Title
Transportation in Cities

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Transportation in Cities

Urban transportation has to do not only with moving people and goods into, out of and through the city but also with the spatial organization of all human activities within it

by John W. Dyckman

Problems of urban transportation are not new in the world. In the first century A.D. the municipal government of Rome was obliged to relieve congestion in its streets by restricting vehicular traffic (with the exception of chariots and state vehicles) to the night hours. Rome was then the only truly "big" city in the Western world, however, and for many centuries thereafter its transportation problem remained the exception rather than the rule. It was not until the process of industrialization was well under way in the 19th century that vehicular traffic began to present serious problems in cities. Today descriptions of the conditions of movement in cities express the alarm of the observer with words such as "choke" and "strangle." Not only are there now more big cities; some of them are tending to consolidate into huge megalopolitan networks, further compounding the comparatively elementary difficulties that faced the Romans.

Among the complaints commonly heard about modern systems of urban transportation are congestion, the overloading of routes and facilities, the overlong trips, the irregularity and inconvenience of those services that are publicly provided and the difficulty of parking private vehicles at desired destinations. These are problems that arise not only out of the sheer size of modern cities but also out of the organization of their land uses, the rhythm of their activities, the balancing of their public services with private rights of access and movement, and the tastes and preferences of their citizens with respect to mode of travel, route, comfort and cost. There is in fact no isolated "transportation problem" in the modern metropolis; there are problems of the spatial organization of human activities, the adaptability of existing facilities and investments, and the needs and aspirations of the people in moving themselves and their goods. For the individual city dweller, nonetheless, the contemporary transportation problem remains in large measure a "traffic" problem.

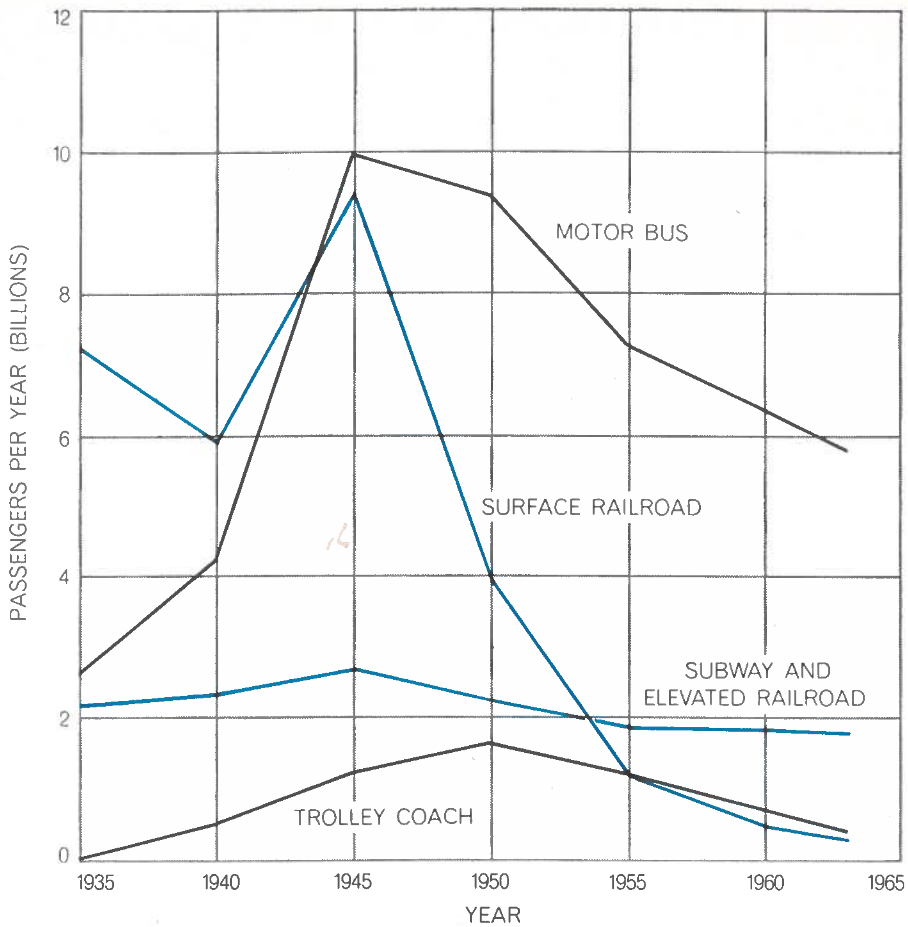
The origins of the modern traffic problem are rooted in the very nature of industrialization in an open society. For example, the modern journey to work, which accounts for a large part of the urban traffic problem, is the product of a comparatively free choice of residence and place of work, made freer in industrialized societies by the greater number and variety of both. In the early industrial centers of the Western countries workers were grouped in dwellings close to their respective places of work. In the U.S. even employers did not commute long distances but typically drove to work in carriages from houses within convenient reach of their factories.

