vehicles developed might be simple, short range electric vehicles. Developing markets neighborhood by neighborhood, vehicle producers might push for facility improvements. Neighborhood organizations and developers might also serve as change agents. Responding to public policy goals relating to transportation for the disadvantaged, energy use, and air pollution, public agencies would also encourage development.

In some situations corporations might purchase vehicles for use in the vicinity of their facilities. Neighborhood groups might purchase vehicles for shared use and transit agencies might play roles by encouraging vehicle purchases and their use as station cars.

Mostly, however, households will purchase and use vehicles. A small vehicle might replace a retired older car or it might augment households' vehicle holdings. The vehicle would be used for the "too far to walk, to close and too much hassle to drive" (in a large vehicle) trips.

A special attraction would be the availability of the vehicle to persons who ordinarily would not be driving. This might be because of the cost of a large vehicle, but a small simple vehicle might also be use by those without the skills needed to drive conventional vehicles. Vehicles might be used by young people for school, social, and recreational trips or by adults for trips where they would otherwise have to be chauffeured.

The topics suggested above and others will treated as the discussion in the report proceeds.

To Follow

The section of this report immediately following this introduction will position the neighborhood design studies in the context of two trends: the trend toward smaller cars and the increasing interest in less auto dominated neighborhood designs. The latter are achieved through traffic calming: limiting street spaces, arranging land uses and movement paths to encourage walking, and providing easy access to mass transit. The last part of the next section will stress topics that would enter into evaluations of alternative designs and some barriers to introducing changed designs. Topics to be included extend from the nature of travel from the home through safety issues.

The third section of the report will present the designs developed in this study. The text accompanying the designs will comment on the design strategy adopted and on the evaluation of the designs.

The work reported here is exploratory, and the fourth and final section of the report will summarize findings and suggest additional design and other studies.

References:

1. James W. Hanks, Jr., and T. J. Lomax. "Roadway Congestion in Major Urban Areas," **Finance, Planning, Programming, Economic Analysis, and Land Development 1991.** Transportation Research Record, 1305. pp. 177-200.

2. Small Cars and Suitable Roads, Neighborhood Improvements, Constraints

The discussion to follow seeks to flesh out topics mentioned in the previous section and provide a context for the design studies to be presented in the next section of this report. Small passenger vehicles and appropriate road designs will be treated first, followed by a review of emerging ideas and trends bearing on neighborhood designs. The section will close with a discussion of some of the issues or constraints associated with changes in neighborhoods and vehicles, issues such as markets and use potentials, how well neighborhood scale travel will meet travel needs, and safety and regulation. The first parts of the discussion are supply side in content, the last part is market clearing, regulation, and demand oriented.

The authors have discussed the small cars-improved neighborhoods topic with many informants. In crafting the discussion below, we are sensitive to the difficulties of transmitting our line of thinking and the "it can't be done" reaction that we often receive. So the discussion to follow is organized and presented so as to raise and treat the questions that readers may have in mind, assuming that present readers have questions along the lines of those we have heard before.

Some of the questions are "conversation stoppers," they identify barriers: for instance, Will folks purchase and use small, unsafe vehicles, they haven't in the past. As suggested by the example question, absent suitable answers to such questions, a case can not be made for much of a market for small vehicles. Because of the importance of questions of this type, they will be highlighted as the discussion proceeds.

Interpreting the Context:

It was said that the discussion in this section will provide the context for the design based analyses to be presented later. This statement requires interpretation. There are no close precedents for the neighborhood car, the services it would provide, and the facilities it would require. Thus the discussion of context requires considerable extrapolation from today's context and judgements about what is relevant and what is not relevant. A similar statement holds for the applicability of emerging ideas about neighborhood design. Ideas respond in the main to the improved provision of walking, transit, and conventional automobile facilities. Extrapolation and judgement are required to extend those ideas to facilities for neighborhood vehicles.

As also stated, this is report of work in progress. Topics will be explored. Many "loose ends" for further consideration will remain.

Small Vehicles, Appropriate Roads

The discussion now turns to two supply side topics, small vehicles and appropriate road facilities for such vehicles.

Small Vehicles

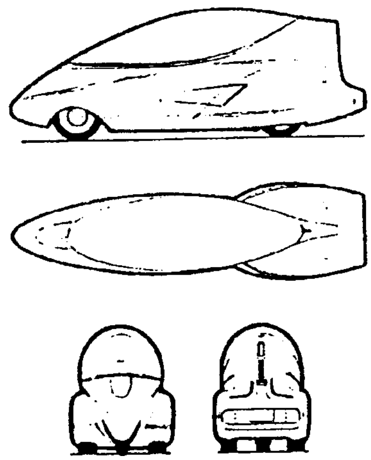
As stated in the **Introduction** to this report, the small car concept used in this study is different from conventional notions of small cars. For one thing, weighing about 500 pounds (empty) the small car we imagine is much lighter than conventional vehicles. As Table 2.1 indicates, weights of conventional vehicles range from about 2,500 to 3,500 pounds. (1) As the Table also indicates, there has been a downward trend in the weights of vehicles, but the vehicles imagined in this study lie well outside of the weights the trend is achieving. (The vehicle classification shown in Figure 2.1 is based on vehicle interior space rather than weight.) There has also been an overall trend toward decreased vehicle interior space. But this is a modest trend. The smaller conventional vehicles have about 80 cubic feet of interior space (passenger and trunk space combined) and larger vehicles about 130 cubic feet. Over the last decade, the interior dimensions of the smaller vehicles have increased modestly and larger vehicles decreased modestly. (1)

Model Year	1976	1990
Minicompact	NA	2,651
Subcompact	2,577	2,368
Compact	3,609	2,637
Midsize	4,046	3,065
Large	4,563	3,594
Two Seater	2,624	2,828

Table 2.1: Sales Weighted Curb Weight in Pounds of Domestic and Import Automobiles: Model Years 1977 and 1990.

According to the reference cited, 212 nameplates were marketed in the U.S. in 1990, and to illustrate the size classes shown in Table 2.1 the names of typical vehicles will be given. The minicompact class includes the Porsche 944 and the Volkswagen Cabriolet; the subcompact class included the Honda Civic, Ford Mustang, and Pontiac Firebird; the compact class includes the Ford Probe and Tempo, Oldsmobile Calais, Saab 900, and Toyota Camary; the midsize class includes the Plymouth Acclaim, Mazda 929, Ford Taurus, and Buick Century; and the large class includes the Chrysler Imperial, Saab 9000, and Buick LeSaber. In addition to vehicles classified as in the Table, the reference used as the source for information also reports curb weights of vehicles sold to fleets (rental, utility, government, etc), and the weight of these has decreased about 800 pounds since 1976.

Automobiles smaller than those sold in the U.S. are marketed outside of the U.S. and have been presented as concept cars at automobile shows. Usually termed micro cars, these weigh about 1,200 lbs, are about 12 feet in length, and have a wheel spacing



LEAN MACHINE SPECIFICATIONS

Wheelbase	71 in.
Tread Width	28 in.
Overall Length	122 in.
Overall Width	36 in.
Overall Height	48 in.
Curb Weight	400 lbs.
Drag Coefficient	.15
Engine	2 cylinder, liquid cooled, four cycle, 38 HP
Transmission	Continuously variable automatic with cog belt final drive to differential and solid axle.
Suspension: Front	Telescopic fork
Rear	Tailing arms with spring over shock units.
Performance 0-60 mph	6.8 sec.

Figure 2.1: A Proposed Commuter Vehicle

(tread) of about 5 feet. (For a review of these vehicles, see Reference 2.) Many judge that such small cars will be needed in urban areas the future. For instance, Fiat has announced that it is planning production of a city car 10 feet 6 inches in length. These micro cars are not small when compared to the proposed neighborhood car.

One-half, One-fifth Cars:

Our investigations, of which the work reported here is a part, are exploring two small car concepts. Using terms to suggest the functions the vehicles would perform, one concept is termed the commuter car and the other the neighborhood car. The neighborhood car might be used as for access to transit terminals and serve as a station car.

The commuter car is about one-half the width of a conventional vehicle. It weighs about 500 pounds (empty), seats one person plus, and has high performance stability and acceleration characteristics. A prototype of such a vehicle is the General Motors Lean Machine (Figure 2.1). An electric version of a small flexible electric vehicle has been proposed by Monica Sutter (Figure 2.2). Even though the vehicle is small, the battery weight required by high performance brings the gross weight of this vehicle to about 1,300 pounds. If purchased and used for commuting, commuter vehicles should ease congestion and parking problems, for they require only one-half of a roadway lane. Achieving 100 miles per gallon or more (if electric, the energy approximating 100 miles per gallon of gasoline), small cars should reduce energy consumption and emissions. Work on vehicles of this type and their behavior in traffic has confirmed the potential for easing congestion as more and more such vehicles are adopted and used. Perhaps the

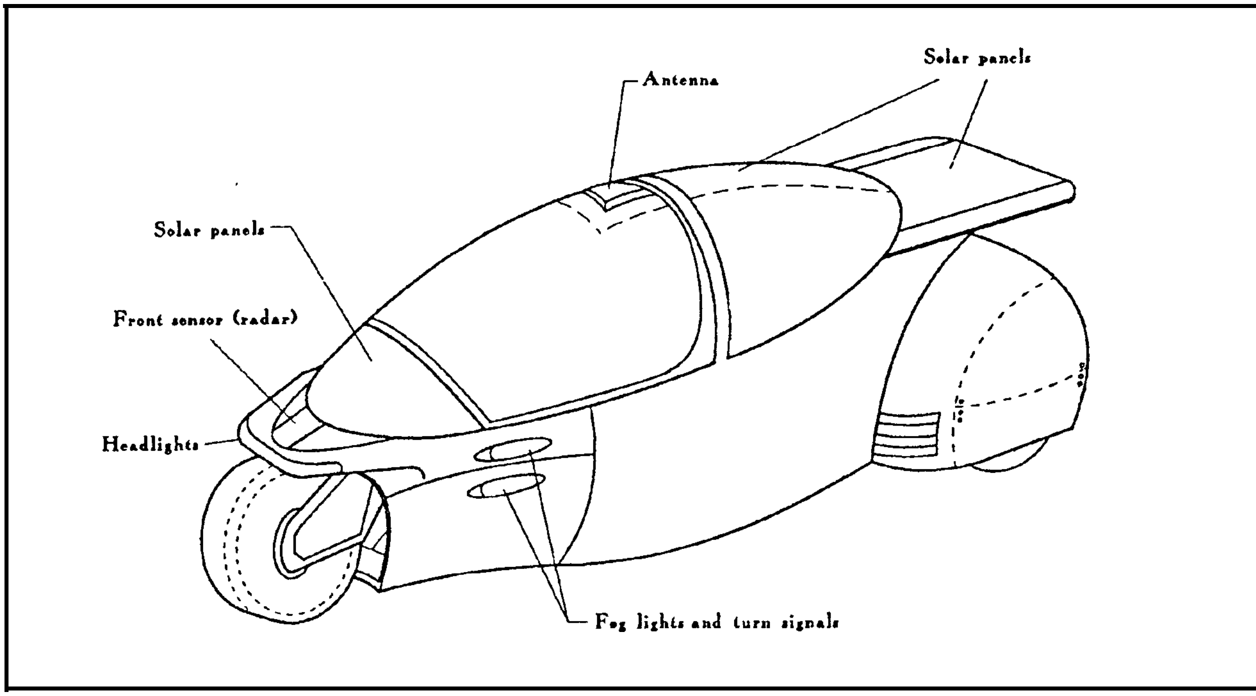


Figure 2.2: Another Proposed Commuter Vehicle, Courtesy of Monica Sutter.

most important finding has been that today's road infrastructure can be modified incrementally to accommodate the commuter vehicle in a cost effective way. (3)

The neighborhood vehicle that is the focus of the present work also weighs about 500 pounds, about one-fifth the weight of conventional passenger vehicles. Accommodating several passengers with side-by-side seating for two persons, this vehicle is somewhat wider than the commuter vehicle (about 50 inches, compared to 40 inches or less for the commuter vehicle). Even so, because it is operated at low speeds, its width permits either carving increased numbers of lanes from existing road space or reducing road width. Golf cart and small vehicles used for short trips in resort areas, airports, and other market niches are existing prototypes, and some manufacturers are developing new designs (Figure 2.3). Many of these vehicles are battery powered, and present day battery technology is quite suitable in situations where travel is not more than about 20-30 miles per day. As the name suggests, neighborhood travel would be served by this vehicle. As mentioned, it also can be imagined as a station vehicle, a vehicle driven to and from the home and transit stations (Figure 2.4). Station vehicles might be owned by transit agencies and rented to users.

Why a weight of about 500 pounds; why the narrow width? A low weight is sought for fuel efficiency reasons, and for corresponding reductions of emissions of pollutants. There are other advantages.

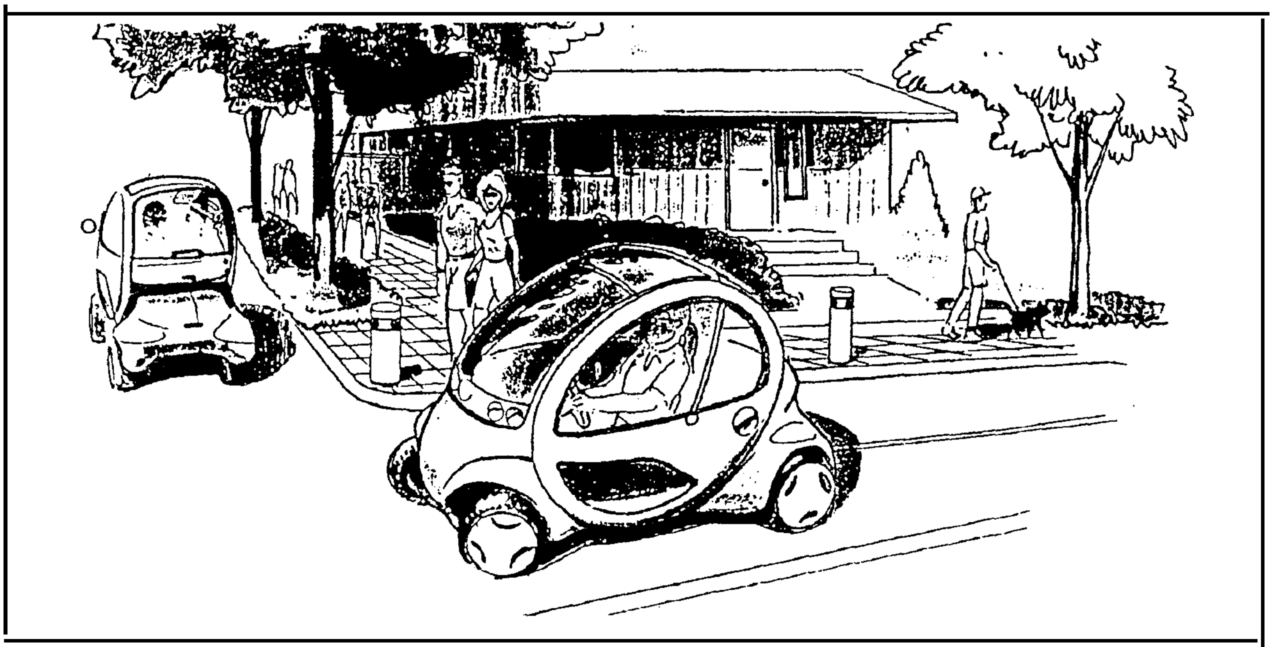


Figure 2.3: A Two Passenger Neighborhood Scale Vehicle. Courtesy the Trans 2 Corporation

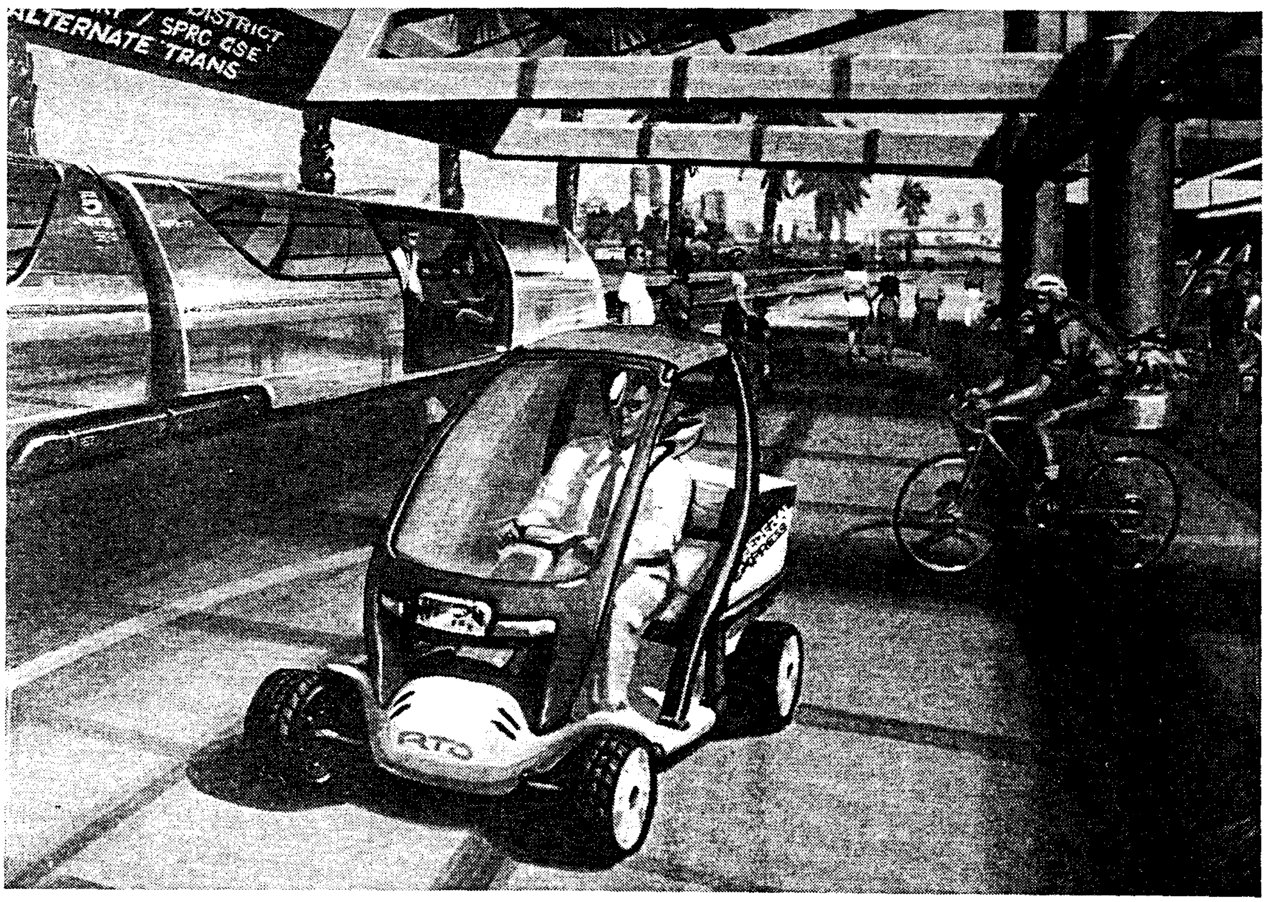


Figure 2.4: A Station Vehicle Serving a Light Rail Line, Courtesy the Trans 2 Corporation

From a load carrying requirement standpoint, weights on this order seem practicable. Narrow vehicle width decreases road and parking space requirements, congestion should be eased. Small, light vehicles may be served with inexpensive, relatively unobtrusive road facilities.

Because of the environment in which it operates and its function, a commuter vehicle would have one set of size and performance requirements; for the same reasons, a neighborhood vehicle another. Transit access requirements differ from place to place. Access might be by local streets in some places; in others, busy arterial streets might need to be followed or crossed. So situation specific designs might be needed for station vehicles.

Golf carts have been mentioned, and will be mentioned again. Used for a special purpose in golf course and vicinity areas, they are an useful example of a familiar specialized small vehicle. But golf carts are not a good prototype of a neighborhood vehicle. One would expect a varied mix of neighborhood vehicles that are tailored to consumers' desires. Most vehicles would be fully enclosed.

The narrow widths of the vehicles give them a one-half car character. Weight gives them their one-fifth car character. What about their price, about the mobility they would provide? If there are market niches for such small cars, why is there not much use of small vehicles? Why have small cars not achieved significant markets?

Manufacturing Considerations:

A price of $5,000 or less is imagined for the neighborhood car. If vehicles are affordable and improve mobility, and have social values as well--improved neighborhoods, lower energy consumption, reduced congestion, etc.--why are they not available in markets and in use now? Consideration of how vehicles are produced and used, suitable street spaces, safety, and other factors will assist in treating that question. (A review of previous efforts to market small cars is given in Reference 3. Comments on those efforts will be made later in this discussion.)

Price is a first consideration, how do vehicles have to be priced to cover production costs and profits. If a vehicle weighs one-fifth as much as a conventional vehicle, would a price one-fifth that of conventional vehicles be expected?

Assuming that a large conventional car is priced at about $20,000, it is priced at about $7.00 per pound, and assuming a $12,000 price for a subcompact car, it is priced at about $5.00 per pound. Using the subcompact price per pound, the neighborhood vehicle would be priced at about $2,500. At $7.00 per pound, it would price at $3,500. This suggests that if weight is the relevant criterion, the estimated price of $5,000 for the neighborhood vehicle is too high.

But the price to the consumer and the cost of production are different matters, and cost and price considerations yield a wide range of possible prices for the neighborhood vehicle. Costing is complex, for it depends on the number of vehicles produced and how corporate overhead is allocated among product lines. Because disclosed cost data may be misunderstood and/or adversely affect the competitive positions of firms, manufacturers' cost data are not available, except for cost estimates of actions required by government regulation. Their "stonewalling" or "you couldn't possibly understand" reaction to cost questions is quite understandable. Given this situation and the points to be made here, the approach below is adopted as a workable approximation.

Two components of manufacturing costs are materials and the complexity of manufacturing. Manufacturing involves complex material shaping, welding of about 250 steel pieces, subassembly of components, and assembly of the final product. Steel sells for about 30 cents per pound or a little more, and when averaged with other materials used in car manufacturing a materials cost of, say, $1.00 to $1.30 per pound results. Materials become parts or subassemblies, and in car manufacturing about 12,000 items are merged into the finished product. Beyond manufacturing cost, there are also costs of administration, design, procurement of materials, distribution to dealers, advertising, etc. Finally, the scale of production bears on costs, the unit cost for many copies is less than the unit cost for a few.