Improvements in living standards have contributed almost as much as the growth of cities to contemporary urban traffic conditions. Expectations of greater comfort and convenience, as well as the ability to sustain higher costs, have affected the choice of both residence and mode of travel. The transportation plight of cities—at least in the prosperous, developed countries of the world—is a condition people have themselves brought about by taking advantage of individual opportunities. Accordingly if major changes are to be achieved in the present condition of transportation, deliberate individual and collective decisions on the whole question of the quality of urban life must first be made.

The task of an urban transportation system is to move people and goods from place to place. This elementary statement of purpose is useful because it reminds one that the task is defined by the location of the terminal points as well as by the channels of movement. For this reason the problem of urban transportation is one of city layout and planning as well as one of transportation technology.

The city planner's approach to the transportation problem can be viewed as having two aspects: (1) the definition of the tasks and requirements of the system and (2) the devising of socially acceptable and economically feasible means of achieving those objectives. This approach depends on the existence of basic studies of the use of land in cities in order to relate these uses to transportation needs. Fortunately such

NEW RAPID-TRANSIT TRACKS (*opposite page*) near Concord, Calif., are part of a 2.5-mile test stretch of the Bay Area Rapid Transit District (abbreviated BARTD), the first wholly new public-transit system to be built in the U.S. in 50 years and the first openly to challenge the automobile-transportation system in the era marked by the ascendancy of the automobile and the freeway. When it is completed in 1971, the BARTD system will be a suburban electric rail system with some of the characteristics of local transit. Trains will have average speeds of 40 to 50 miles per hour and maximum speeds of 80 miles per hour. A maximum interval between trains of 15 to 20 minutes at any time of day is contemplated. The proposed interval between trains during hours of peak traffic is 90 seconds. The completed system will have a total length of 75 miles and will cost $1 billion.



DECLINE IN USE OF MASS TRANSIT in the U.S. since the end of World War II is depicted in this graph. Gasoline and tire rationing, together with booming employment, led to an all-time high in the use of public transit during the war years; since 1945 total transit use has declined nearly 64 percent. In the same period overall route-miles of transit service have increased by 5 percent. The loss of transit riders is largely attributable to enormously increased use of private automobiles for commutation to and from work.

basic data on land uses have been available in several U.S. cities, notably Philadelphia. Robert Mitchell and Chester Rapkin of the University of Pennsylvania drew on the Philadelphia data for a prototype "city planning" study of urban transportation in 1954. Their thesis was that different types of land use generate different or variable traffic flows. Such work shifted the emphasis from the study of the flows themselves to the study of the land uses that give rise to the flows. It underlined the basic city-planning proposition that traffic can be manipulated by controlling and rearranging the land uses that represent the destinations and purposes of transportation.

This approach—sometimes called the functional approach because it emphasizes the relation between city functions and transportation—has come to dominate large urban transportation studies supported by the U.S. Bureau of Public Roads and other public agencies. The approach has been applied in the Detroit Area Transportation Study, the Chicago Area Transportation Study, the Penn-Jersey Transportation Study and the Tri-State New York Metropolitan Transportation Study. These elaborate investigations (costing approximately $1 per capita in the regions mentioned) have done much to organize existing information about urban transportation, in spite of a heavy preoccupation with automobile traffic and road networks. Surveys of travel behavior are usually made at the homes and places of work of commuters. In addition, the Bureau of Public Roads has long conducted surveys to sample the purposes of householders' trips as well as their actual travel behavior; these data are integrated in the large transportation studies with such information as the addresses of workers by place of work, and sample origins and destinations of travelers en route.