Considering the weight and complexity of an automobile, its price per pound is quite an industrial accomplishment. It compares very favorably with much less complex products, such as wheelbarrows (about $5.00 per pound), and somewhat comparable products, such as streetcars (about $30.00 per pound). The per pound price of motorcycles with weights comparable to neighborhood cars is on the order of $10 per pound- it's much more for very high performance cycles.

Assuming that the motorcycle example as not relevant to the neighborhood vehicle, a doubtful assumption, and also assuming there is a large enough market for the achievement of economies of scale, costs increase somewhat as cars are increased in size, but most cost elements are independent of car size. Extending this observation to the small neighborhood and commuter cars, the $5,000 price is much too low. Perhaps $8,000 to $10,000 would be more reasonable, and some new conventional vehicles are available at this price level, as well as many used cars.

However, these price levels assume that small cars are produced and marketed in the same way that today's cars are, and that need not be the case. As is widely discussed in the press and technical literatures, a revolution is underway in the production processes used in car manufacturing. The usual name given to describe the revolution is just in time (JIT) manufacturing, but there is much more.

Quality assurance, more effective use of labor and tools, and streamlined design and decision processes all enter the equation. In addition to reduced costs and improved product quality, more flexible modes of production appear to be reducing the thresholds needed for achieving economies of scale in manufacturing. (4)

In addition to the possibility for reductions in manufacturing costs, a reduction in complexity would be expected for the neighborhood vehicle, and reduced complexity should yield reduced costs. This appears to be the case for golf carts which are priced in the vicinity of $3,000 to $5,000. A low acceleration and velocity vehicle to be used on paved roads, the neighborhood car could incorporate relatively simple suspension and brake, power and drive train, and body-structure systems. Lowered strength requirements might enable extensive use of relatively inexpensive plastics and plastic forming processes. Alternatively, advances in traditional materials such as aluminum might offer options for new production processes. If the small vehicle is an electric vehicle, transmissions, motors, batteries, and control systems already on the market might be used as sub assemblies.

The Trans 2 Corporation of Troy Michigan has proposed a family of lightweight electric vehicles, and simplified production processes appear the key to their low estimated retail prices. Depending on the vehicle, prices are estimated to begin at $3,500. The simplist of the vehicles weighs 375 pounds without batteries, has a 4 foot width, and is about 7 feet long. A driving range of 30 miles is projected, so this vehicle is in the neighborhood vehicle size, weight, price, and performance class.

Cost and Price; Influence of CAFE and CAFE-like Regulation:

As stated, costs are one thing, prices another. Automobile manufacturers strive to achieve corporate average fleet economy (CAFE) standards to avoid penalties for failure to improve the fuel economy of vehicles. It is asserted that American manufacturers must sell small, fuel efficient vehicles at or near cost in order to average their fuel economy with large, less fuel efficient and more profitable cars. A vehicle that is very fuel efficient, such as the neighborhood car, might be an attractive product to manufacturers for this reason. To sell neighborhood cars in order to incorporate their fuel economy into the overall fleet average, producers might keep the price of neighborhood vehicles close to cost, perhaps even below cost.

There is the special California requirement that manufacturers begin to sell zero emission vehicles, and this may make the electric neighborhood car attractive, over and above its CAFE standards advantages. In 1998, 2 percent of a manufacturer's light duty vehicle sales in California are to be zero emission vehicles, about 20,000 vehicles in all. In year

2003 the percentage increases to 10, or about 100,000 vehicles.

The 1990 amendments to the federal Clean Air Act emphasized clean fuel vehicles and fleets. Starting in 1998, 30 percent of the light duty vehicles added to fleets in non attainment areas must be clean fueled, and percentage requirements increase in subsequent years. The Clean Air Act established a pilot program in California requiring that 150,000 clean fuel vehicles be sold in California in model years 1996 through '98, with the number increasing subsequently. In effect, the California and Clean Air Act requirements are applying the CAFE approach to vehicle emissions, and it should have the a similar affect on manufacturers' actions.

Although the CAFE standards, California requirements for zero emissions vehicles, and Clean Air Act requirements have somewhat different implications for the vehicle fleet, together they press for changes in vehicles. Electric vehicles are the only practicable option to meet the zero emissions requirements.

Although attractive to existing manufacturers because of CAFE and CAFE-like requirements, as a relatively simple vehicle, the neighborhood car might well be produced by new entries to manufacturing. Many entrepreneurs have built prototype electric vehicles, and these persons might focus on the neighborhood car market. If successful in markets, vehicles might be marketed neighborhood by neighborhood, and this would simplify product distribution and after market servicing.

Why No Neighborhood Vehicles?

The discussion now turns to the question, Why are producers not now selling neighborhood vehicles; why are consumers not purchasing and using them? On first consideration, this question seems a conversation stopper. Since small vehicles have not been successful in the market place, there is not much hope for them in the future.

This is one of several conversation stoppers to be treated as this discussion continues; safety is another such topic, as is the suitability of today's roads that serve vehicles of varied sizes and weights. These topics do not treat easily, and they all have a "we haven't tried" component in response to them.

Economic darwinism reasoning is behind the conversation stopper. It says we have tried everything: all possible types (mutations) of vehicles have been tried. The survival of the fittest has been fought out in the tooth and claw of the market place, and the types of vehicles now produced and marketed are the survivors. In the overall scheme of things, their survival says they are the best for the market environment. Extending beyond the market, methods of production, materials used, technologies incorporated in vehicles, and methods of marketing have passed the test of best for the situation.

Historic path dependence reasoning provides an alternative to darwinistic reasoning. Its reasoning emphasizes first decisions and their long term consequences: the die happened to be cast this way, and decisions down stream in time were conditioned by the way the die landed rather than by some overall optimility calculus. Some other cast of the die might have given different results. The lay out of the QWERTY typewriter key board is often used as an example of path dependence. One of the first successful typewriters used that lay out, and subsequent manufacturers followed the lay out. The QWERTY lay out persists, even though it is known that other key board arrangements are more efficient.

Applied to highway vehicles, the historic path dependence view complements the social darwinism view but leads to quite different conclusions. The reasoning goes this way. The nature of today's automobile can be traced back to horse drawn vehicles and early bicycles. The first steam, gasoline, and electric vehicles were essentially wagons, buggies, or carriages using new types of power. First technical questions bore on appropriate propulsion, steering, and braking and ways to couple the power plant to drive wheels. With first answers to such questions, the predominant vehicle technology began to emerge in the 1910s: the Otto cycle engine up front, Ackerman steering, etc. Today's automobile vehicle results from refinements to the vehicles of the 1910s, especially refinements made during the 1930s. Today's automobile production processes are also refinements of processes adopted early on.

That interpretation is a mixture of path dependent and darwinistic processes. But note that the darwinistic struggle was fought in the context of the products and production processes first developed and tools and the markets of the times. The competitive solutions reached then hold in the changed times of today. Once the predominant technology was discovered, the path for the evolution of the technology was fixed. Historic path dependence has yielded modern versions of vehicles that were best for past times.

The evolution of the automobile is more complex that the short darwinistic and historic path dependence interpretations reveal. Factors extending beyond the automobile and its production bear on the inflexibility of the system technology: including the relations between the vehicle, roads suited for it, and patterns of vehicle use and the risks run if a radically different products were to be produced. In the vehicle case, risks are largely due to the loss of economy of scale in production if the product is unsuccessful. Consumers' perceptions are limited to experiences with familiar vehicles in the same way that QWERTY typewriters limit notions of what a key board should be like.

With respect to size, the first vehicles were expensive and suited the needs of the upper classes. Most were carriage like in size, although there were markets for smaller sporty models. As less expensive vehicles were developed, the mass market then defined needed vehicle size. The multipurpose multipassenger vehicle was the choice. The vehicle had to accommodate the family and the many purposes the vehicle was expected to serve. First uses in urban areas, for example, were for week end social-recreational trips. Street cars served the journey to work and CBD shopping. Once established, the multipassenger, general purpose vehicle continues as the norm.

Historic path dependence also holds because the environment was shaped to accommodate the standard automobile, for example, roads and garages were built to accommodate it. Oriented to mass production, the industry honed production processes for the mass market, and product improvements were made to track on the tastes of the mass market. Over the same period the road environment, parking spaces, vehicle licensing and standards, and other aspects of the environment were shaped for the multipurpose vehicle.

Historic path dependence is one of the reasons small cars have not sold well in the past. Also, small cars have been small conventional automobiles which adversely affects price/performance/quality attributes. Approaching the complexity of full size vehicles and having similar corporate overhead burdens, costs are reduced somewhat by lighter weight, but not much. As explained in Reference 3, such small cars were produced as "Depression cars" during the 1930s without much market success. Another round of small car production occurred after World War II, especially in Europe, but markets largely disappeared as consumers became more affluent.

Things are different today: the small vehicle is less likely to be the single household vehicle and required to serve many types of trips. Also, the need to adjust road and parking facilities to accommodate small vehicles and improve the effectiveness of their use is beginning to be recognized.

In summary, the present pattern of vehicle production follows because the development of the industry has been locked-in on a path, the product is path dependent. The present situation is locked in by the production processes that have evolved, including labor and government relationships, the choices historically available to consumers, the environment of roads and streets suited to historic products, custom, and many other factors. That path did not explore small special purpose vehicles and environments where it might be superior to multipurpose vehicles.

Development paths differed somewhat nation-to-nation. Mira Wilkins has provided a sketch of the evolution of the automobile in Europe, the U.S., and Japan. (5, see also 6 and 7) She remarks on how vehicles emerged with a national character, in other words, how they suited the national mass markets and other conditions such as relative fuel prices. Methods of production also suited the national environments. In addition, Wilkins points out how European and Japanese producers were well poised to invade the U.S. market as petroleum prices and government policy began to reshape the U.S. mass market toward lighter and more fuel efficient vehicles. The well known difficulties of the adjustment of American manufacturers illustrates how the path along which American vehicle development moved was locked-in.

Breaking the Lock-in:

Automobile manufacturing in the U.S. is a mature industry. The predominant technology is well established and the market is saturated. Gains in productivity due to product or process of manufacturing improvements are not as marked as they were decades ago. Based largely on his studies of the automobile industry, William Abernathy termed the slowing of productivity growth in mature industries the productivity dilemma faced by aging industries in the American economy (8). Generalizing, once a product and its method of production is established and honed, productivity improvements come harder and harder.

The pace of improvements in automobiles was rapid between 19 10 and 1940, and the pace has certainly slowed since that time. The pace of improvements does not compare well with improvements in some other products. Actually, however, the pace of improvements in vehicles is open to much interpretation because consumers have asked for improved quality. Also, old features that were options, such as sound systems, and new features, such as anti-locking brakes (ABS), are now routinely purchased. Consumers are obtaining more car per car because they are buying more features. Taking that into account, it's whether they are receiving more car per dollar that is arguable. At any rate, improvement is not as blatant as vehicle improvements were decades ago. Improvements do not compare well with products of less mature industries where value per dollar obviously increases yearly, for example, computer work station computing power per dollar has doubled each of the last few years.

Producers in a mature industry are forced to be very risk adverse, as mentioned, and that is especially true in situations where achieving economies of scale in production is critical. Producing a product that fails to attract a mass market results in a short production run and high unit cost which may spell ruin for the manufacturer. The folk lore of Detroit recalls the Chrysler Corporation's failed efforts to market radically streamlined vehicles in the 1930s, and this story is heard whenever a new product is proposed.

To avoid risks yet achieve satisfactory market penetration, manufacturers specialize products to market niches. The 200 plus name plates for automobiles sold in the U.S. are one result. Considering accessories and colors available there is an automobile for every taste. To achieve product variety and maintain scale economies, producers seek to use interchangeable parts and subassemblies across a varied product line. Put another way, a standardized product is produced in order to achieve economies of scale, but products are varied to reach diverse market niches.

Avoid risk; for production efficiency standardize the product on the mass market; yet provide enough diversity in products to reach market niches within the mass market are the understandable producers' strategies.

There is another aspect of strategy, and that is to take some risk to produce a product where a new technology and/or a new design strengthens a producer's competitive edge. Historically, this strategy has been followed in annual design changes and marginal improvements in products. The introduction of the small convertible produced by Mazda and passenger vans produced by several manufacturers illustrate recent use of this competitive strategy. There are two elements of risk in this strategy. One is the possibility of failure with its high cost. The other is that a new product may cannibalize (reduce) sales of innovators' existing products, and this is part of the reason why changes to existing products have been made instead of producing radically new products.

In 1983 Abernathy stated that "...the process of dematuring is occurring in the automotive industry...," and he indicated that dematuring is occurring because of increased competition. (9, p. 34; see also Reference 10) He points to increasing innovation as an indicator of the process, and states that economies of scale are no longer as important as they have been in the past. New methods of manufacturing are enabling achieving economies of scale at lower levels of output.

Students of the automobile industry are agreed that the structure and performance of the industry is changing. CAFE and CAFE-like standards may push decisions to produce radically different vehicles, as might the entry of new firms into the business who could focus on the neighborhood market niche. There is the issue of whether these forces alone will induce much change absent changes in roads and exploration of new arrangements of vehicle use. Would, for example, changes in road infrastructure be necessary to opening a market niche for neighborhood vehicles?

Roads for Neighborhood Vehicles

Although vehicle producers, road producers and managers, and vehicle purchasers and users have different motives and styles of decision making, the system is an integrated one: roads fit vehicles, vehicles fit roads, roads and vehicles fit uses, etc. Actors all optimize in one way or another. Subject to time and money budget constraints, users purchase and use vehicles on roads in the way that is best for them.

Road agencies seek to efficiently provide roads for vehicles and traffic, and vehicle producers react to uses and roads. Changes are at the margins,as market sizes change, roads are improved or deteriorate, energy prices change, etc.

Striving to imagine the redesign of the system, the discussion of roads to follow will ask, What kinds of roads are needed for neighborhood cars? All that can be done is explore the question, for the design or redesign of roads should track on vehicles and uses. Uses have not yet been discussed; they will be discussed in a later part of this section.

General Considerations:

Neighborhoods exist in endless variety. It is imagined that vehicle suited on average for the residents of one neighborhood may not fit another so well. For example, a driving range of 5 miles may be suited for one neighborhood and its residents and 15 miles for another. If the neighborhood car is an electric vehicle, a extra batteries may be needed to serve the longer driving range. Climate and topography would make a difference in vehicle use and performance requirements. Neighborhoods under development may be designed anticipating uses of neighborhood vehicles, while redesign of road facilities is the question for existing neighborhoods. Considering this variety and other matters, what can be said that applies in general?

1. Trips made by neighborhood cars in a community could range from a very small number to near dominance. Although larger passenger vehicles could be parked at the edges of development, large vehicles will have to be accomodated: moving vans, fire engines, delivery trucks, etc. So some roads must be suited for large vehicles. Perhaps a neighborhood would have roads exclusively for small cars, dual purpose roads, and roads for large vehicles only. For already built communities, a transition plan to gradually shift road designs would be needed.

2. It goes without saying that roads ought to be designed using appropriate physical and human factors considerations. These apply to the superelevation of curves, radii of curves, horizontal and vertical sight distances, and strength of bridges and pavements.

3. The stability characteristics of relatively narrow tread and wheelbase vehicles need to be accomodated. Comfortable seating results in a relatively high center of gravity relative to tread width. A short wheel base may make for difficult handling on drainage slopes, shoulder edges, etc. In addition, sign posts, bus stop seats, trees, and other off road structures pose hazards for light weight vehicles. Safety requires appropriate consideration of the matters.

4. When operating in a neighborhood and accessing shopping, schools, and other trip ends, neighborhood cars will of necessity merge, cross, or otherwise mix with larger vehicles. Special intersection designs and/ or traffic control protocols may be required.

5. If the neighborhood car is an electric vehicle, then parking where recharging is available will be required. In some cases, this may require that recharging-parking spaces be reserved for home owners. Parking is also a consideration if neighborhood cars increase the number of vehicles stored in the neighborhood.

6. Improved mobility is one goal of neighborhood car. An important additional goal is improvement in the quality of residential neighborhoods. Although some new path-like exclusive small car roads may be desirable, overall the neighborhood car ought to reduce requirements for road space. Plans and protocols for the reuse of space will be needed. Achieving improved quality requires reducing conflicts between cars and pedestrians, street spaces and recreational spaces, parked vehicles and home access, and many other things.

7. Neighborhoods may lie in more than one government jurisdiction or have private roads. However, within-neighborhood roads are usually maintained and improved by a single local town, county, or city government. At the edges of neighborhoods there may be local government or state arterial or other roads. There are questions of who is responsible for roads suited to neighborhood cars, planning, and financing and appropriate arrangements would need to be made. If there are mobility and community improvements, then local assessment districts might take responsibility. But even in this case, there might be needs for up-front road developments preceding the flow of benefits and their recognition.

Road Designs:

Most neighborhood roads were built to local government standards. Local governments set such standards because once constructed and accepted by the local government, road maintenance becomes a local government responsibility. In addition to requiring acceptable design and construction, local government assures that roads are safe, suitable for emergency access,

Class	ADT	Pavement Width (feet)
Access	O-250	22-24
Subcollector	250-1,000 2	6
Collector	1,000-3,000 3	6

(ADT = Average Daily Traffic)

Table 2.2: Street Classes, ADT, and Pavement Width

Terrain Class	Level			Rolling			Hilly		
Development Density	Low	Med	High	Low	Med	High	Low	Med	High
Right-of-Way	50	60	60	50	60	60	50	60	60
Pavement Width	22-27	28-34	36	22-27	28-34	36	28	28-34	36

Table 2.3: Local Street Design Guidelines
(Right-of-way and Pavement Widths in Feet)

are properly drained etc. Contra Costa County, California, for example, asks that minor roads span 32 feet curb to curb on a 50 foot right of way and that collector streets span 36 feet on a 56 foot right of way. There are also requirements for pavements, sidewalks, drainage, etc. We have not yet investigated the consistency of requirements among local governments or design exceptions made for special circumstances. Because requirements have changed from time to time, the inventory of roads may be different from present day acceptance standards.

Pavement Width:

Our primary interest is in the fitting of roads for neighborhood cars into neighborhoods. Questions are mainly those of the geometrics of design, and American Association of State Highway and Transportation Officials (AASHTO) publishes **A Policy on Geometric Design of Highways and** Streets. (11) Where does this policy apply? It certainly bears on state facilities, and in most states that's the federal-aid system. (A few states provide local as well as federal-aid roads, e.g., North Carolina.) That system accounts for about 29 percent of urban roads and about 25 percent of rural roads--it's sort of everything but collector and local roads. Only about 15 percent of vehicle miles of travel occurs on local roads.

AASHTO policy bears on local facilities, not because these are state facilities but because the technical contents of AASHTO standards apply everywhere and there is a long history of cooperation between local and state highway officials. Indeed, there were local government representatives on the task force that produced the AASHTO policy on geometric design.

AASHTO policy for local roads and streets deals with design speeds, sight distances, grades, pavement width, curbs, and other topics. (Chapter V of Reference 11) The tone is advisory rather than prescriptive. Width of roadway is of particular interest, and

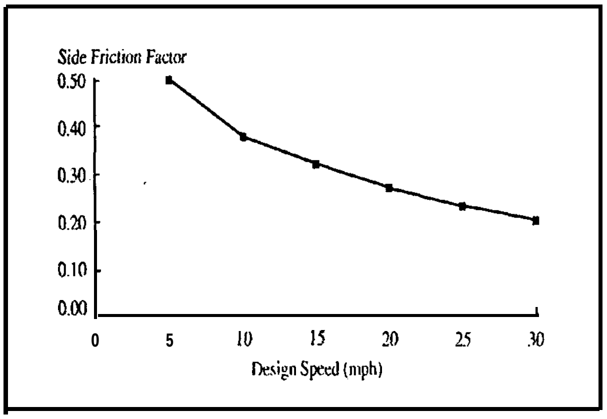


Figure 2.5: AASHTO Design Values for Side Friction

AASHTO states that lanes preferably should be at least 10 feet wide in residential areas, but where there are severe limitations, 9 foot lanes can be used. Seven foot lanes for parking are recommended if parking is to be allowed. The AASHTO design passenger car is seven feet in width, so AASHTO is allowing for 1.5 feet to 1 foot on each side of the car in driving lanes. If the neighborhood vehicle is, say, four feet in width, then a minimum lane width of 6 feet is suggested with 7 feet preferable.

The American Society of Civil Engineers, National Association of Home Builders, and the Urban Land Institute publication **Residential Streets** is also a source for recommended practice. (12) It talks about "factors influencing" design and makes recommendations stated in a suggestion tone. For instance, in discussion right-of-way width, it says, "should only be as wide as necessary for....," and remarks that 50-feet are seldom justified.

Some suggested street widths from **Residential** Streets are given in Table 2.2. There is the remark that if there is on street parking on the subcollector, a 28-foot pavement may be preferable. If residencies do not front on a collector, a 24- to 26-foot pavement with shoulders is sufficient. According to the reference, a free-standing residence generates on the order of 10 trips per day. So an access road serves up to about 25 dwellings. Apartments, town houses, etc., generate about 5 trips per day.

The Institute of Transportation Engineers' (ITE) **Recommended Guidelines for Subdivision Streets** (Reference 13) uses development density as one criteria for geometric standards:

Low	***2 or less dwelling units per acre***
Medium	***2.1 to 6***
High	***over 6***

Corresponding right-of-way widths and pavement widths are given in Table 2.3. The ITE publication is written in a formal "standards" writing style, although the word guidelines appears over and over.

There are some differences between the three publications just reviewed, for instance, AASHTO recognizes 9 or 10 foot pavement widths in low traffic situations, other recommendations (Tables 2.2 and 2.3) are for wider widths. **Residential Streets** says that 50 foot right-of-ways are seldom justified, yet that the minimum recommended by the ITE. The discussion will return to interpretation of differences and other matters following the

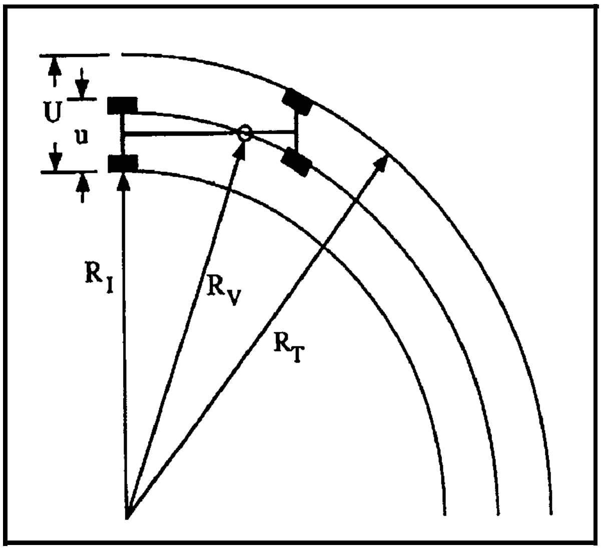


Figure 2.6: Illustrating Relations Between Inside and Outside Turning Radii

discussion of curves below.

Curvature:

As stated, width of pavement and right-of-way are two of many aspects of geometric design. Other design considerations include sight distance, grades, sidewalks, shoulders, vertical curves, etc. Horizontal curves are of special interest to the fitting of routes into restricted spaces. What dimensions should curves have to accommodate neighborhood vehicles? Straight forward calculations will begin to answer that question.

The minimum radius of curvature for a vehicle traveling at a given speed (R_v) depends on the superelevation of the outside of the curve and the available side friction, how the tires grab the road. From fundamental considerations (see, e.g. Reference 14):

$$R_v = V^2/g(e + f) \qquad (1)$$

Where:

V = vehicle speed in feet per second.

g = gravitational constant (32.2 feet/sec^2).

e = tangent of the angle of superelevation.

f = coefficient of side friction

And:

e and f are dimensionless parameters.

The coefficient of side friction (f) depends on the design and quality of vehicle tires, wet or dry conditions, and the nature of pavement surfaces. While it a physical quantity, it has a behavioral dimension. The higher its value, the greater the lateral acceleration forces felt by vehicle occupants. Before preparing AASHTO recommendations, typical behaviors of drivers rounding curves were observed. One finding was that drivers accept higher friction values at low speeds than at higher speeds (Figure 2.5), and these AASHTO values are used for design. Put in a simple way, drivers are willing to whip around corners at low speed, but when driving faster tend to be more cautious or desire more comfort.

For a given velocity and radius, superelevation (e) could be set so that the side friction is zero. But as a practical matter, superelevation is generally not recommended for local streets. The AASHTO document remarks, ". ..but in built up areas the

Vehicle	height	width	length	front overhang	rear overhang	wheel base
Passenger Car	4.25	7	19	3	5	11
Straight Truck	13.5	8.5	30	4	6	20
Tractor and Trailer	13.5	8.5	74	3	3	20 + 45-47

Table 2.4: Selected AASHTO Design Vehicles, Data in Feet.

Vehicle	Minimum Design Outside Radius	Minimum Inside Radius
Passenger Car	24	13.8
Straight Truck	42	27.8
Tractor and Trailer	45	0.0

The minimums are for near zero velocity.

Table 2.5: Turning Radii of Selected AASHTO Design Vehicles, Data in Feet.

combination of wide pavement areas, proximity of adjacent development, control of cross slope, profile for drainage, frequency of cross streets, and other urban features combine to make the use of superelevation impracticable or undesirable." (11, p. 436)

With these considerations, for design purposes R_v is computed using e = 0 and using desired values of V and values of f as given by Figure 2.5. Before doing this, however, we have to take into consideration vehicle dimensions and turning ability. Figure 2.6 shows the relations between R_v as already defined, and the inside, R_I, and outside, R_T, turning radii. The vehicle track, U, is also shown.

$$R_I = R_T - U \qquad (2)$$

$$U = u + R_T - (R_T^2 - L^2)^{1/2} \qquad (3)$$

The radius for the center of gravity, R_v is approximately the average of the inside and outside radii.

$$R_v \sim (R_T + R_I)/2 = R_T - U/2 \qquad (4)$$

Combining equations 2, 3, and 4, the track width can be expressed in terms of R_v.

$$U = u + 2[R_v - \{R_v^2 - (L/2)^2\}^{1/2}] \qquad (5)$$

Working with equations 1 and 5, one can calculate radii for curves. The track of wheels around a curve will allow determination of pavement width. However, vehicles typically overhang their wheels and suitable clearance must be provided.

Table 2.4 gives the measurements of some AASHTO design vehicles. (11, p. 21) Table

2.5 gives the inside and outside turning radii for these design vehicles. (11, p. 22)

To estimate the turning radii for a vehicle in the neighborhood car class, an example vehicle with wheelbase of 6 feet and a tread with of 4 feet was selected. Using equations 2 and 3 the minimum inside turning radius is about 7 feet and the track width is about 5.5 feet. The vehicle could go around that curve at about 7 or 8 miles per hour accepting the side friction factor used by AASHTO.

Discussion of Geometric Design Topics:

Emphasis in the discussion of road facilities has been on pavement and road widths and the radii of horizontal curves. There is existing design practice suited to existing vehicles, and there is the question of what designs might be like if they were configured for neighborhood cars. Neighborhoods already have facilities for conventional vehicles and new neighborhoods or communities will also need such facilities. The design task in existing neighborhoods would be that of fitting spaces for neighborhood cars within existing facilities, with, perhaps, some special facilities developed for access to parks, shopping centers, and other activity locations. Options should be broader in communities under development where there might be restricted facilities for-conventional vehicles and more extensive provision of facilities for neighborhood vehicles. In both cases there are questions of staging facility development to match the build up of the neighborhood vehicle population.

Again, the discussion of curvature was limited to horizontal curves. Although not considered in the analysis, vertical curves should also be considered. That's partly because comfortable side-by-side seating set on the narrow tread width of small cars gives them a relatively high center of gravity. For this reason and for easy access and egress, especially for mobility limited persons, the body of the car should be set as low as practicable. (Not too much should be made of the relatively high center of gravity. At low velocities, stability problems should not be of concern.) In addition, vertical curve requirements bear on road facility design options.

Suppose a new community is under design and paths for neighborhood vehicles are to be developed. If vertical curve requirements are not binding, then there would be the option of fitting paths to the existing terrain and little earth moving would be required. In cases, this might reduce costs and provide for interesting landscapes.

The discussions reviewed conventional design protocols because facilities sized to neighborhood cars will be designed in the spirit of those protocols. Making some assumptions about the size of neighborhood cars, some suggestions were made about pavement widths (lanes on the order of 6 to 7 feet) and the minimum inside and outside radii of curves (at low velocities, on the order of 7 feet inside and 21 feet outside.Single lanes might be provided for one way traffic or for two way traffic if turn outs were provided. If traffic conflicts can be tolerated, lanes might be configured using present street space with large vehicles giving way to small ones when vehicles meet. Many other arrangements can be imagined.

It must be emphasized that the discussions yield no conclusions. Their intent was to introduce topics, identify questions, and make suggestions. To an extent, the questions introduced could be further explored without additional empirical information. But usable answers to questions must wait on experience with vehicles in neighborhoods. For example, the projected widths of cars and calculations of vehicle tracking suggest pavement widths. But actual pavement widths must respond to the ways vehicle operators position vehicles on lanes and select speeds and maneuver when curving. To make this point further, we know of cases (golf courses, resort hotels) where 5 foot wide paths are provided for small vehicles, although we have noted some off-pavement tracking on small radius curves. With vehicles operating at near walking speeds, the narrow pavements seem suited to the situation although these pavements are narrower than those we suggested based on AASHTO and other recommendations.

Neighborhood Improvements

This short discussion takes a look at the evolution of neighborhoods in the United States since the beginning of the twentieth century. First, the beginning of urban planning and the general city form it created are described. Then, the origins and consequences of the typical suburb design are explored. This section also discusses departures from typical residential development. Finally, this section briefly considers the age of housing stock and its rate of increase and some trends that may bear on the future of neighborhoods and communities.

City Planning and the American Urban Form:

From the middle of the nineteenth century, traffic congestion was a problem for many large cities. In the mid-nineteenth century, traffic congestion was caused primarily by horse-drawn wagons, buggies, busses, and trams. When the trams went electric, the congestion eased somewhat. However, the bicycle had come into common use during the last decades of the nineteenth century and the car emerged at the turn of the century -- ultimately creating more congestion than had been eliminated. (15)

At the turn of the century, the concept that cities should be planned and controlled in order to avoid the most negative developments which had plagued industrialized cities (the Industrial Revolution was well underway by 1860) became prominent. The municipal task of urban planning included road planning. By the end of the nineteenth century, German engineers and planners had developed the concept of controlling traffic by a hierarchy of streets; Baumeister's book on the subject had been published in 1876. American transport planners were not generalists but specialists and did not see themselves as a social force, unlike planners in Germany and Britain. (15)

In the United States, planners from Thomas Jefferson and later favored the grid-iron street layout for towns and town extensions. Normally, the street widths were fairly uniform, with main streets being somewhat wider. (15) The gridiron pattern for urban development in the US is unlike patterns in Europe, with their many narrow streets and alleys. With the rapid establishment of new towns in the U.S., the grid layout was popular because it came directly from the land survey which had to be completed in any case. (The Continental Congress required the surveying of western lands with the Land Ordinance of 1785 -- essentially establishing a large grid for the western U.S.) The grid pattern also made the lots easy to locate and describe, so that they could be more easily sold. There was much land speculation as new towns were developed and the ability to sell lots quickly was an asset. (16)

Philadelphia was the first large U.S. city laid out on a rectangular plan. The plan was viewed as a great success and was widely copied. For Philadelphia's flat, undifferentiated topography, the grid layout was a reasonable choice. Philadelphia's plan included open space (although not a lot, by today's standards) and space for public buildings. The idea of the commons, a central public space, did not become a dominant aspect of the urban form. (16)

In 1790, Thomas Jefferson proposed a grid similar to Philadelphia's as the first plan for the nation's capital at Washington. In 1791, Major Pierre L'Enfant received the commission to plan the capital. L'Enfant proposed a plan which took advantage of the site's natural features and which looks like a grid heavily modified by diagonal streets, open space, monuments, and other aesthetic features. Although Jefferson opposed the use of diagonal streets, L'Enfant's plan was adopted with few modifications. This was the first and most important altercation between rational (grid) and aesthetic city plans. (16)

During the late 1800s, the City Beautiful movement (with its spiritual origins in Pierre L'Enfant's Washington, DC) began and constituted the beginnings of city planning as a field. The landscape architect Frederick Law Olmsted was a key influence during this period. Olmsted abandoned the grid-iron pattern when laying out his streets and was adept at designing curved streets. Importantly, Olmsted separated pedestrian and other forms of traffic. His influence on the field of landscape architecture is important, for the people in this field often designed streets for residential areas. (15)

In 1916, the American Charles Mulford Robinson published a book mixing engineering and planning, discussing the widths of streets and planning of lots. In his opinion, good street planning is "the product of philosophy, of sociology, and of economics as much as it is of engineering."' (15, p. 41) The sociological aspect was new. His main argument was that often the major roads were too narrow and the minor ones too broad. Robinson was against the artificial classification of roads, but in favor of classifying roads by social and economic function. He favored separate pedestrian footpaths between gardens, both for shorter walking distances and because they contributed to the "restful rural charm" of neighborhoods. (15)

In England during the late 1800s, the garden city movement was an important social counter-movement to the forces of industrialization on cities. Using Ebenezer Howard's principles, Raymond Unwin and Barry Parker led Britain's garden city movement which aimed to create affordable, lower density housing with more light and air. Key attributes of a garden city were: design and grouping of housing around a yardlike square, curved streets, separate motorized traffic and pedestrian street networks, and low density. The designers controlled traffic by making longer blocks and using streets of different widths. Roads and streets became an integral part of the overall planning of the housing development, expanding from a purely functional use. Unwin and Parker wanted to create open space and interesting streets. They also wanted to protect residents from through-traffic. (15)

The Regional Planning Association of America (RPAA) was formed in 1923, primarily to build a garden city according to Ebenezer Howard's principles. The garden city known as Radburn (1929), in Fair-lawn, NJ, influenced neighborhood street design in the US. The key characteristic of its street design was to provide separate networks for motorized traffic and pedestrian (and cyclist) in order to reduce conflicts between the modes. With the gridiron arrangement, traffic could move easily throughout all parts of the city (including residential areas); pedestrians and residents were not well-protected. Henry Wright, one of the main planners of Radburn, had trained and practiced as a landscape architect in the tradition of Frederick Law Olmsted; Wright favored curved streets and separation of traffic modes. Radburn was not very successful and only the separation of traffic modes was widely copied. (15)

From Radburn, the sociological concept of units was developed (beyond that initiated by Robinson) by the sociologist Clarence Perry of the RPAA. Perry thought that small-scale community facilities would create ideal neighborhoods. He wanted housing areas which were grouped around different cultural and commercial centers, perhaps consisting of a school, community buildings, shopping, and so on. Pedestrian and bicycle traffic was separated from other motorized modes. The specialization of streets was not very sophisticated in the Radburn design; there were only cul-de-sac roads and wide residential streets. Radburn was designed both to protect pedestrians and to provide plenty of road space for the car. (15)

During the 1920s and 1930s, a shift in emphasis occurred for city planners. The "city efficient" replaced the earlier City Beautiful goals. (16) Proponents, such as Nelson Lewis, of this new direction saw a lot of mistakes to be corrected from the previous period. Lewis spoke for the movement as he dedicated his textbook on city planning to the municipal engineers. This new type of planner focused on traffic and land use problems, which remained from the previous period. (17)

Both the City Beautiful and "city efficient" movements have yielded useful elements to planning in the United States. Future designs will do best to draw from both, rather than being either dysfunctional and elitist or rational but limited to existing street classes and layouts.

Suburb Design:

Suburbs began as residential areas for commuters into the central business district of a city; the advent of electric trolleys at the beginning of the twentieth century made them possible. At that time, work, shopping, and entertainment were concentrated in the central core of the city. Now, suburbs are increasingly self-sufficient, eliminating the need to travel to the central core.

The suburban pattern that is familiar to us began in the 1920s. The pattern was firmly established with the "...large-scale development in the years following World War II of single-family housing on large raw tracts of land -- the 'subdivision,' and since has extended to the creation of an entire auto-centered way of life, whose key physical elements include 'the strip,' the shopping center, the workplace, and entertainment, all woven together along a horizontal grid." (18) (Current road design practices were discussed in an earlier section.) The basic building blocks of a modern suburb are: "1) the limited-access highway linking together an entire metropolitan region of suburban cities and providing commuter access to industrial and commercial workplaces; 2) the strip arterial lined with commercial services; 3) the regional shopping mall and commercial center; 4) the block pattern of detached houses designed for nuclear families." (18)

As suburban areas have have become multi-functional, many suburban streets have become severely congested. The congestion poses safety problems and has led to unacceptable levels of air pollution. Addressing the transportation problems of suburbs has been difficult because trip patterns are complex. Suburbs have trips from many origins to many destinations with few concentrated corridors of demand; these trip patterns are hard to serve by transit. Buildings are difficult to access by transit, foot, or bicycle in the auto-dominated suburbs; the use of cul-de-sacs does not allow through travel, buildings are separated from sidewalks by seas of parking, and walls separate different subdivisions. (19)

In their report to the Urban Mass Transportation Administration (UMTA), Beimborn et al. propose guidelines for transit sensitive suburban land use design to address the problems of our suburbs. They suggest designating "Transit Corridor Districts" (TCDs) which would separate transit- and auto-oriented land uses. They specify that these TCDs should have a mix of land uses at higher densities and be located near a transit route. The group also requires an access system to buildings and transit for pedestrians and bicyclists. (19)

Departures From the Dominant Suburb Pattern:

Since the suburb pattern just described was established, there have been various experiments in other directions. During the 1960s, Charles Abrams recommended several means of protecting pedestrians, such as pedestrian islands and maintenance of the elevation of sidewalks where they cross streets. (20) During the 1970s, Donald Appleyard explored different residential designs to control traffic and create walkable, liveable neighborhoods. He highlighted the "woonerven" (residential yard) concept pioneered in Holland. (21)

Recent experiments in suburb design are compatible with Beimborn's recommendations for departing from the usual suburb pattern. Variously called neotraditional neighborhood design, transit-oriented development, or pedestrian pockets, these strategies do not represent anything new or innovative except in the manner in which they combine existing design elements. Major proponents of this movement include Peter Calthorpe, Andres Duany, and Elizabeth Plater-Zyberk.

A pedestrian pocket is defined as "...a simple cluster of housing, retail space, and offices within a quarter-mile walking radius of a transit system." (22) The basic idea involves higher-density, mixed-use neighborhoods, oriented around transit. Beimborn's group recommended to UMTA that either node- or corridor-based TCDs be created; pedestrian pockets look like their proposition for node-based TCDs. (19) Pedestrian pockets are designed to conserve land and energy, reduce traffic congestion, provide greater access for the elderly and children, and unburden workers of long commutes. (23)

In a recent study for the Washington State Department of Transportation, Richard K. Untermann examined existing land uses and activity patterns along Highway 99 north of Seattle to identify the land use changes supportive of walking and bicycling. (24) The changes recommended are intended to encourage walking and bicycling to bus or carp001 stops. Changes included concentrating retail activities into several nodes, increases in high density housing, and mixing commercial, office, and residential activities. Special facilities would be provided to accommodate bicycling and walking. The suggestions are to redesign existing land uses in a neotraditional fashion and they offer an alternative to the more usual discussions of neotraditional designs for new communities.

Trends:

The discussion above provides a terse review of ideas and practice of neighborhood/ community/urban design. With the exceptions of work by Untermann and Appleyard, ideas mainly apply to new developments. To clarify the rate of new development and its relation to existing housing stock we examined data on new housing construction.

Considering data covering the past 20 years, private residential construction is now at a low point (Figure 2.7). As of 1987, the median age of the nation's housing stock was 25 years. (25) Another data source gives a data series of the mean age of our nation's gross stock of residential housing. The mean is different from the median, but the series might give something of a reference point. The average age of the gross housing stock was 27 years in 1925 and, with low

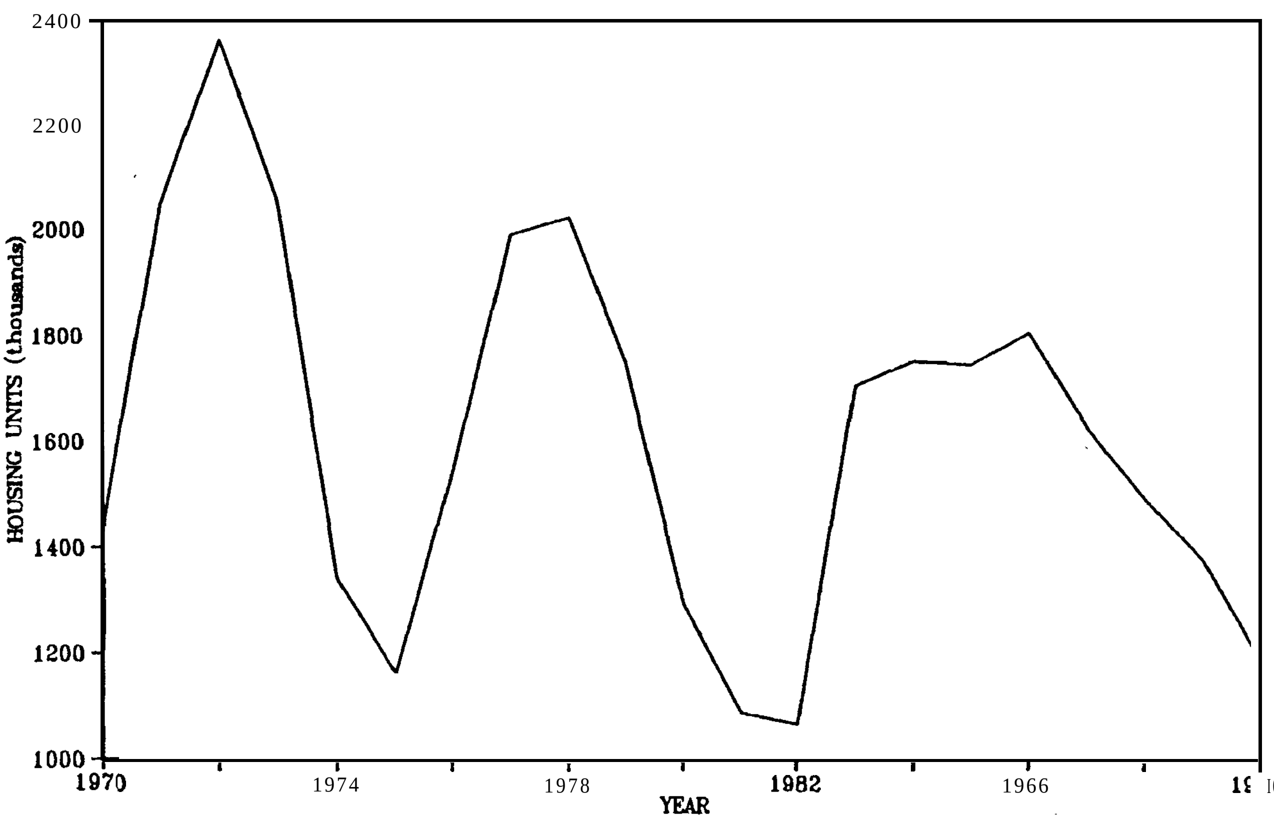


Figure 2.7: New Privately-owned Housing Unit Starts, 1970 to 1990.

investment through the depression and World War II, increased to 34 years in 1945. The average age declined after this period and reached 1920s levels again during the 1970s. Even though the average age in 1970 was 20 years, over half of the gross stock in 1970 was over 50 years of age. So, in 1970, the median age of the gross housing stock would have been 50 or more. (26) Comparing the median age in 1970 (50+ years) to the median age in 1987 (25 years), it appears that the housing stock in the US. is relatively new at this time. Even so, there is lots of aged housing in the inventory.

The conclusion to be drawn is very simple: If the neighborhood vehicle is to fit into community situations and serve well, it and the associated adjustments of road infrastructure will need to be sufficiently flexible to match highly diverse situations.

Turning to other trends, there is the question of whether the neotraditional designs promoted today are consistent with overall social and economic trends. There is the broader question of whether the kinds of travel, life styles, urban activities, etc., that it is imagined the neighborhood car would serve are consistent with broad social and economic trends.

The seminal work on social trends is that by the sociologist W. F. Moore. (27) After sorting through a large number of perceived trends he reaches one conclusion: the predominant trend is specialization in all things. That's observing that education, work, social relations, recreation, etc., are all increasingly specialized.