The customary unit of travel—the "trip"—takes many forms, and in these studies the purposes of various kinds of trip must be differentiated. Shopping trips and recreational trips, for example, have many characteristics that distinguish them from trips to and from work. From an analysis of such characteristics the possibility of replacing one mode of travel (perhaps the automobile) by another (perhaps mass transit) can be considered.

The outstanding contributions of the major transportation studies, apart from the accumulation and organization of data, have been (1) the approach to transportation as a comprehensive system of interrelated activities; (2) the recognition of the importance of land uses, demographic and social characteristics and consumer choices in determining transportation requirements; (3) an appreciation of the role of transportation itself in shaping the development of cities and metropolitan areas, and (4) the acceptance of the inevitably metropolitan scale of transportation planning in a society in which daily activities that generate travel move freely across the borders of local government and form the functionally interdependent fabric of the metropolitan region.

In focusing on the whole system of relations between users and facilities these elaborate studies should furnish the material for the solution to the two major problems of urban transportation: how to obtain efficient movement and how to promote new activities. The promotion of new urban activities is the province of city planning, but the city-planning results of the major transportation studies have not yet clearly emerged. The studies reflect the current condition of the planning profession, which is ambivalent toward the automobile and split on the issue of centralization v. dispersal.

The city-forming role of transportation facilities is well known to city planners. The New York subway of 1905 opened up the Bronx; the radiating street-railway systems of the late 19th and early 20th centuries created the working-class suburbs of Boston, Chicago and Philadelphia. Today, of course, expressways are opening up a far greater number of new suburban housing developments and shopping centers than the subway and street railways did.

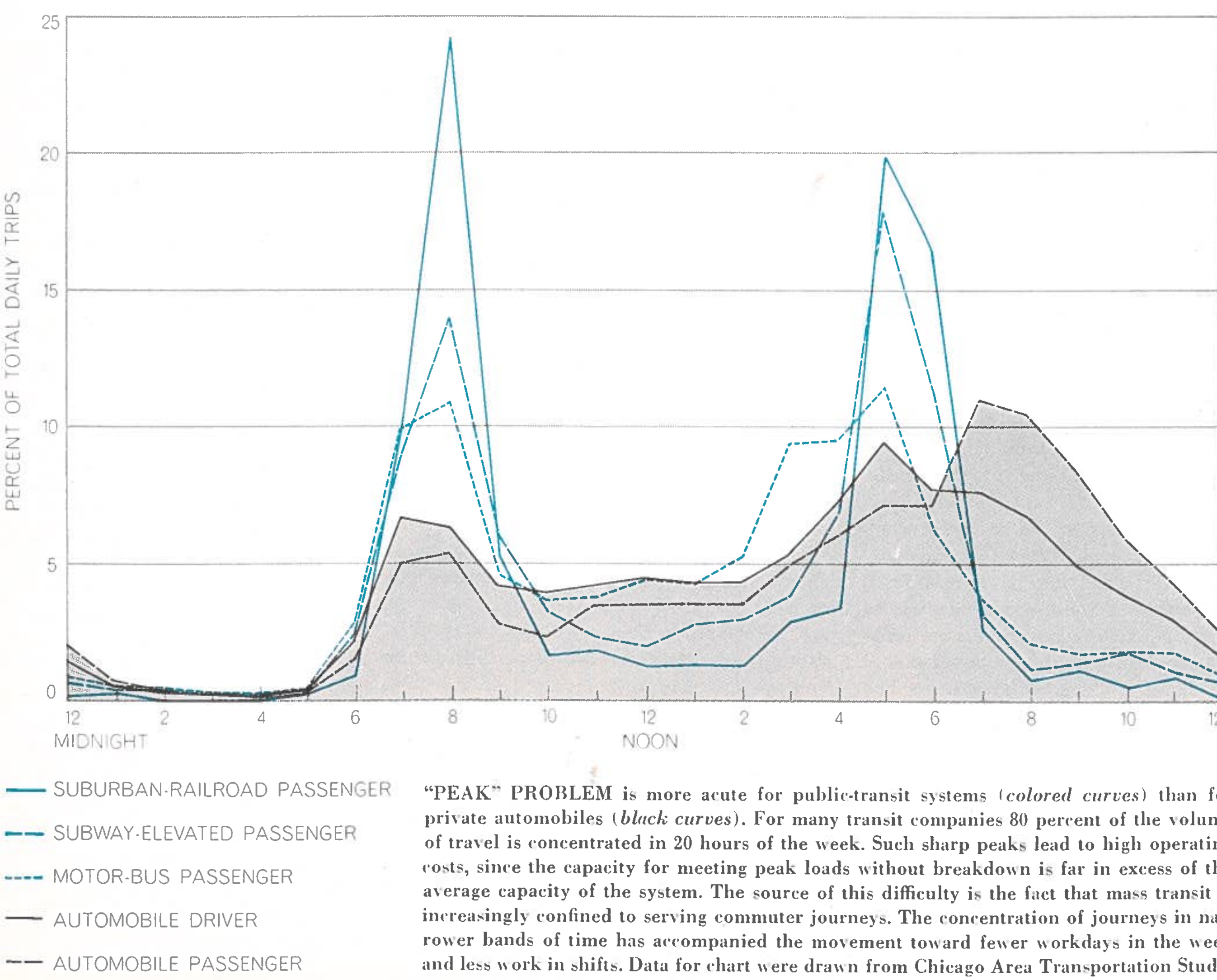
To many city planners the central contemporary problem is one of conserving cities "as we have known them." These planners believe the issue is between centrality and spread, between efficient downtowns and disorganized ones. They see the present use of the automobile for the bulk of urban trips as destroying the amenities of the established downtown by contributing to congestion, eating up real estate for parking and storage, interfering with pedestrian flow and poisoning the air of the central city. Almost equally bad from their standpoint, the automobile makes possible the scattering of residences, of auxiliary commercial facilities and ultimately even of the downtown headquarters function. The planners' views are shared by many realtors holding downtown property, by some established merchants and by civic leaders who see the new emphasis on highway building as inevitably creating competing centers in outlying areas. If we are to have compact cities with centrally located places of work, relatively high-density residential zones, concentration of shopping and public facilities as well as employment, the currently dispersive effects of the automobile will have to be checked.