Moore's conclusion is consistent with the notion that the neighborhood car and associated road facilities would specialize services, the notion presented in the **Introduction** to this **Report.** At this time, however, we do not have a well thought out interpretation of the specialization trend with respect to evolving neighborhood market niches for the neighborhood car. It could be that the trend says that individuals and families are increasingly less able to meet their needs with neighborhood scale trips. For instance, they must increasingly travel to megastores to choose from a vast selection of goods for consumption. The trend might also be saying that neighborhoods will be increasingly specialized around the needs of those who elect to reside there: specialized stores, recreation opportunities, work places, etc. With the exception of work places, such specialization is seen in emerging retirement communities.

Whatever the implications of specialization, it suggests that varieties of vehicles and road arrangements would be needed to provide improved neighborhood mobility. "Cookie cutter" designs, for neoclassical neighborhoods or for transportation, seem not viable.

Constraints

The two previous parts of this section dealt with supply-side topics: 1. aspects of conventional vehicles and road design and how they relate to the neighborhood vehicle and 2. some emerging ideas about the desirable attributes of neighborhoods. The discussion now turns to a mixture of topics, some of which are market structure and demand-side in character. The word constraints has been used in the title for this part of the discussion because the discussion goes beyond strictly demand topics. Topics to be discussed include patterns of home based travel, safety, mobility, consumer choices of vehicles, and vehicle registration and the licensing of drivers.

The task is to position the neighborhood vehicle and neighborhood design possibilities in the context of these topics. As stated before, because neighborhood cars and related neighborhood designs nowhere exist, extrapolation and judgement are necessary, and precise findings can not be given for the topics to be covered. That is partly because of data limitations and also because of the difficulty of interpreting some matters, such as the perception of safety by regulators and vehicle users. Another reason for lack of precise findings is lack of precise system definition. It is imagined that varieties of neighborhood cars and road infrastructures suited for them may evolve. The answers to questions of safety, vehicle registration, vehicle purchase and use, etc., depend on the evolution of cars and roads. At the same time, the evolution of cars and roads will respond to how such questions are asked and answered.

Vehicle Markets and Use

What are the markets for neighborhood cars and how would they be used?

Markets:

Addressing markets first, the answer to the question has time and quantity dimensions. A new product enters the market. If successful, it penetrates the market, first at accelerating and then at decelerating rates (Figure 2.8). Eventually the market is saturated. The quantity question is that of the number of sales at each time period and the total number sold when market saturation is reached. Time also enters for one would like to know how long it would take to reach market saturation.

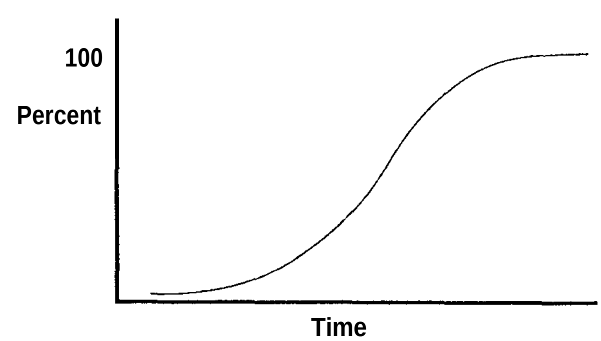


Fig.2.8 Market Penetration

Figure 2.8 shows a smooth curve. However, as we imagine market penetration it would have a step by step character. It might begin, say, when an entrepreneur develops and promotes a vehicle suited for mild climate retirement community enclaves. As that market begins to be penetrated, products designed for other markets might begin to be developed and promoted, say, products for cold climate retirement communities, central city congested residential neighborhoods, and 1920s suburban neighborhoods. The nature of the vehicle would vary situation to situation to meet differing requirements for driving range, heating and cooling, etc. Retirement community enclave designs (gated, ample street spaces, and local community management) might not require much road infrastructure redesign; other situations might be more demanding of road changes. Also, the pace at which neighborhood improvements (improved recreational spaces, gardens, housing alterations, etc.) unfold may affect the rate of vehicle market penetration.

Another market question has to do with the purchase decision. Who purchases, how do purchasers value the attributes of vehicles? We would also like to know how road infrastructure and neighborhood designs influence the purchase decision.

Absent neighborhoods configured for neighborhood cars and purchasers making choices, the answers to these market questions can not be known. The situation is different when there are existing products. Choices made in real situations allow one to study the revealed preferences of choice makers, that is, what buyers choose. The analysis of revealed preference is the preferred method for market analysis. Stated preference is a useful alternative method when a choice is to be made about a hypothetical product. Decision makers are asked what choices they would make when presented with a set of hypothetical alternatives and they state their preferences. The stated preference approach works well in some situations, but we are skeptical about its applicability to the neighborhood car situation. That's because the hypothetical situations that might be enumerated for the neighborhood car are far from choice makers' experiences.

Electric Vehicle Studies:

The neighborhood car could well be an electric vehicle. Although the neighborhood vehicle's estimated price and travel range are lower than the prices and travel ranges of the electric vehicles discussed in the literature, there have been studies of electric vehicles that are suggestive for the neighborhood vehicle.

Electric vehicle studies begin with the assumption that electric vehicle prices will be in the range of conventional vehicle prices as batteries and vehicles are developed and as efficient methods of production and marketing evolve. Assumptions are also made about permitted driving ranges. Experience with other products and expectations about battery (or fuel cell) price/

performance improvements are used to justify the assumption. Holding for any product, this assumption would be applicable to the neighborhood car, however, its affect may not be strong. The neighborhood car is relatively simple compared to electric vehicles designed to compete with conventional automobiles. Its off-the-shelf components (electric batteries, controllers, motors, etc.) have already achieved price/ performance improvements and further improvements in the future may be limited. Finally, the step-by-step market penetration with vehicles tailored to situations may limit price/performance gains from product standardization and economy of scale of production.

Although a variety of analytic strategies have been used to estimate markets for electric vehicles, the results are quite similar. Potential purchasers are very sensitive to driving range and first cost (purchase rather than operating cost) considerations. They also desire the amenities characteristic of conventional vehicles: ride quality, acceleration, sound systems, air conditioning, etc. There is a direct relation between driving range and first cost. A range increase requires greater expenditure for batteries and this increases purchase cost, and an increased number of batteries also increases vehicle weight. To accommodate the batteries required for range objectives, vehicle designers use strong light weight materials.

Many vehicle producers have developed prototype electric vehicles. The General Motors 1990 Impact, for example, has a range of about 120 miles using 32 lead acid batteries that are rechargeable in 4-8 hours for about the cost of a gallon of gasoline. It has a low drag coefficient and a small cross sectional area, and it makes extensive use of light weight materials. A BMW prototype is designed for a range of about 160 miles. Expected prices for vehicles of this type have not been announced, although costs in the vicinity of $60,000 for early production vehicles are mentioned in the automotive press for relatively high performance electric vehicles. Lower performance vehicles would be less expensive. Additionally, a number of interested vehicle designers have refitted conventional vehicles with batteries and electric motors. Vehicles we have examined are priced at $20,000 to $30,000.

The design of electric vehicles and their expected market acceptance is a complicated matter. Producers choices about types of batteries are complicated by driving and recharge cycle considerations, the expected life of batteries and the costs of replacement, and unknowns about improvements in existing or new batteries. Operating and battery replacement costs, driving range, and performance must be tuned to uncertain market windows. By performance we refer to acceleration, ride, steering, braking response, and other things that make vehicles suitable and fun to drive. The potential producer must make difficult and complicated decisions and expect small markets.

Although we have not seen the full specifications for the General Motors Impact, it appears to have incorporated a high level of optimization applied to aerodynamics, rolling resistance, power train, etc. It uses an power inverter so that AC motors may be used, and regenerates power when decelerating. Using lead acid batteries, the specific energy available is between that in one-half to a gallon of gasoline. Considering that the batteries weigh on the order of 800-900 pounds, it's quite an accomplishment to achieve an estimated range of 120 miles, and that must be the range for undemanding driving.

Weight could be reduced by using batteries with higher specific energy (energy available per unit of weight), such as sodium-sulfur batteries. An advantage of the lead acid battery is its high specific power (ability to release energy quickly), although its life is shortened if it is subjected to deep discharges. For this reason, used frequently at the advertised 120 mile range, Impact batteries would probably have to be changed each year or so at a cost of about $2,000.

The discussion of the Impact suggests the status of the development of conventional automobile-like electric cars; a much longer and more technical discussion would be required to treat all proposals and prototypes, as well as to review research and development programs. The status of electric vehicle development explains why a leading researcher in the area, Daniel Sperling, recently remarked "Estimates of around 1 percent (of the market) are probably reliable if one were to market electric vehicles now." (28) Batteries especially remain a problem. (29, 30)

A final point has to do with battery recharging. Vehicles having the ranges now being considered would require overnight recharging from 230V 50 amp circuits. Investment in electrical wiring at a suitable place would be required. Depending on the situation, costs would range from $100 to $1,000.

Inferences for the Neighborhood *Car:*

Because of the limited range of the electric vehicles just discussed, their price, and charging requirements, Nesbitt, Kurani, and DeLuchi used an approach different from approaches previously used to estimate market size. (30) A cut-off or eligibility analysis was made. Reasoning went this way: The requirement for charging and overnight parking says that only home owners are among those eligible to own electric cars. Because the (eventually to be developed) electric vehicle compares in price with conventional vehicles and because range limitations will limit purchases to homeowners who have a conventional vehicle available, eligible owners are households with incomes greater than $50,000 per year. Applying these eligibility rules, market saturation quantities were estimated. Also, some additional estimates were made by relaxing eligibility rules.

(The Nesbitt, Kurani, and DeLuchi 1992 study contains an excellent summary of consumer choice and life cycle costs studies. Because this study is available, we have not presented a literature review in this present text.)

The reasoning just described was about the ultimate market for the electric vehicle. A similar approach might be used to reason about initial markets for the neighborhood car.

1. Its markets will be found in neighborhoods where suitable parking and recharging facilities are available. Because of the limited range and battery requirements, recharging may be from a 115V 15 amp socket. These are already available in most garages or car ports, or could be made available relatively inexpensively.

2. Although a low price is imagined for the neighborhood car, price and the availability of conventional vehicles for long range travel are considerations. Families that already have a conventional car available and that reside in relatively affluent neighborhoods would be first purchasers.

3. Range limited, markets will be found where neighborhoods are relatively close to trip ends, such as neighborhood and community shopping, churches, medical offices, etc.

4. Absent road facilities specially designed for the neighborhood vehicle, its markets will be in neighborhoods where there are ample street spaces.

5. An initial market segment that is not defined by criteria 1 through 4 might be the mobility disadvantaged. Persons even with limited incomes might find that a neighborhood vehicle provides access to social visiting, recreational, and neighborhood services. The neighborhood vehicle would serve as an alternative to transit, walking, or riding as passenger with a car owner and driver. The disadvantaged might be found in any neighborhood, but criteria 1, 3, and 4 would bear in part.

Because of the neighborhood niche criteria (Nos. 1, 3, and 4) and absence of data on neighborhood niches, these criteria can not be made operational at this time. (As will be discussed later, safety regulation may limit expansion beyond an initial market.)

Work is needed to characterize the nature of neighborhood market niches. That work should examine neighborhood morphologies: population densities, arrangement of roads and streets and land uses, etc. Travel and socioeconomic data for neighborhoods are also needed. Using information about neighborhoods and travel, the requirements for neighborhood vehicles and for road infrastructure redesign could be estimated. By requirements for vehicles we mean size, travel range, price,. and the like. Road infrastructure requirements might have to do with needs for arterial crossings, marked lanes on through streets, and parking where recharging is available.

Uses of Neighborhood Cars:

The Federal Highway Administration (FHWA) has sponsored several surveys of personal travel since the late 1960s, and there is now about a 20 year record of the results of those surveys. Additional travel data are available from the Census of Population, travel surveys made by metropolitan transportation planning organizations, and other sources. The results of those surveys say that trip distances average about 9 miles. A trip is from one place to another. So the 9 mile length of trip datum doesn't say that the average round trip is about 18 miles, for many trips are linked into chains: for instance, a traveler goes from home to a movie theater, to a shopping center, and then returns home.

Table 2.6 displays some preliminary data from the 1990 FHWA sponsored survey, as does Table 2.7. (32) So far as the neighborhood car is concerned, the tables provide only impressionistic information. Examining average length of trips, there is the impression that many trips are in the 10 mile range, and even with some trip chaining, they could be easily satisfied by a

	Person Miles of Travel (percent)			Average Vehicle Trip Length (miles)			
Purposes	1977	1983	1990	1969 auto only	1977	1983	1990
Work	19.9	20.1	23.2	9.4	9.2	8.6	10.9
Work Related Business	7.1	5.9	3.6	16.1	11.9	11.3	14.0
Shopping	9.8	11.3	11.3	4.4	4.9	5.3	5.1
School/Church	6.2	6.7	6.7	4.7	6.1	5.5	7.4
Doctor/Dentist	1.6	1.3	1.3	8.4	10.8	9.8	10.5
Other Personal Business	10.5	13.2	19.6	6.5	6.7	6.5	7.2
Vacation	1.5	8.0	3.6	160.0	95.4	113.0	80.0
Visit Friends/Relatives	13.4	14.6	11.7	12.0	11.2	10.7	11.3
Pleasure Driving	1.1	1.2	.8	20.0	15.7	19.7	20.9
Other Social/Recreational	14.1	15.5	17.5	11.4	9.1	8.7	10.1
Other	14.8	2.1	.7	9.4	9.8	7.2	10.7
All Purposes	100.0	100.0	100.0	8.9	8.3	7.9	9.0

Table 2.6: Person miles of Travel and Average Vehicle Trip Length By Purpose.

Year	Daily Vehicle Miles per Household	Persons per Daily Household	Vehicle Miles per Capita	Vehicles per Household
1969	34.0	3.2	10.8	1.2
1977	33.0	2.8	11.7	1.6
1983	32.1	2.7	12.0	1.7
1990	41.4	2.6	15.9	1.8

Table 2.7: Trends in Selected Travel Parameters.

neighborhood car. A trip to work with a stop for shopping on the return home would accumulate 23 miles or less on average if the shopping stop was on the way home from work. If one-half of the vehicle miles per household (Table 2.7) where served by a neighborhood vehicle, on average a vehicle range of only 22 miles would be needed. The impression is that there are lots of trips that could be served by a neighborhood car with a range of about 20 miles, a range comparable to that of today's golf cart.

Looking at the data another way, they indicate that on average a vehicle with a 20 mile range could serve all family trips on about 50 percent of the days of a year; a 40 mile range vehicle would serve for about 80 percent of the days. Again, those calculations are for present patterns of vehicle use. Patterns would be expected to change if neighborhood vehicles were owned and operated.

[These are aggregate national data for a day of travel. More informative information becomes available when data are cross classified and matched with information on the attributes of households. Such analyses were published from previous surveys. (33)]

But would these travel patterns hold if the neighborhood car was available to the household? The neighborhood car is imagined as either a substitute for a second or third vehicle in a household or as an addition to the household's inventory of vehicles. The kind of information in the tables would reflect travel patterns only if the neighborhood car is a strict substitute for an existing vehicle in the household, a vehicle which is already used in the ways a neighborhood vehicle would be used. Then, it would be used for those trips where it served well, presumably for short trips on routes with little traffic and/or to places where parking a larger vehicle might be difficult. But it seems plausible that with a change in the inventory of vehicles available, households would change trip making. They would match their choices of vehicles and road facilities to be used with trip purposes.

As stressed earlier, the neighborhood car is imagined to have velocity, handling, and other attributes suited to local street operations. What's missing in the available travel data is information on the fine detail matching of routes (local streets, etc.) of travel, trip purposes, and trip lengths.

This discussion of vehicle purchase and use decisions has compared the neighborhood vehicle with the electric car and discussed available data on trip making. As pointed out at several places in the discussion, hard findings can not be given. The attributes of the neighborhood vehicle (cost, range, etc.) are such that it does not compare well with existing vehicles. The travel services it might provide would be different from those provided by conventional vehicles.

Safety

Fatalities per 10^8 passenger vehicle miles of travel per year is a common measure of the trend in highway safety. Taking the form of a reverse J-shaped curve, the trend traced sharply downward during the 1940s and 50s. It subsequently flattened, and annual decreases in fatality rates in recent years have been modest. Early safety gains were mainly due to improved highway facilities, traffic controls, and vehicles, with law enforcement, driver training, and other factors also playing roles. AASHTO and other highway organizations, traffic engineers and traffic enforcement organizations, private organizations, and the National Highway Transportation Safety Administration (NHTSA) have played important roles, with public attention in recent decades mainly focused on safer vehicles.

Crash Severity:

Focusing on the vehicle and considering it alone, a first conclusion is that the neighborhood car cannot be as safe as a conventional vehicle. The main reasons are its lighter weight and smaller size relative to conventional vehicles. Size limits the amount of crush space available to absorb energy in a crash, and at a given speed, occupants of neighborhood cars would be subjected to greater deceleration forces than occupants of larger vehicles. A measure of crash severity in frequent use today is delta-V, the change in velocity during a crash and crunch. If a small car without crush space struck a strong barrier at 20 miles per hour, the occupant would almost instantaneously reach zero miles per hour. The delta-V would be 20 miles per hour. Crush space would increase the time for deceleration and decrease delta-V.

Suppose a, say, 500 pound neighborhood car is involved in a head on collision with a 3,000 conventional automobile, each car moving at twenty miles per hour. The heavier vehicle will continue forward (conservation of momentum) and push the lighter vehicle backwards. As a consequence, the delta-V for the heavier vehicle will be less than 20 mph and for the lighter vehicle, the delta-V will be greater than 20 mph.

The probability of a fatality increases at an increasing rate as delta-V increases. It is about .01 at 20 mph and reaches about .2 at 40 mph. Returning to the collision between a light weight and heavy car as just discussed, the probability of a fatality in the lighter car would increase from about .01 if were involved in a head on collision with a fixed barrier at 20 mph to about .08 when colliding with a heavy car. The lighter car, and all cars for that matter, would be very much at a disadvantage in a collision with a heavy truck.

In addition to crush space, the probability of a injury or a fatality is affected by seat belt and air bag use, the incursion of the windshield or steering apparatus into the passenger space, lack of dashboard flexibility, and other matters. Vehicle lighting, braking, tires, and other vehicle attributes affect accident involvement and the severity of accidents.

NHTSA:

To improve vehicle safety, the National Traffic and Motor Vehicle Act of 1966 established the National Transportation Safety Administration (NHTSA) with safety as its charge. That Act represented a new approach. The view in part was that previous approaches had emphasized safe facility designs, including separation of traffic, and legal control of driver behavior through licensing, police, and court actions. It was felt that the gains from these approaches were diminishing if not nil. That is not to say that the approaches were not effective in the past. Improved highways improving safety, the interstate was three times as safe as ordinary designs. Traffic controls and enforcement efforts had positive impacts, but impacts were thought to be tapering. Approaches to vehicle safety improvements implemented by manufacturers were said to be half hearted and subservient to style changes. At any rate, consumers would not buy safety enhancements such as seat belts.

The approach in the Act, and especially in NHTSA actions, was public health in thrust. (34) That approach is not to rely on changed human behavior, but to implement interventions that prevent the hosts (vehicle occupants, pedestrians) being hurt by agents, the causes of injury or death. Examining an injury or fatality in this conceptual frame, the focus is on proximate cause. To illustrate, suppose a vehicle hits a tree (first collision), there is an energy transfer and the occupant strikes a decelerating but unyielding dash board (second collision). The failure of the dash board to yield and absorb energy is the cause of the injury or fatality, and the action needed is dashboard improvement. This illustration is over simplified, of course, but it does illustrate the pattern of thinking and NHTSA actions.

Number	Subject
201	Occupant Protection in Interior Impacts
203	Steering Wheel Impact
204	Steering System Rearward Movement
214	Side Door Strength
216	Roof Crush Resistance

Table 2.8: Selected Subjects From the MVSS 200 Series

Applicability of NHTSA's MVSS:

Since its inception, the NHTSA has issued numerous motor vehicle safety standards (MVSS). How might these apply to neighborhood vehicles? With respect to the MVSS, many of the standards could be met easily, especially the standards in the 100 series. These standards deal with tires, theft protection, rearview mirrors, glare from reflecting surfaces, controls and displays, lights and reflectors, and other vehicle attributes that it has been desirable to set minimum quality standards for and to standardize vehicle to vehicle. These are low or no cost requirements for vehicle manufacturers. It would be expected that any vehicle manufacturer would meet these standards as a matter of course.

It is the 200 MVSS series that complicates the neighborhood car situation. Table 2.8 provides a list of the 200 MVSS series we have identified as very difficult for an inexpensive, small, and light weight vehicle to meet. Meeting them would either be costly and/or add weight and size to the vehicle. Redesigning the vehicle to meet the standards would require size (for crush space) and weight (for strength) increases. In turn, there would be a need for larger engine size. In effect, the vehicle would increase in size and weight and become a conventional vehicle.

Applicability of Vehicle Definitions:

Anticipating increased numbers of small vehicles in the vehicle fleet, about a decade ago Sparrow and Whitford proposed that a new vehicle definition would be desirable. (35) The vehicles of interest to Sparrow and Whitford were micro/mini cars weighing about 1300 pounds and about 10 1/2 feet in length, smaller and less expensive versions of vehicles of a size class found in several nations other than the United States. They proposed that if conventional crashworthiness standards were applied, there would be weight and cost increases shifting these vehicles into size classes already available in the U.S. market. Concerned mainly with energy efficiency, the authors see the application of MVSS as thwarting the marketing of a possibly socially valuable product.

Sparrow and Whitford reviewed the history of NHTSA rule making. At first (in 1967) all four wheel vehicles under 1,000 pounds were exempted from NHTSA rule making because it was not possible for such vehicles to meet the standards. In 1970 NHTSA was petitioned to revoke the exemption because of risk of harm to the motoring public, and it did so in 1973. At that time no such vehicles were in production, and NHTSA stated that exemptions could be made on a standard-by-standard basis. As already mentioned, some standards, such as those treating glaze could be met with ease. Today, rule making recognizes:

> **The Passenger Car.**
>
> **Open Body Type** Vehicles...no occupant compartment or a top that can be removed and installed by the user.
>
> Motorcycle...having a seat or saddle...and designed to travel with not more than three wheels on the ground.
>
> **Multi-purpose Passenger Vehicle**...on a truck chassis or with features for off road operation.

And other vehicles not of interest in this discussion. The vehicles other than the passenger car are expected to meet certain passenger car standards and are exempted from others.

The discussion above is a short version of the Sparrow and Whitford discussion; there are omissions not directly relevant to the present discussion.

For the neighborhood car, the passenger car classification is not workable, as already discussed. The car could be an open body type in fair weather areas. By using three wheels, it could be a motorcycle although some motorcycle features, such as the throttle arrangement, would not seem reasonable or necessary. Also, if the three wheel vehicle is classified as a motorcycle, it is not to be fully enclosed. (The classification accommodates a two wheel motorcycle with a side car added.)

Sparrow and Whitford concluded that a new definition was necessary for the small vehicles of interest to them. For the neighborhood car, we reach a similar but tempered conclusion. The open body or motorcycle classes provide some opportunities for vehicle producers, perhaps enough for the exploration of vehicle purchase and use, appropriate roads, and markets in some market niches. Put another way, for a beginning exploration of market niches, NHTSA regulations are a bother but not an absolute barrier to initial experimentation. They may become a barrier to market expansion beyond limited market niches.

Compensatory Behavior:

Delta-V considerations say that small cars must be inherently less safe than large ones, and safety researchers have quantified risk increases as weight is reduced. For example, risk increases were found by Redmond, Schmitz, and Friedman's extensive analysis of 1976 and 1977 fatal accident record system data (FARS). (36) On page 111 they provide a figure plotting fatality rates against curb weights, and,the figure strikingly illustrates the finding: vehicles in the Chrysler New Yorker and Buick LeSaber weight range have about one third the fatality rates of lighter weight vehicles such as the Dodge Colt and Ford Pinto (data for 1974-1977 vehicles).

The delta-V inference is an all other things being equal inference. Compensatory behavior may intervene in the relationship, especially for the neighborhood vehicle. There has been a vigorous debate about compensatory behavior in the context of mandated safety improvements to vehicles. To illustrate to notion, suppose regulations require that a vehicle have antilocking brakes and an air bag. Knowing the contribution of these to safety, the driver might take more risk than otherwise, indeed, take enough more risk that the expected advantages of the safety devices are not achieved. Needless to say, the compensatory behavior conjecture is not welcomed by regulators and those in related efforts. After study and debate it is generally agreed in the safety community that the influence of compensatory behavior is nil or zero.

But the situation could well be different for the operators of neighborhood vehicles. Drivers would certainly be aware of the safety characteristics of the vehicle and behave accordingly. But that is a conjecture that is yet to be proved, and it is counter to conventional views of the affects of compensatory behavior.

But there is some evidence that compensatory behavior does play a role in small vehicle situations. On the downside, it appears that small vehicles are tailgated more than conventional vehicles. (The headway between a small vehicle and a following vehicle is smaller than average. See Reference 35 for a full discussion.) The result is relatively increased rear end collision involvement.

Safe or Unsafe:

Quoting a study by Yanese that we have not examined, Sparrow and Whitford report that small cars in Japan cause about 40 percent fewer fatalities (fatalities per vehicle km) than the average for the Japanese fleet and they compare this finding with data from the U.S. dealing with where vehicles are operated. The General Accounting Office (GAO) has questioned whether weight reductions have increased highway fatalities. (37) We have not full analyzed the materials just mentioned or sought other materials that might be pertinent, but have examined enough material to agree with Sparrow and Whitford that one should be cautious about the conclusion that smaller vehicles mean less safety.

Whatever the situation for smaller conventional vehicles, the neighborhood car, it seems to us, may be quite safe. Certainly the neighborhood car would be enough different from conventional cars that operators would engage in defensive compensatory behavior. Also, the situations in which neighborhood cars would be used would reduce conflicts between small and large vehicles and call for low speed driving. There is enough evidence of the type that Sparrow and Whitford cite to suggest that increased use of neighborhood cars would reduce fatalities.

But would NHTSA be comfortable with that conclusion. First, it's speculative and is based on extrapolation from data on small conventional vehicles. NHTSA's experience in rule making has taught it that endless and costly challenges to rules turn up when information is fuzzy. It is not likely that it would offer exemption for neighborhood vehicles on the basis of a probably-as-safe argument. Second, because neighborhood cars would be light weight and small, occupants of neighborhood cars will be more at risk that occupants of larger cars in given accident situations. NHTSA can properly ask if users should be less well protected in any vehicle; users have a right to the level of safety that the rational rule making process has achieved. On broader grounds, recall the public health ethic that guides NHTSA thinking. The agent is to be controlled, e.g., the steering wheel post must be controlled so that it does not injure vehicle occupants. There is no way to know whether NHTSA would regard the neighborhood car as safe because it operates in benign environments and because users compensate for its characteristics or regard it as unsafe because of light weight, lack of crush space, etc.

Vehicle Registration, Drivers Licenses, Constrains on Uses

Again, our hypothesis is that neighborhood cars might encompass a variety of vehicle sizes and performance characteristics suited to environments and uses, although they would have the common characteristic of being much smaller and less expensive than vehicles currently available on the market. They would be operated mainly on the local road system and/or on routes specially tailored for them. States have vehicle registration and drivers licensing systems. They allow the operation of passenger cars on most roads. How would these state regulations apply to neighborhood cars? One option would be to apply them as is. Another would be to develop regulations specially applicable to neighborhood cars.

Uniform Vehicle Code:

The Uniform Vehicle Code dates from the 1920s. With the growth of the motor vehicle population and uses after World War I, accidents, injuries, and fatalities increased and part of the blame was placed of the lack of uniform laws among states. Following a meeting called by the Secretary of Commerce in 1924, a National Committee on Uniform Traffic Laws and Ordinances was established in 1926. The Committee had about 160 members representing interested groups, and was divided into working groups. (38) Its work continues, and the Committee has published, revised, and republished its recommendations from time to time. (39) The states and cities have adopted most of the recommendations of the Committee, although some differences among government units remain.

The Act establishing NHTSA in 1966 empowered NHTSA's establishing standards in areas many of which were already treated by the Uniform Vehicle Code. Areas included: 1. vehicle registration, 2, motorcycle safety, 3. highway construction and maintenance, 4. pedestrian safety, 5. traffic control devices, 6. vehicle inspection, 7. driver education, 8. driver licensing, 9. traffic courts, 10. alcohol in relation to traffic safety, 11. identification and surveillance of accident locations, 12. traffic records, 13. emergency medical services, 14. police traffic services, 15. hazard control and clean up, and 16. codes and laws. The codes and laws area shapes the main aspects of the other 15 areas, of course.

The Department of Transportation subsequently asked that the individual states develop and implement programs to achieve uniform codes and laws within the state and consistent with other states. The existing mechanism of the Committee and the Uniform Vehicle Code continued in its role, with the role strengthened by NTHSA enforcement. Enforcement involves withholding federal highway funds if plans and progress falter. The most recent materials we have found indicate some divergence remains among the states with respect to the adoption of the Uniform Vehicle Code. (40)

Classification, Registration, Driver's License:

The closest model for the neighborhood vehicle is the golf cart. The Uniform Vehicle Code classifies the golf cart as a motorcycle. A motorcycle is any vehicle, other than a tractor, that has a seat or saddle for the rider, weight not more than 1,500 pounds, and has not more than three wheels. Four wheels are allowed if two are part of a sidecar. The golf cart is expected to comply with motorcycle equipment and other requirements except for equipment solely applicable to a motorcycle. For instance, motorcycle operators are required to wear helmets in most states, but they are not required for a golf cart. While the golf cart is classified as a motorcycle, it is registered as a passenger car in the State of California.

The Uniform Vehicle Code recommends classes of drivers' licenses, with the motorcycle requiring a special license.

The Attorney General of the State of California has provided an Opinion of the California Vehicle Code with respect to golf carts. (41) In California, a golf cart must have an empty weight of less than 1,300 pounds and be designed to carry not more than two persons and golf equipment. It must be designed to operate at less than 15 miles per hour.

The Attorney General's Opinion should be consulted for a full statement of the situation. As we understand the Opinion:

> A golf cart may be operated on local streets and highways with speed limits of 25 miles per hour or less if the golf cart is properly registered and equipped and is operated by a licensed driver.
>
> Local authorities may designate streets for combined golf cart and other traffic, but not on streets with speed limits greater than 25 miles per hour. Golf carts may not cross streets with speed limits greater than 25 miles per hour.
>
> Local authorities may ban golf carts from certain local streets if particular conditions warrant.

The Opinion was motivated by two sections of the Vehicle Code, sections that lead to uncertainty of interpretation. Prior to 1968, the Vehicle Code did not treat golf carts differently from other vehicles so far as registration and required equipment were concerned. In 1968, golf carts were exempt from registration requirements if they were operated on roads and streets designated by local authorities.

Discussion:

As stated at the beginning of this subsection, it is imagined that varieties of neighborhood vehicles might emerge, with vehicles and their uses depending on local situations and the ways road facilities might evolve or be redesigned. In the‘best of possible worlds, requirements for vehicle equipment and registration, constraints on road facilities where vehicles may be used, and requirements for the licensing of drivers would be tailored to situations. In reality, of course, the issue is that of how the Uniform Vehicle Code might be changed to accommodate neighborhood vehicles.

With respect to golf carts, local communities in California can designate suitable roads and streets and registration requirements are bypassed for equipment operated on those streets. Similar in many ways to golf carts, it appears that minor changes to the Vehicle Code would permit similar actions with respect to neighborhood vehicles, needed would be defining neighborhood cars as a class of vehicles to which golf cart regulations apply. The probation against crossing roads with speed limits greater than 25 miles per hour would remain, however, and unless changed this might limit available market niches. This is because residential neighborhoods are often traversed by arterial roads with speed limits greater than 25 miles per hour. It may be necessary to cross such an arterial to reach some trip ends such as a shopping center.

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3. Neighborhood Cars for Livable Neighborhoods

Case Study: "A Community of Four Neighborhoods."

In this section of the report we describe a future community where residents drive small neighborhood cars. The drawings explore how a design professional might plan the physical dimensions of a community taking into consideration the reduced space requirements for small vehicles.

The four neighborhoods differ in character and density. They are placed in a gently sloping valley. Located at the entrance to the valley are stores and services including parking for regular cars and storage of special purpose vehicles. The neighborhood with the greatest density is situated on the valley floor. Lower density neighborhoods are located on the slopes.

A community designed for residents with small cars has a number of important benefits. They are discussed here and in summary they include: a surplus of space gained from reducing circulation space, an ecological advantage of road designs that can follow topography without cut and fill of land, and a greater variety in the types of circulation spaces. These advantages result in a

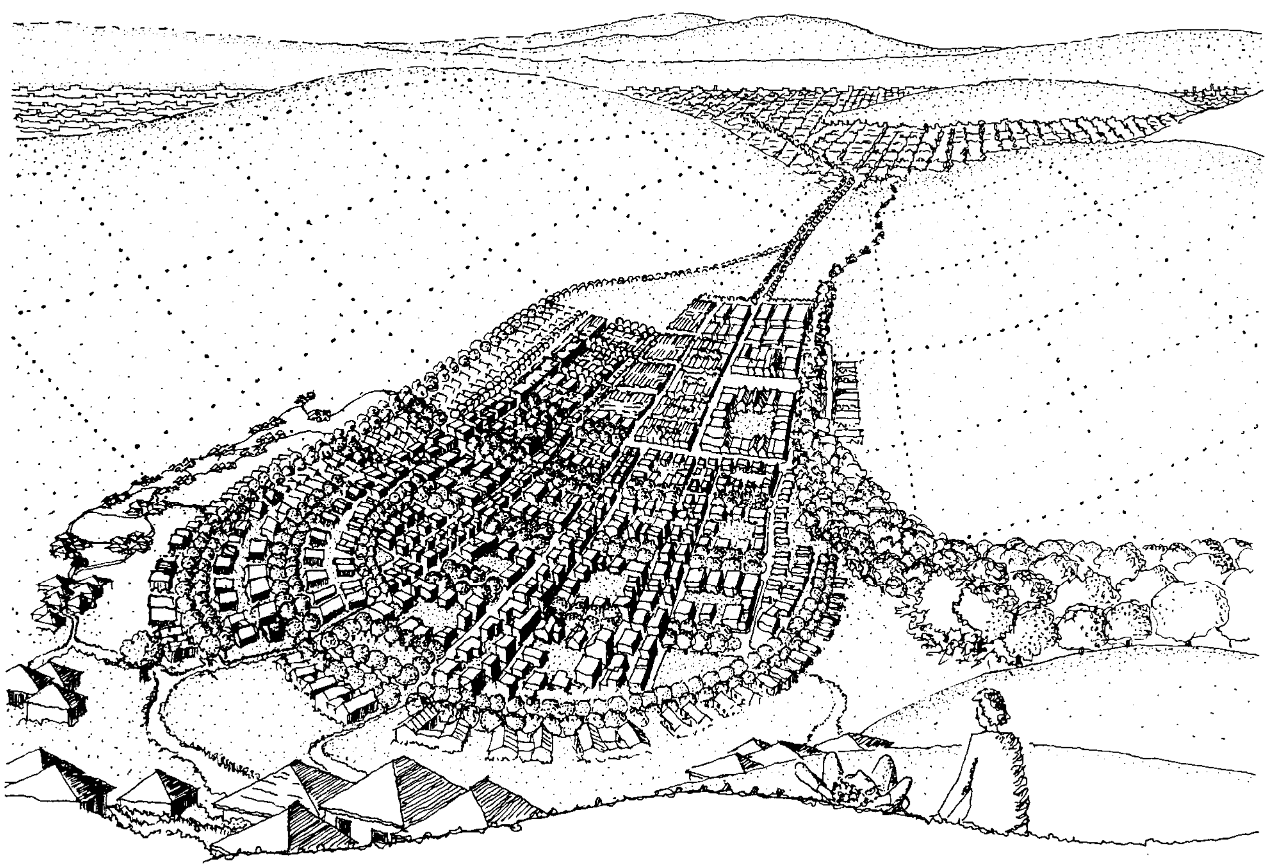


Fig. 3.1: Community for Small Neighborhood Cars

community that is reminiscent of places layed out early in this century, prior to the widespread use of automobiles.

We designed four neighborhoods and assumed that they would be built by one developer. This planned community would be large enough to sustain stores, recreation, medical and other services.

For the purpose of our designs, we simplify the design parameters of the community by assuming that road ways would need to accommodate small cars only. We assumed that in this community of the future all residents would have small neighborhood cars. The residents would have given up their regular sized cars, or would park them at the periphery of the community to be used for trips outside the neighborhoods. Also, we assume that the community is large enough to invest in its own fleet of small garbage vehicles, weighing not more than 2000 pounds. Similarly, our community has its own fleet of small fire trucks and emergency vehicles.

Truck deliveries are made to one or several central facilities where there is shopping. Goods destined for home delivery are transferred to small vans and trucks that

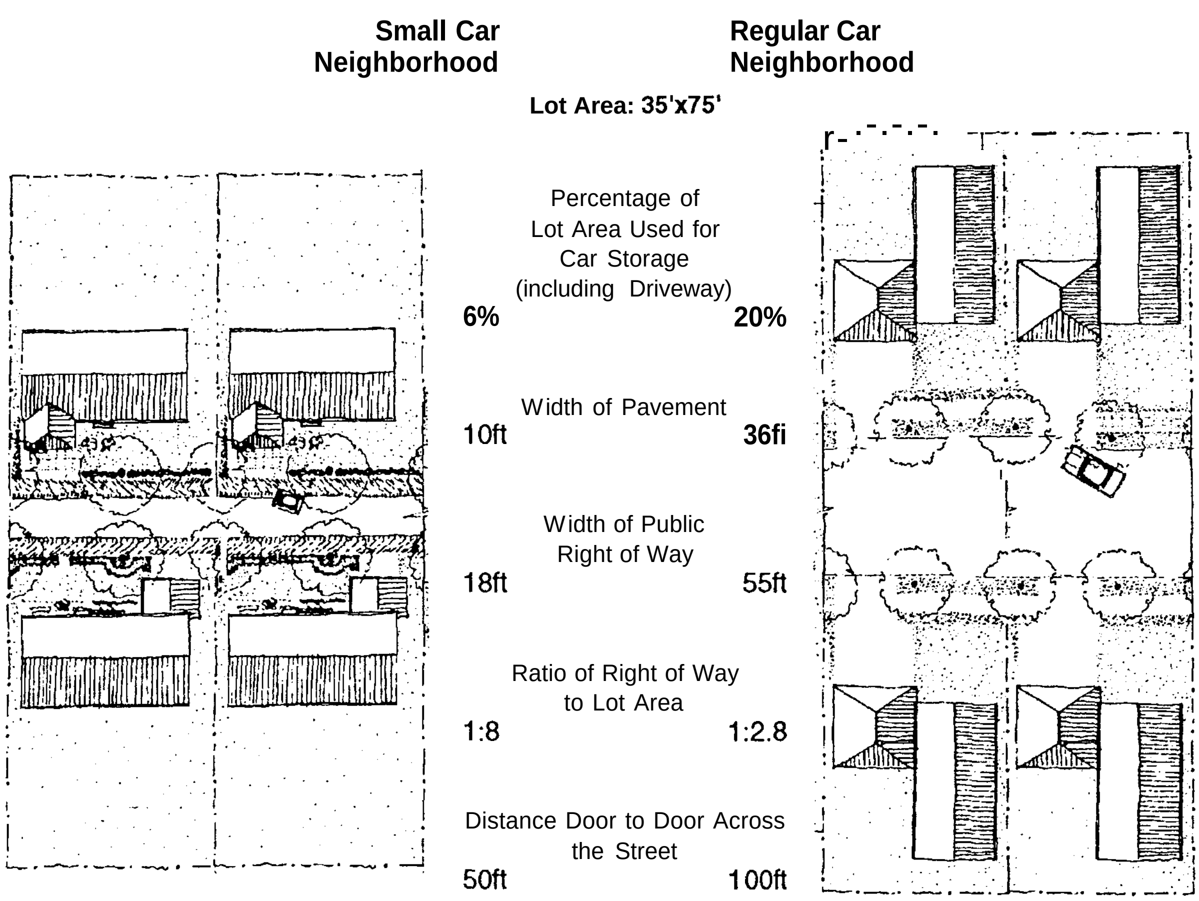


Fig. 3.2: Comparison of Neighborhoods

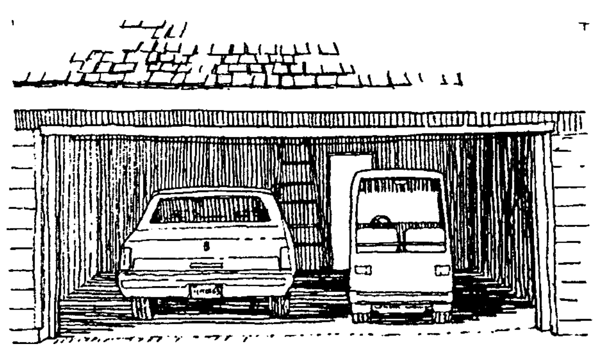
measure 5 by 8 feet. A family moving into the community will have the moving vans park at the periphery of the community where their load is transferred to small vans and brought to'the individual home.

In the planned community, the space gained from reducing the circulation area could be used in a number of ways to benefit the people living in such a neighborhood. In principle there are two ways of using this surplus space. It can be used to build additional housing, thus increasing the density and lowering the cost of residential units, or the space can be used for additional recreation space. In a large community like ours the surplus in space has been divided to increase density as well as to provide additional open space.

Prior to designing the four neighborhood scenarios, we visited a number of leisure communities with extensive recreational facilities, such as golf courses, created for people approaching or at retirement age.

In leisure communities, we observed many people already using golf carts for most local trips. In one place people take golf carts to nearby shopping centers and to banks outside the community. In front of stores and banks, separate parking spaces are designated for small golf carts. (generally three spaces per regular parking space). Powered by gasoline motors or electric engines, these vehicles travel on roads alongside regular size cars and various types of delivery and service vehicles.

Several of these communities exist in Southern California and in the Bay Area. Not necessarily would our neighborhood scenarios take place in such a community for the elderly, they could describe neighborhoods where people of all ages live. However, visiting communities for the elderly allowed us to observe how people move from their home to the golf course, to stores and services all within their community.



The Four Neighborhoods

Houses in Clusters.

In the first neighborhood, up on the slopes of the valley, houses are clustered around courtyards with the land between clusters left unchanged in its natural condition.

The clusters are connected by lanes similar to those in rural areas that follow the gently sloping terrain without cut or fill (fig. 3.4). The lanes, called swaths, have soft edges without curbs. The surface can be made from a variety of materials hard enough to support a small truck. In addition to the

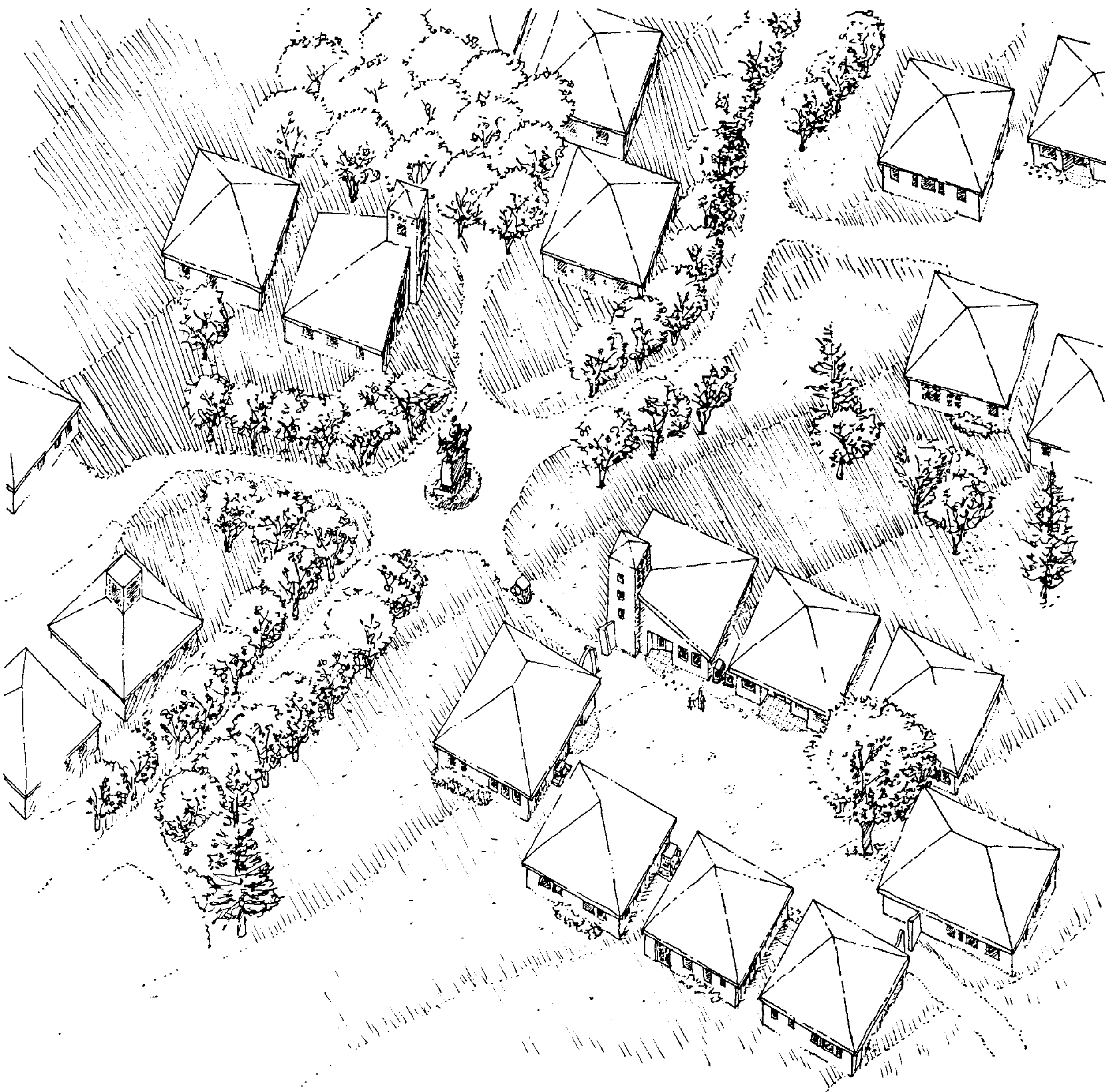


Fig. 3.3: Houses in Clusters

swaths, footpaths would connect each cluster on the shortest route with the other neighborhoods down the slope. Pedestrians are free to walk along the swaths. They are shared space of generally 10 feet in width, but depending on terrain, swaths might narrow to 8 feet. If two swaths cross, they are free to meet at an angle determined by topography. At these intersections the surface widens to 12 feet.

In this type of neighborhood, the density is low at 4 units per acre or less. The space gained by reducing the dimensions of the roadways is added to the open space between clusters. This results in an open rural setting allowing for distant views across the valley and down the slope to the adjacent neighborhoods.

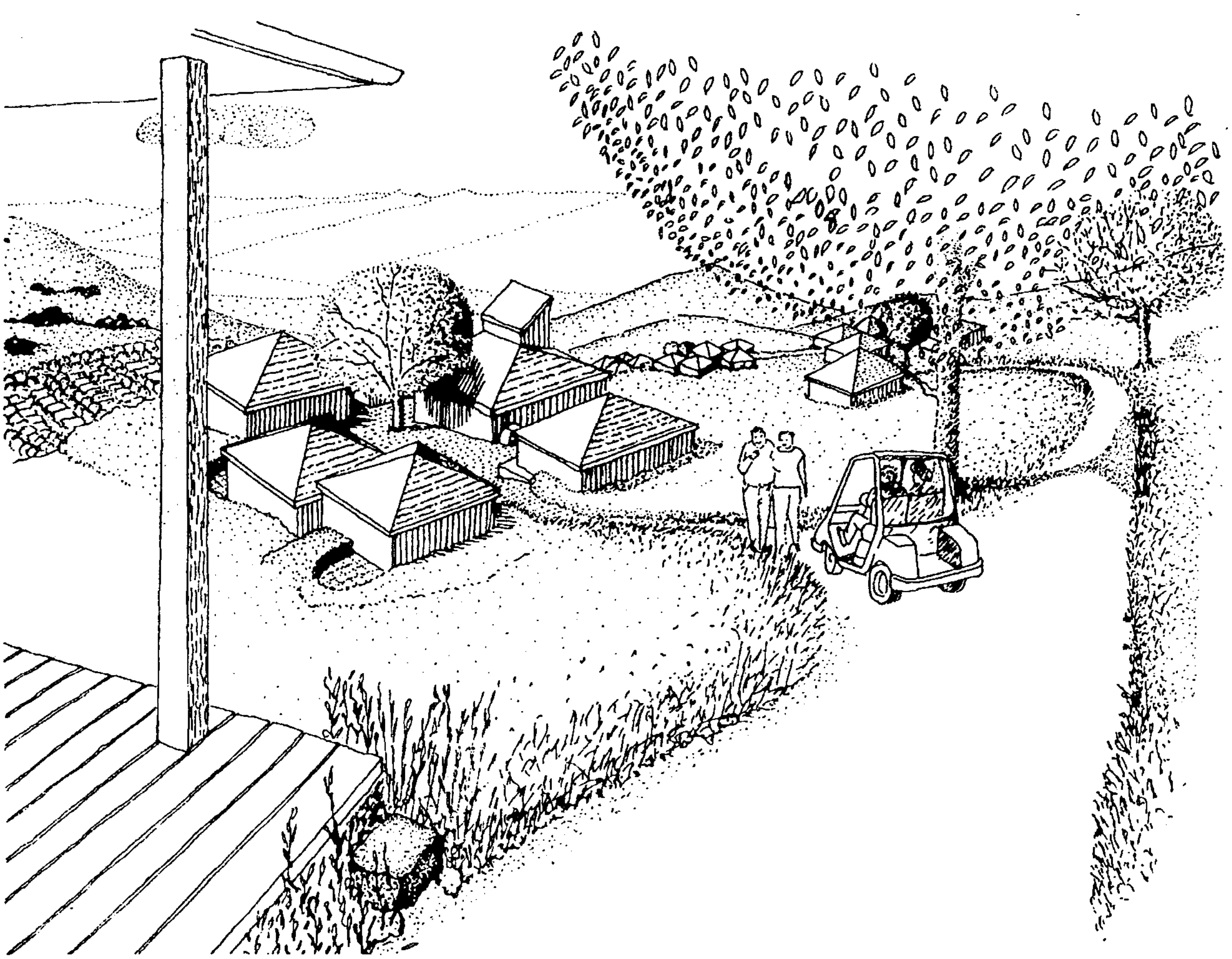


Fig. 3.4: Lanes That Follow the Terrain

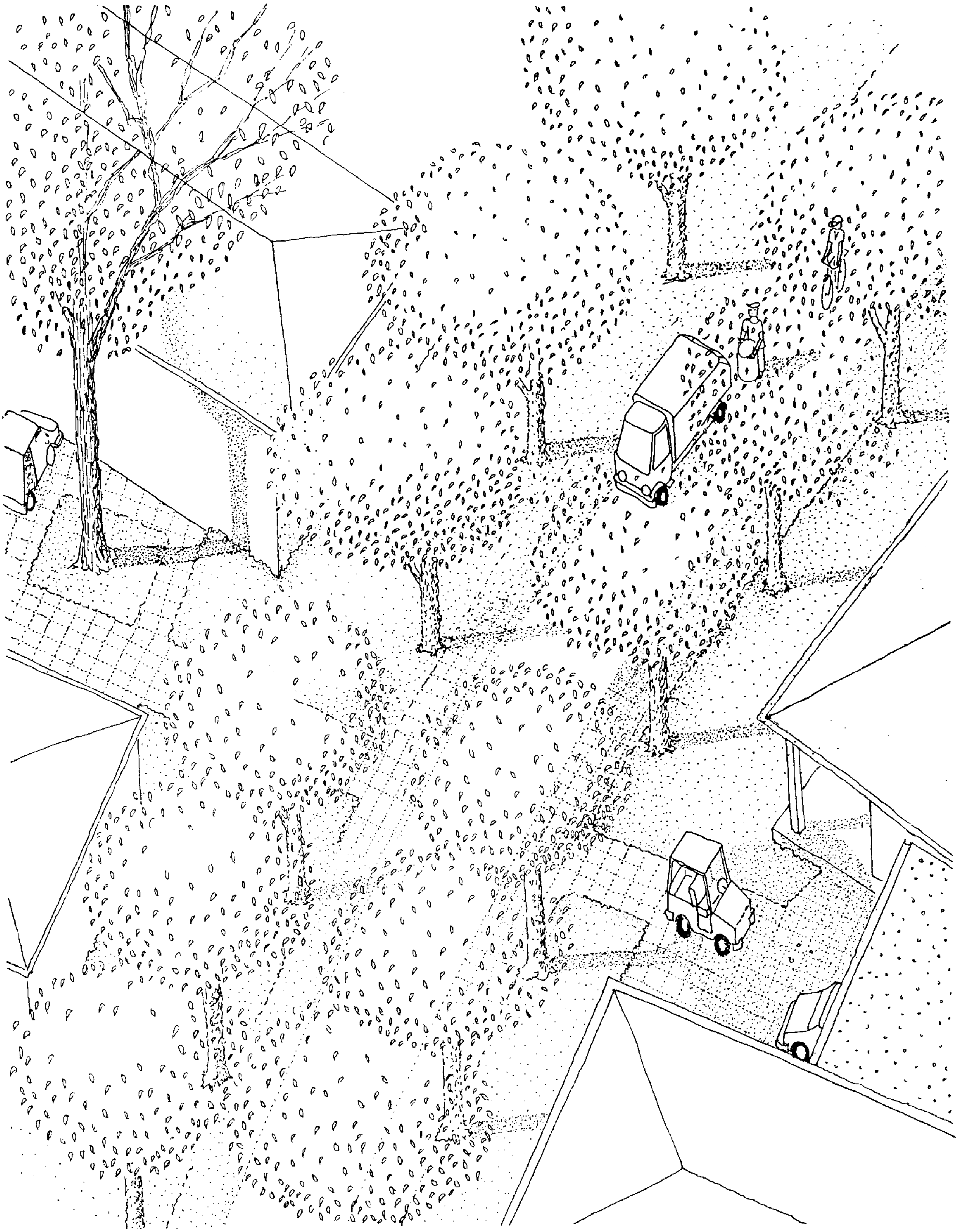


Fig. 3.5: Houses Along Tree Shaded Lanes

Houses Along Tree Shaded Lanes

Upon entering the second neighborhood the swaths turn into formal lanes shaded by regularly spaced trees. Here the pedestrians have the legal "right of way". Car drivers share the street space with pedestrians. The lanes are 10 feet wide with 5 feet for parked cars on both sides resulting in an entire hard surface width of 20 feet between trees (Fig. 3.6). At intersections an inner radius of 7 feet is observed allowing neighborhood cars to turn at approximately 8mph. The lanes curve slightly with the terrain. Every 130 feet lanes intersect at right angles to form blocks that measure 400 x 130 feet. The distance between buildings measured across the lanes is 50 feet.

The houses are small single story semi-attached homes with small carports near the entrance porches. The distance between the porches and the lane measures 15 feet. Pedestrians walk along the lanes, sharing the space with small cars.

Along a conventional street with semi-attached single family homes, this layout would yield a density of approximately 10 units per acre. With roadway narrowed, the density increases to 14 units per acre (assuming an identical lot size of 35 x 75 feet, Fig. 3.7).

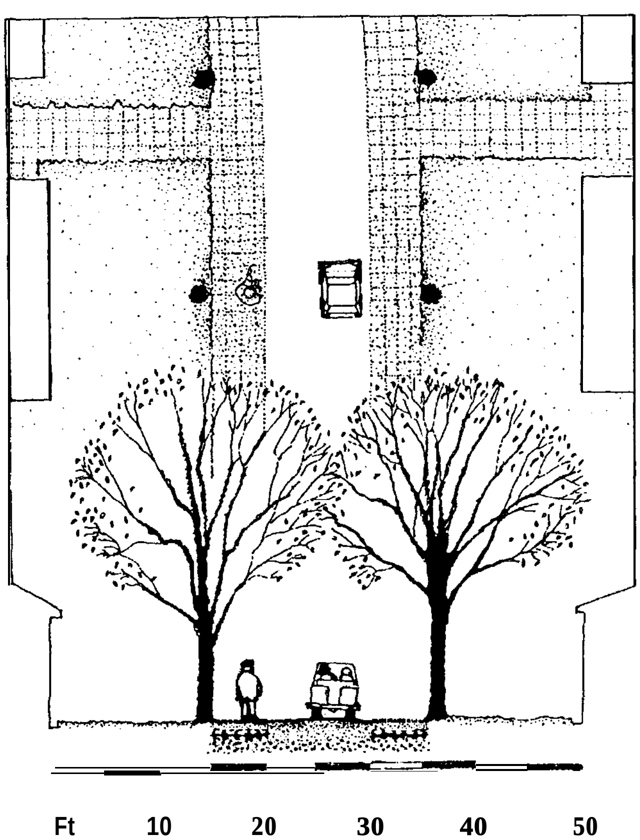


Fig. 3.6: Twenty Foot Right of Way

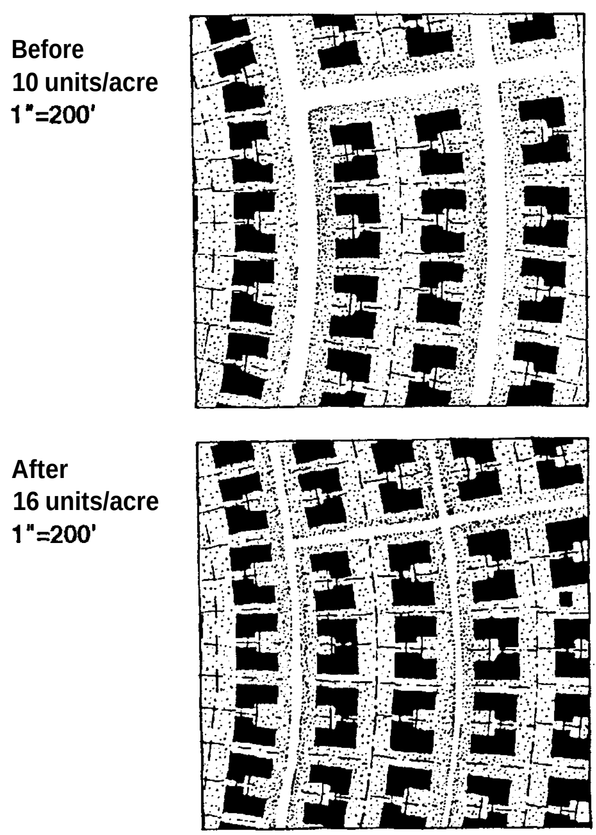
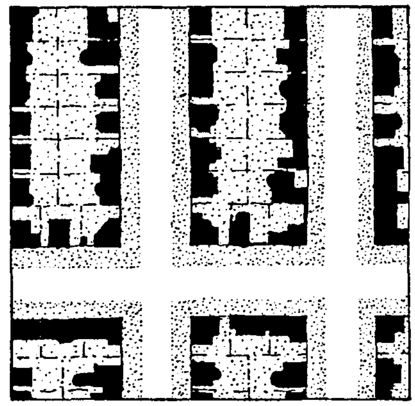


Fig. 3.7: Comparison of Street Layout

Houses Around Garden Squares

The third neighborhood is built up of two story houses containing upstairs and downstairs units. The houses form small squares used for gardening, pools or tennis courts. Short streets without sidewalks connect the squares. The squares and the two story building height give this neighborhood a more urban character than the previous neighborhood.

Before
12 units/acre
1"=200'



After
14 units/acre
1"=200'

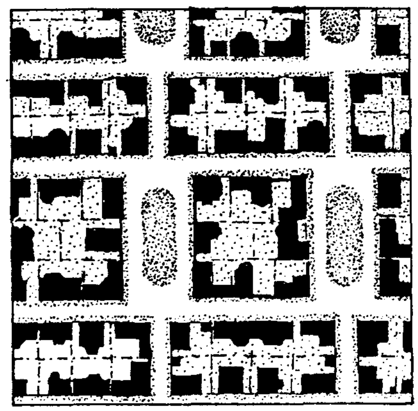


Fig. 3.8: Comparison of Street Layout

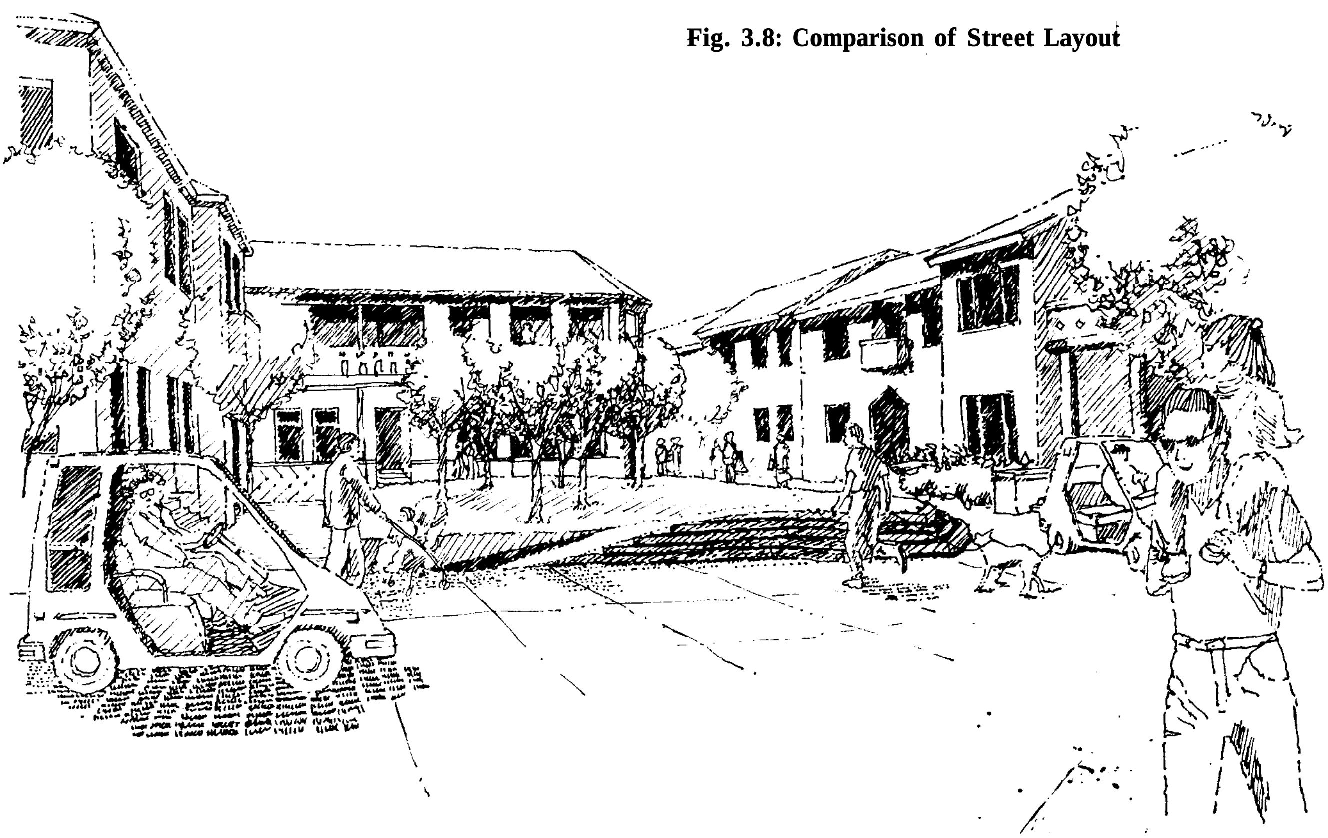


Fig. 3.9: Houses Around Garden Squares

Part of the surplus space gained from reducing roadways is arranged in the squares. The width of these squares equal the cross section dimensions of a conventional right of way, but the width is now used as recreational spaces. The other part of the surplus is used to increase the density. Due to the reduced roadway width this design yields a density of 14 units per acre compared to the 12 units per acre of a design with conventional roadways (Fig. 3.8).

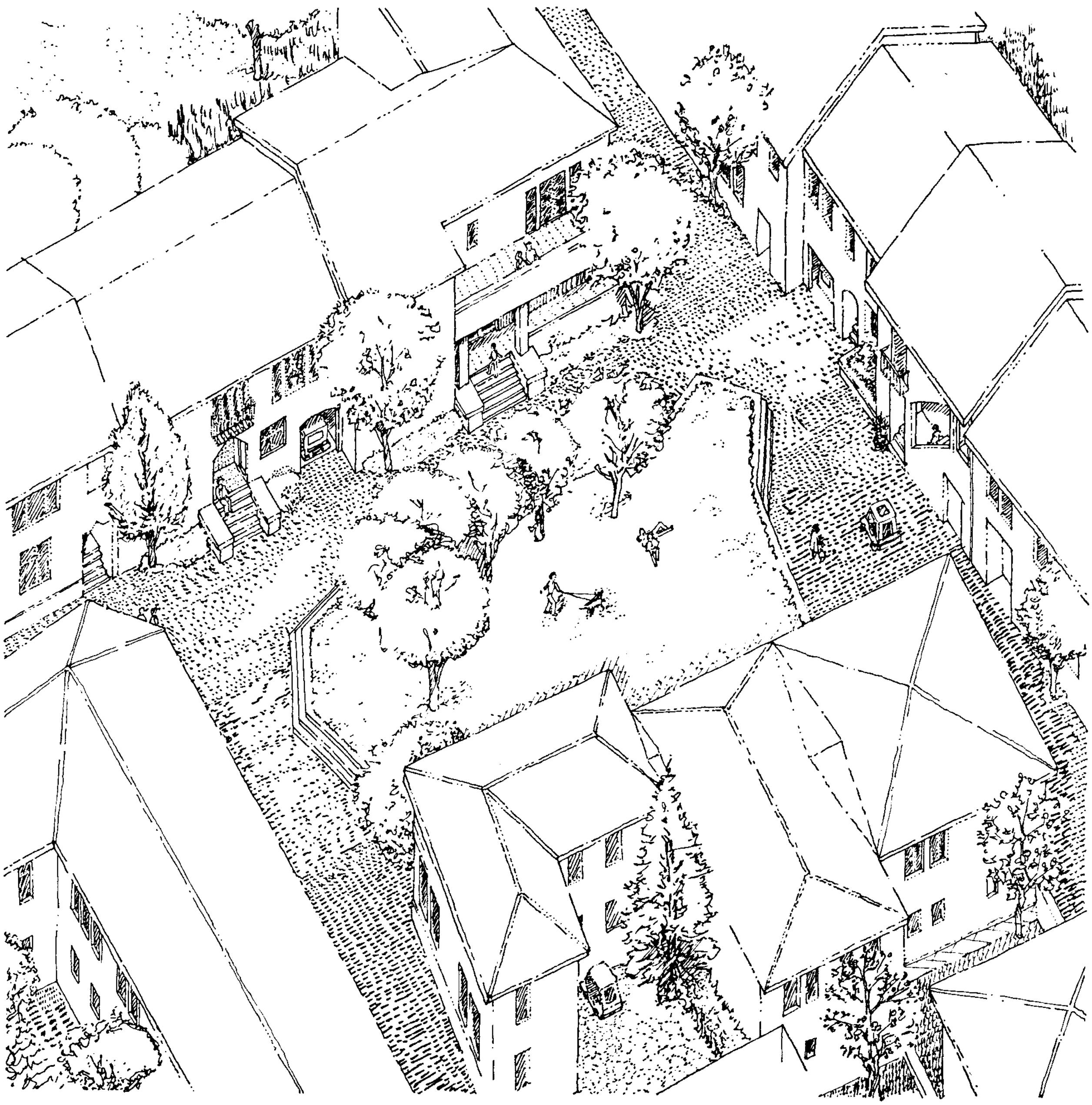


Fig. 3.10: Houses Around Garden Squares

A Small Town at the Center

The character of the fourth neighborhood is that of a small town. Row houses front the property line. Their entrances have porches or archways directly off the street. The small cars are driven through a 6 foot wide gate into carports. The streets, paved across their entire width with stone or bricks, are shared by pedestrians and small cars.

Of the four neighborhoods, this one has the most urban appearance. The dimensions of street and city blocks resemble a community built prior to the widespread use of automobiles, like the Chinatown or Northbeach sections of San Francisco, the downtown portion of Carmel in Central California, or even the remnants of the historic Spanish center of Los Angeles. In this future community such a layout is now well suited to accommodate small neighborhood vehicles.

Space gained by reducing the roadway is used to increase the density. The density of this neighborhood ranges upwards from 16 units per acre, with the maximum density at about 32 units per acre. The public right-of-way has cross-sections between 17 and 24 feet to allow easy movement of small cars and pedestrians in both directions (Fig. 3.11). Wherever required, bollards separate travel space from walking space.

People who decide to live in this neighborhood would be closest to services, including meals and medical care. Due to the relatively high density and close distances, services can be provided more efficiently.

17 ft
Wide

24 ft
Wide

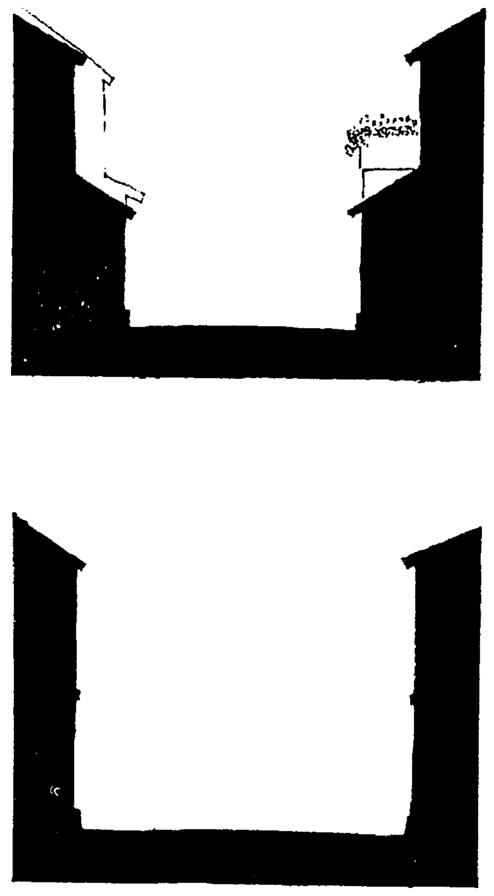


Fig. 3.11 Street Sections

1"=200'

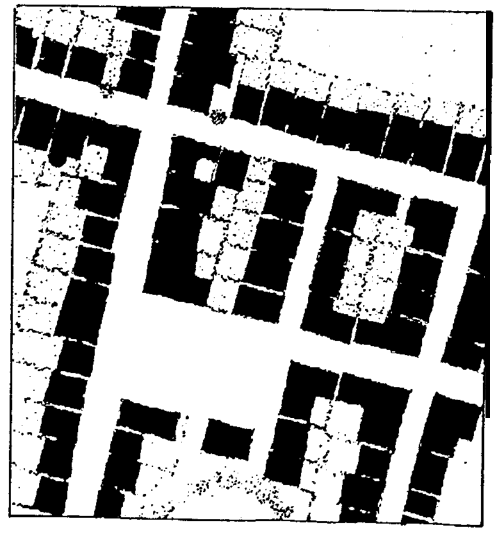


Fig. 3.12 Street Layout

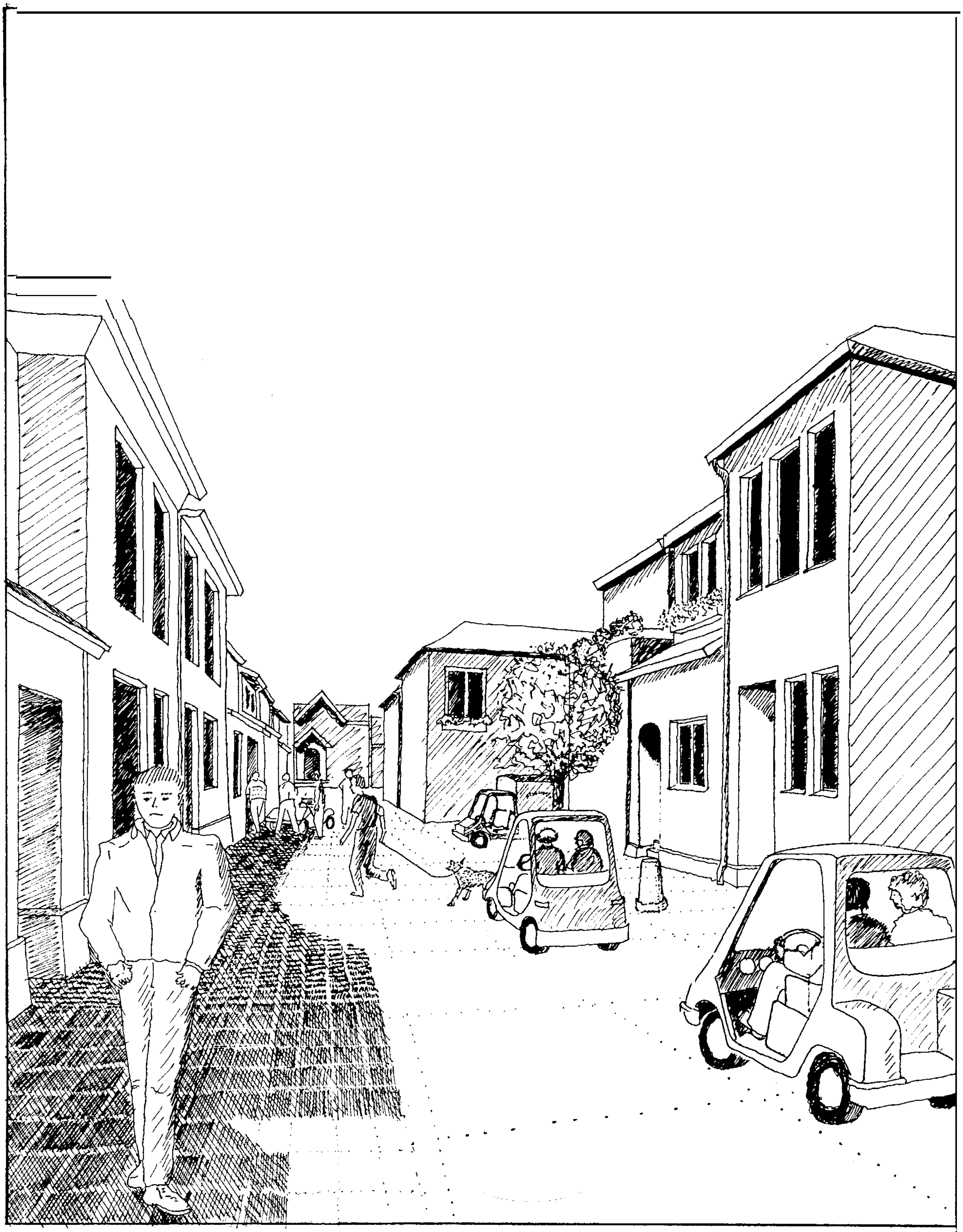


Fig. 3.13: Small Town at the Center of the Community

Case Study: Emeryville

In the preceding part of this chapter we assumed that neighborhoods could be built with roads that are exclusively used by small neighborhood cars, Regular sized cars would reach the periphery of the community where they could be stored and passengers would transfer to smaller vehicles. In the remaining part of this section we explain how an existing town, the City of Emeryville in California might be transformed after the introduction of small neighborhood cars. Here, we assume that an increasing number of small cars would circulate on streets designed for both neighborhood cars and regular sized vehicles.

We have selected a one thousand by one thousand foot square of land in the City of Emeryville with a mix of land uses and trip modes. The square reaches to the north and south of Stanford Avenue, a major artery that crosses San Pablo Avenue. Here Stanford turns into Powell Street, a street that connects to Interstate 80. The right of way is 100 feet

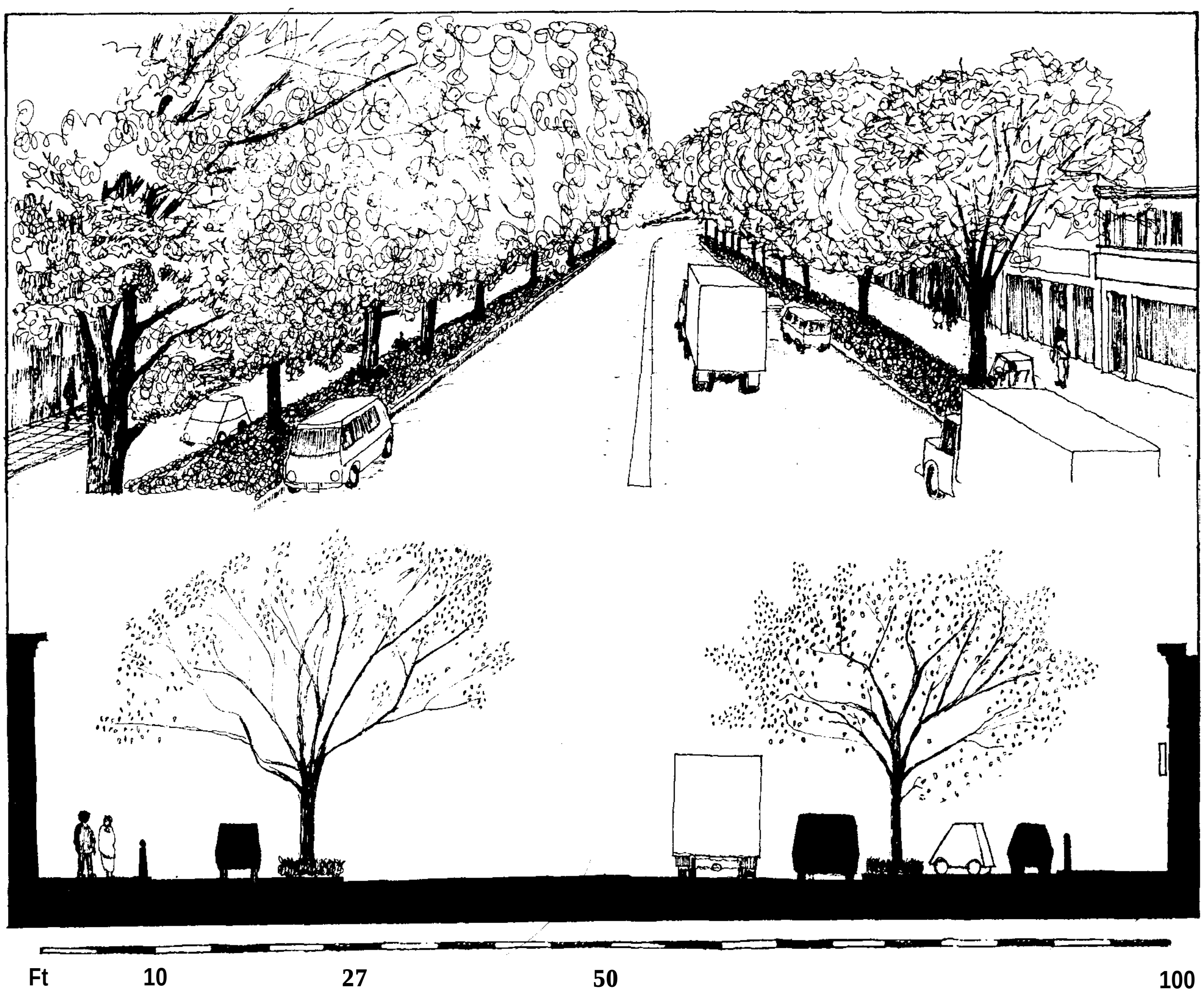


Fig. 3.14 Stanford Avenue with Local Access Street

wide east of San Pablo Avenue and narrows to 80 feet at Powell Street.

The Avenues are crossed by residential streets lined with predominantly single family homes on 35 foot wide lots. Small side yard and driveways connect to garages or carports on the side and to the rear of properties. The homes originally built after the turn of the century are occupied by families in the low to median income groups. Households have two or more cars. Many have vans or pickup trucks.

Fig. 3.15 Emeryville, Before

After small neighborhood cars have been introduced the transformation would be incremental. If only a few residents own and use small neighborhood cars, there would be no need for major physical changes. Those who use small cars would be concerned about conflicts between their small cars and regular sized cars, especially trucks. To respond to this concern, Emeryville might install traffic lights at the intersections of the residential street with Stanford, Powell and San Pablo Avenue. Similar to bicycle lanes, lanes exclusively for small cars might be set aside near intersections and traffic lights phased to accommodate the movement of small cars separately from regularly sized cars. We have illustrated such an intersection in Fig. 3.16.

Emeryville in the Future

Physical changes to roadways and at intersections would be considered if most people in this neighborhood and everywhere

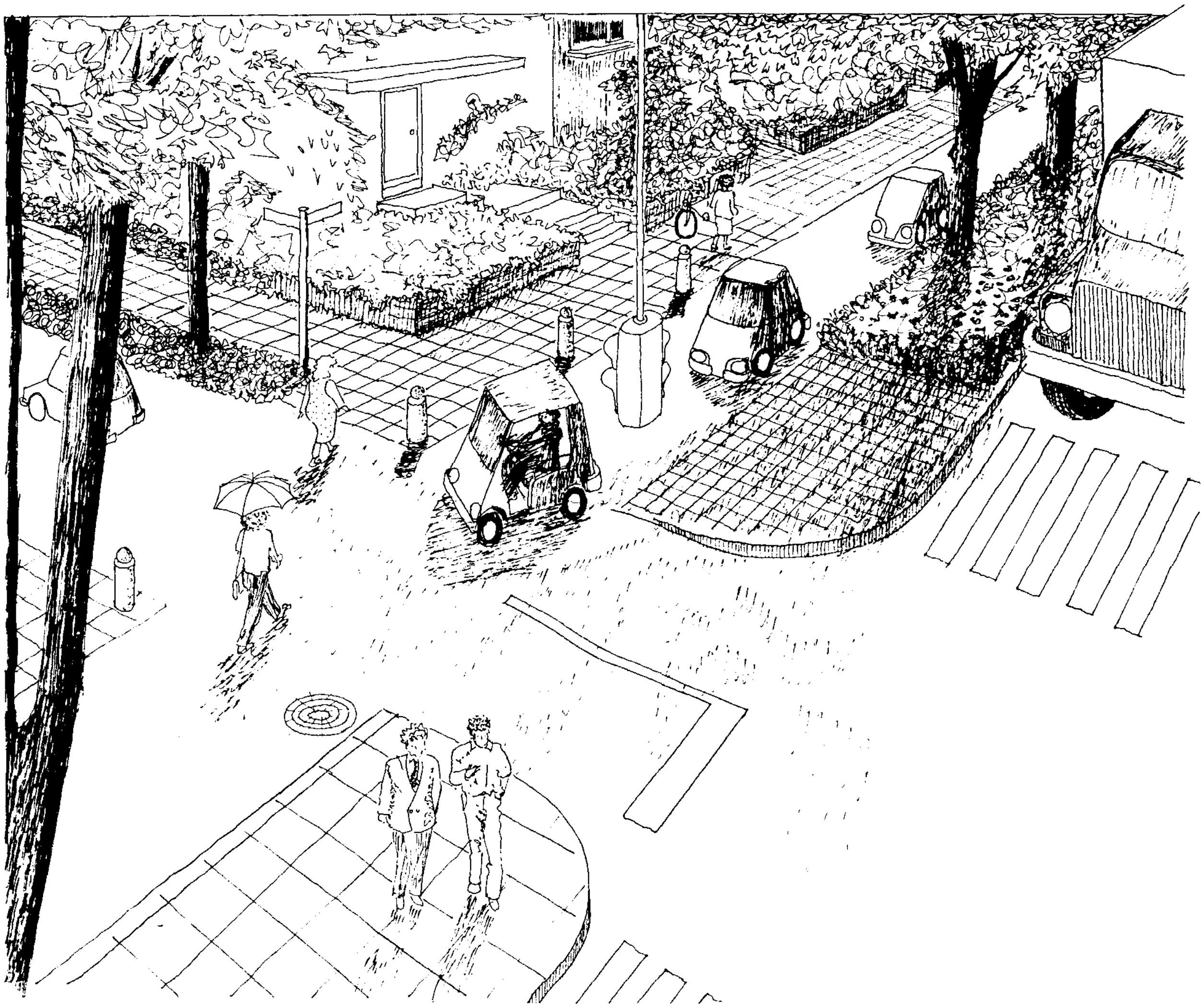


Fig. 3.16 Separate Lane for Small Cars Along Avenues

else would start to use small cars. In fact, local communities would resist physical changes to roadway width and intersection dimensions unless they see the need to invest in a fleet of small service and emergency vehicles. In the next scenario we have assumed that small garbage trucks and small fire engines are now in use. We also assume that most local private delivery services have converted to small cargo vehicles. Only the trucking companies still use large trucks and they would still travel on Stanford and Powell Avenue to the freeway or to Port of Oakland container terminals.

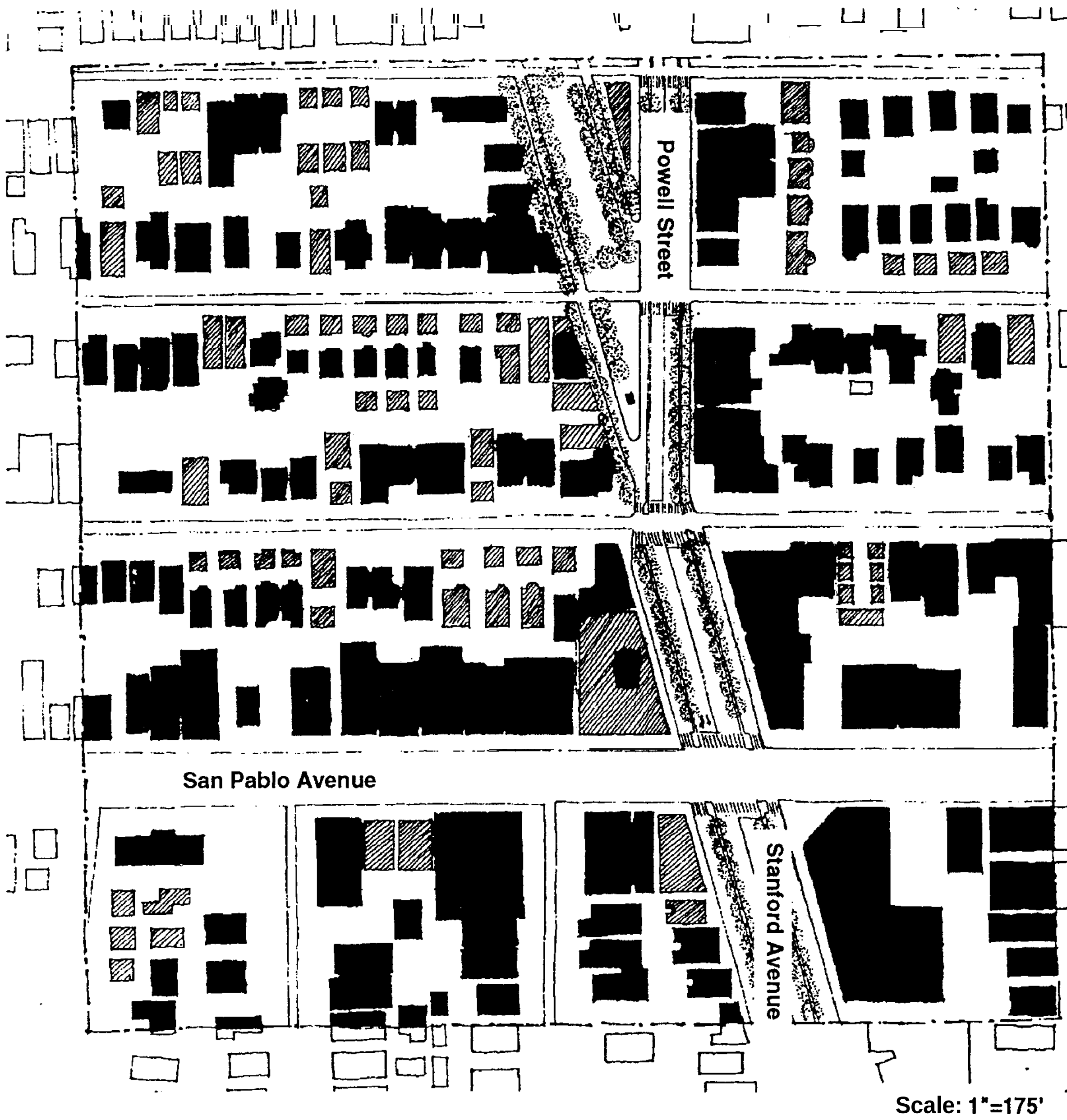


Fig. 3.17 Emeryville, After

In a scenario that would bring physical changes the local residential streets would be repaved from 30 feet curb to curb to a smaller width of 12 feet plus a four foot wide parking strip on both sides: Existing right-of-ways would be landscaped by allowing residents to extend front yards out to a new frontage line.

Alternatively the zoning of the area could change and over time additional structures could be built in front of the existing houses, turning the existing structures into rear yard cottages (Fig. 3.18). On first reading, such a transformation appears unlikely, but such developments have taken place in the history of our exiting neighborhoods. For example, in several older neighborhoods of San Francisco, rear yard cottages can be seen that at one time stood alone on their lots, but are now located behind more recent construction facing the street.

This transformation would create narrow landscaped streets serving a potentially greater residential density. The narrow street dimensions force drivers of regular sized cars to drive carefully and slowly.

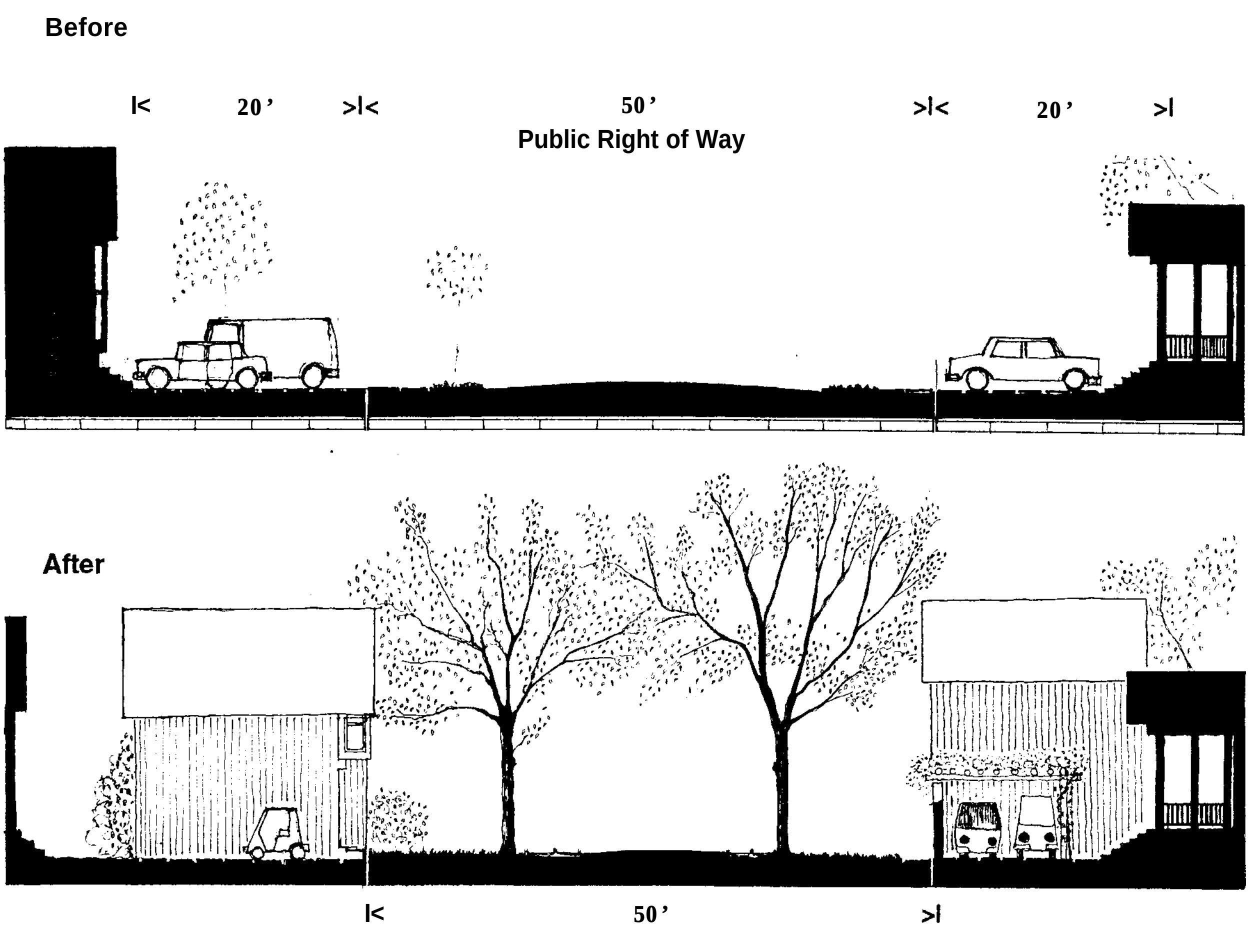


Fig. 3.18 Fifty Foot Right of Way along Residential Streets

Along the busy Powell-Stanford Street corridor, the existing right of way is redesigned to accommodate a local access street, designed for one-way traffic. Residents with small cars can turn into the access street and park in front of stores. The access streets meet San Pablo Avenue and cross separate from the wider lanes for trucks (Fig. 3.19).

To reduce the conflict between small neighborhood cars and regular sized cars two design strategies have been illustrated. On local streets the road width is narrowed, allowing regular sized cars but forcing drivers to move slowly through the narrow space. Pedestrians are free to share the narrow space with car traffic.

Secondly, on arterial streets with truck traffic, space for small cars is separated from regular sized cars. The lanes for small cars are level with sidewalks, designed to appear as part of the pedestrian domain of the street.

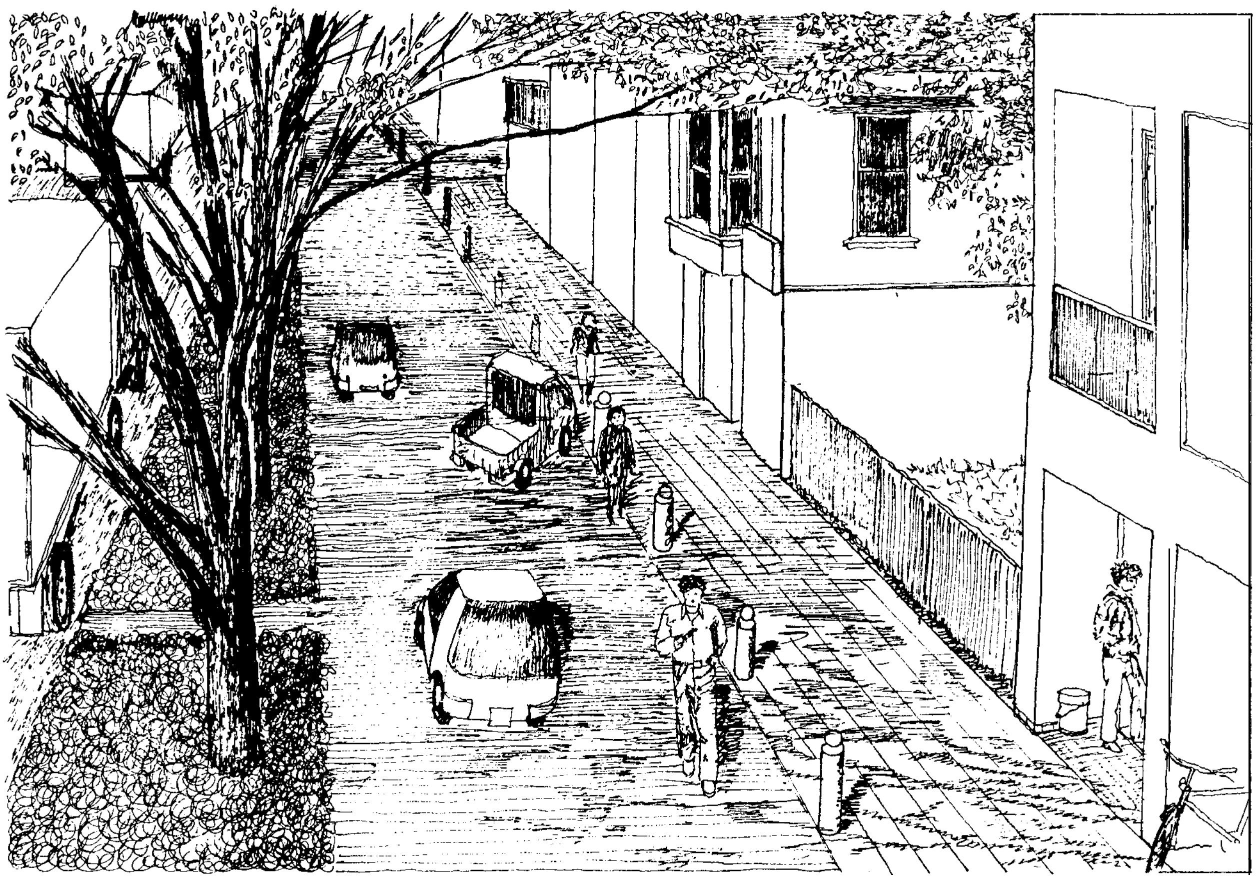


Fig. 3.19 Local Access Street along the Avenues

4. Stocktaking; What Needs to be Done

In the introductory paragraph to this report is was stated that the objectives of the work were to stake out the parts of the neighborhood car-neighborhood improvement puzzle and suggest how the parts might fit together. Work of this sort does not lead to sharp findings or conclusions. Rather, it aids understandings of matters such as: What is partly known and what is not known? Are there "conversation stoppers" that would block neighborhood car development? What relationships beg clarification? What can be learned through analysis as opposed to trial and error? Because most of the text of the report dealt with such matters, this section will only touch on them. Main attention will be given to what needs to be done to further clarify issues.

Stocktaking

This stocktaking discussion will briefly mention topics not treated, topics already treated but where further work would be useful, and topics that call for hands-on experience with neighborhood cars in neighborhoods. The discussion to follow recommending priorities for work will draw partly on this stocking.

Although the stated objective of this work was to deal with all the elements bearing on neighborhood car-neighborhood enhancement questions, work did not accomplished that objective. Many omitted topics come to mind. For one example, How would adoption and use of the neighborhood car support air pollution reduction goals? It is know that the cold start of gasoline engines and short trips contribute greatly to emissions. Using either small and fast-to-warm-up gasoline engines or electric motors, neighborhood vehicles might make a large contribution to emission reductions. For another example, changes in vehicle manufacturing technologies were mentioned, but no notice was taken of emerging technologies for obstacle avoidance, lane keeping, navigation, and vehicle spacing. Some of these technologies might find new markets in neighborhood scale vehicles. Finally, although some notions about how neighborhood designs might evolve were treated, analyses were not made of the ways neighborhoods are changing and how trends might affect development options.

There was reference to "loose ends" in the text of the report, and some of the loose ends overlap with topics not treated. Every topic was not fully explored, indeed, no topic was fully explored. For example, the discussion of NHTSA activities did not treat its work during the last decade, and the discussion of the safety record of small vehicles referred to some not fully analyzed literature. The neighborhood design work examined only a small sample of many possible cases.

Finally, a number of topics were identified of a "the answer can only be known with experience" type. Who would purchase neighborhood vehicles, how might neighborhood designs be altered as residents consider options, etc? One option for neighborhood designs, for example, would be to increase the density of settlement. At another extreme, land not used for wide roads might be used to increase open space, gardens, etc. The market is the ultimate decision maker in this situation. It will determine the density of settlement and the mix of land uses.

With these characteristics of the work so far in mind, the discussion will now turn to what needs to be done.

What Needs to Be Done

The authors' judgement call is that five areas of work should be given explicit priority at this time. These will be identified along with the reasons for their selection. The areas of work will then be further discussed.

Priority areas of work are:

1. Travel and trip ends analyses in order to further identify the ways small vehicles might be used.

2. Analytic design studies that would a. develop a taxonomy of neighborhoods (1920s suburbs, new developments, etc.), b. examine the design options for those neighborhoods, and c. develop and apply quantitative measures of the impacts of design changes.

3. Field studies of neighborhood attitudes about changes, institutional complexities, and the decision processes required for changes to be introduced.

4. Analysis, debate, and consensus about appropriate road design and construction. This work should include analyses of small truck vehicles.

5. Analysis of the market composed of today's non drivers, i.e., the travel disadvantaged.

"At this time" is an operative phrase in the selection of these areas of work, and lying behind giving priority to the areas of work is knowledge of ongoing work. In other words, the assignment of priority reflects judgements about critical things to now that are not already being done.

To illustrate, improvements in the design of vehicles and the processes for manufacturing them are certainly timely but it is not included on the list of priorities. The reason is simple. Existing and potential manufacturers are already motivated to explore process and product technologies, they will accelerate or decelerate their work based on market expectations. So this topic was not included on the list of priority topics.

Also illustrating timely work not included as priority work is inquiry into neighborhood designs facilitating intermodal travel.

Neighborhood designs oriented to transit stations are already receiving much attention. So this work is not included on our list of priority topics, although it could be argued that increased consideration of neighborhood scale cars would enhance the work.

Another area of work that was not given priority is safety, and that, perhaps, is a marginal judgement call. The discussion in section 2 of this report examined part of the record on small vehicle safety, NHTSA vehicle classification and requirements for vehicles, and the applicability of the Uniform Vehicle Code, and those topics were far from being fully treated. Even so, priority is not given to these topics at this time because it appears that they do not portend strong barriers and that they can be taken up at or near the time decisions bearing on neighborhood vehicles are needed. As stated, that is a marginal judgement call and it could well be revised if safety looms large in early debates about neighborhood cars.

Having made brief remarks about the selection of tropics for work, the discussion will now further describe the topics.

Work on Travel Topics:

Tables 2.7 and 2.8 in section 2 provided highly aggregated data on travel trends by functions, as well as information on the characteristics of households. These data do not bear directly on the travel that might be accomplished using neighborhood cars partly because disaggregation is required to identify how trips are linked and the actual mileage required for achieving travel purposes. We also need to know the classes of roads on which trips are made. Further analysis of disaggregate travel data sets is needed to go beyond the generalization that one half of all trips are about nine miles in length and could be served by short range vehicles. Data sets are available for such work.

It was noted in the text that trip making patterns would surely change if households' inventories of vehicles were augmented by small neighborhood vehicles. A primary reason for work with trip data is to identify new patterns of trip making enabled by the neighborhood vehicle.

In the **Introduction** to this report mention was made of the broad need to synchronize road infrastructure and transportation services with urban growth and development. Work with travel data together with studies of trip ends would assist in this task. Consider the grocery shopping trip, for example. It is well known that there is a trend towards larger and larger full service stores. These are spaced father and father apart, and customers trade off longer trips against the price and selection advantages available in large stores. At the same time, there has been the growth of mini markets providing limited services to local markets. This grocery store trend is one of many trends at work in urban areas. The broad issue is that of neighborhood car concept in its larger dynamic environment. Work on travel and trip ends should begin to clarify large issues about cities and transportation services.

Work on Neighborhood Designs:

Although neighborhoods exist in endless variety, certainly classification would assist in identifying types of design and vehicle use situations. There are older intercity neighborhoods, early suburbs, etc. Work to identify types of situations and the generic design problems and opportunities associated with uses of neighborhood vehicles would be very useful. It would yield results for beginning analyses of benefits and costs.

In the introduction it was claimed that the neighborhood vehicle would offer both mobility and neighborhood enhancement benefits and the extent to which neighborhood enhancement might occur and the ways it might occur are key questions.

Field Studies:

The further study of travel patterns and designs have field studies elements, but they will not uncover critical institutional and attitude factors (and perhaps barriers) bearing on the neighborhood vehicle and neighborhood enhancement. Using a systematic approach, work is needed to begin to identify and determine the roles of and the institutional actors that would be involved in the adaption of communities to neighborhood cars. Knowledge of their attitudes and concerns would aid in identifying paths for vehicle deployment, the problems of redesigning and/or providing new road facilities, and possible "conversation stoppers."

It was mentioned several times in the text of this report that answers to certain questions can not be known until there is experience with neighborhood vehicles. That's true, but only partly so. Using designs already completed and those forthcoming, and as information unfolds about possible uses of vehicles, it will be increasingly possible to develop information. For a simple example, local, county, and state agencies provide roads. To what extent will developments be largely a local (including private) matter? Would typical developments involve local, county, and state agencies? What funding arrangements seem workable? What is the perceived incidence of costs and benefits?

There are places where golfs carts are serving neighborhood car-like functions. Studies of these places, vehicle uses, and road facility arrangements should be useful. Although not discussed in the text of this report, our work included visits to and data gathering in communities served by golf carts. A survey conducted at Canyon Lake, CA, in March of 1992 asked 52 golf cart users about the vehicles in their households and the uses of those vehicles. Most of the heads of households were retired (88 percent) and the age cohort 60-69 was the largest (52 percent). Six of the 52 respondents identified golf as the primary use of vehicle. Secondary and tertiary uses where highly varied with getting the mail and visiting the larger classes of purposes. A key finding was with respect to trip frequency: 755 golf cart trips per month were reported compared to 237 non golf cart trips.

We also examined a community, the Swan Lake Mobile Home Park, where large car parking was at the edges of the settlement and access to the home was by electric vehicle. Although we did not evaluate the success of the design, evaluations of these types of situations would be useful.

The empirical work just described had a special case character, but the examination of more cases should prove useful, perhaps not so much for vehicle use information as for information on institutional experiences and community attitudes.

Road Designs:

Work on certain geometric aspects of road design was discussed in section 2 of this report. Work is needed to translate from those and other aspects of design (and such design recommendations as are available for local roads) and reduce design to a set of recommended practices. In part, this is to assist considerations of how communities might be designed or redesigned if neighborhood size vehicles are selected and used by residents.

But the main reason to give priority to this design work is so that if opportunities develop there will not be inordinate delays in adapting road infrastructure. The development and distribution of design standards is a long process, one that might delay and delay neighborhood enhancements.

An additional important reason for emphasis on road facility design are the problems that would certainly arise when providing facilities that mix large and small vehicles in the traffic stream. Options for standards range from limiting the sizes of large vehicles (e.g., only small delivery trucks, fire engines, etc. allowed) to continuing to build generous facilities of conventional types.

There is a trade off between vehicle size and weight and road construction and repair costs, and analysis would provide information on that trade off. Many analyses have been made of large/heavy trucks and the design of high capacity facilities. There is an accompanying debate on limits on size and weight and appropriate cost allocation. (See, e.g., Reference 1.)

By and large analysis and debate has not extended to local roads, although sometimes size and weight limits are placed on local roads. To explain the situation using an example case, suppose garbage (refuse) trucks were limited, say, to a 8 foot wheel base and 1,000 pound axle loads. A debate would swirl immediately about increased rates for refuse removal. Yet limitations on vehicle size and weight might be the low cost solution when the cost of providing local roads for conventional refuse trucks is considered. Today's trucks require wide pavements and large radii curves. Their axles are heavy even when the trucks are not loaded because of the presence of loading equipment. When loaded with wet refuse, the axles are often overweight. (2) As a result, road damage and its cost is high.

One of the authors once lived in an area where large refuse trucks were parked on arterial streets and fed by small residence-accessing Cushman vehicles.

The example used was that of garbage or refuse trucks, and many types of trucks would be involved: fire and emergency vehicles, moving vans, construction trucks, delivery vehicles, etc. Operators of some such trucks, especially fire trucks, would argue overriding health and safety considerations for maintaining the status quo and make technical arguments for the need for long ladders and an onboard water supply. But with thought and analysis it might be recognized that particular vehicle configurations are a matter of custom and a failure to consider full costs of vehicles and roads.

Over and above the trade offs between road and vehicle costs there are the neighborhood design advantages that would be opened if was not necessary to serve large vehicles.

The Travel Disadvantaged:

The augmentation or substitution of vehicles in a households' inventory of vehicles would improve mobility by decreasing the cost of travel, reducing constraints on choices about when to travel and what vehicle to use, and in other ways. The ways in which simple-to-drive, low cost vehicles and their road facilities might provide mobility advantages to those not now driving is a large unknown. Work is needed to define this mobility enhancing opportunity.

Other Priorities:

These recommendations for priority work were judgement calls, as emphasized. Others may have other priorities or question our judgement. The present researchers are agreed only to the belief that our recommendations seem reasonable within the framework within which they are made. We would be the last to say that other work would not be useful.

Transportation Agency Tasks

The discussion above dealt with lines of inquiry that might improve understandings of the neighborhood car opportunity. But inquiring in this style isn't all that is needed. There are institutional, policy, and procedural questions about the road system that need to be addressed. There are also needs for information that is less fragmented than that developed in small studies.

So an important role awaits the state transportation agencies. The state agencies and their national organization (AASHTO) are positioned to and experienced in collecting and disseminating information, coordinating with other agencies, and generating policies and procedures, as well as supporting and implementing research and development, working with legislators, and implementing programs.

The state agencies can work with local public works agencies to evaluate local street systems, driving distances for neighborhood travel, and points of conflict among neighborhood, arterial street, and expressway travel. The design and engineering resources held by state agencies could be used to begin to develop protocols for altering neighborhood road facilities and treating conflicts between small and large vehicles. Perhaps this work could be described as **mobilization,** getting ready for neighborhood cars. It is somewhat similar to the role that state agencies have assumed in the design of bicycle facilities.

There is already experience with golf carts and some other low weight, small vehicles, and the agencies are in a position to collect and evaluate those experiences. If neighborhood vehicles are successfully marketed and roads adjusted for them, there will needs for monitoring, evaluation, and dissemination of information. If it is decided to accelerate obtaining information using demonstrations, then the mobilization of resources and project management would be added to agency tasks.

These activities may sound dry and sterile. They are not. The institutional and personal linkages among all who are involved in delivering, operating, and maintaining the road system are strong and they promise debates and informed judgements and actions. (Reference is to local, state, and federal agencies, professional organizations, contractors, automobile clubs, and interest groups of many varieties.)

Looking to "outside the road system" tasks, there is need to coordinate with energy and environmental groups and legislators. For the state transportation agencies, this means mainly parallel state agencies. The neighborhood car may offer a win win situation for mobility improvement, energy conservation, and environmental enhancement. It could thus offer an alternative to the regulatory constraint policies currently being implemented. While some states, such as California, have their own programs and policies, federal policy is major, such as that expressed in the Clean Air Act Amendments of 1990 (CAAA-90) and the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA-91). Even so, state agencies are positioned for leadership as an examination of the experiences and goals that shaped ISTEA-91 and CAAA-90 will indicate. In important ways, those acts were based on California policy leadership and experiences.

References:

1. Kenneth A. Small, Clifford Winston, and Carol Evans. **Road Work: A New Highway Policy.** Brookings Institution. 1988.

2. U. S. Department of Transportation. **An Investigation of Truck Size and Weight Limits, 1981.**