Other planners, not opposed to dispersal on these grounds, believe the growth of urban population itself is likely to produce a situation in which scale effects rule out present modes of transportation. These observers believe the congestion that will be faced by cities containing upward of 15 million people will be such as to require greatly enlarged capacity for traffic channels, the restriction of vehicles to specialized lanes, controlled timing and phasing of movement and many other adaptations more drastic than those proposed in present transportation plans.

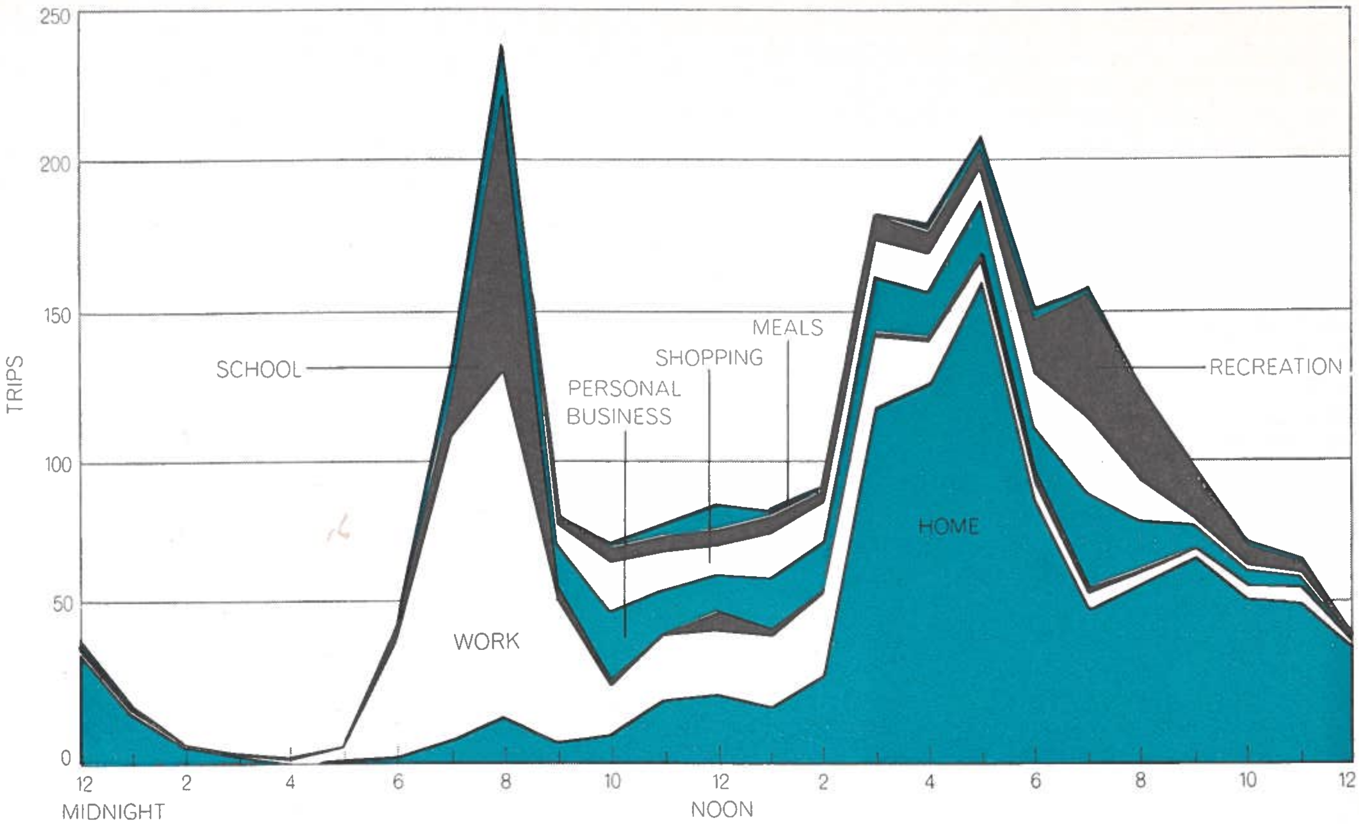
In spite of the fact that every major transportation study has projected an increase in the ownership of automobiles, in the volume of automobile traffic to be accommodated in central cities, in the construction of new expressways and in the spread of metropolitan population, a number of the larger cities in the U.S. are taking steps in the direction of reinvestment or new investment in public mass transportation. In many cases this takes the form of building or expanding subways and related rail systems; in every case a major portion of the system is characterized by fixed routes and separate rights-of-way.

Public transportation systems are frequently a combination of "rapid transit," which uses for high-speed service rights-of-way that are separated by grade crossings, and "local transit," which uses public streets (with or without rail lines) and makes local stops. A truly effective transportation system must offer a full range of service, from the rapid-express system to the local-distribution system. Cities as far apart as San Francisco and Washington intend to build new subways; New York, Chicago and other cities propose to extend their existing systems; in the Northeast particular attention is being given to the problem of resuscitating privately owned commuter railroads and reviving the relation between these roads and the city transit systems. The Federal Government has shown interest in supporting these efforts, but as yet it has mounted no program comparable in scope to its highway-building effort.

City planners and transportation experts have turned to mass-transportation systems at a moment of grave difficulty for the established transpor-



"PEAK" PROBLEM is more acute for public-transit systems (*colored curves*) than for private automobiles (*black curves*). For many transit companies 80 percent of the volume of travel is concentrated in 20 hours of the week. Such sharp peaks lead to high operating costs, since the capacity for meeting peak loads without breakdown is far in excess of the average capacity of the system. The source of this difficulty is the fact that mass transit is increasingly confined to serving commuter journeys. The concentration of journeys in narrower bands of time has accompanied the movement toward fewer workdays in the week and less work in shifts. Data for chart were drawn from Chicago Area Transportation Study.



ANOTHER REPRESENTATION of the peak problem in urban transportation systems is given in this layered chart, which differentiates trip purposes by destination. The data on which the chart is based were taken from the Pittsburgh Area Transportation Study.

tation companies. Transit franchises, which at the turn of the century were prized plums for entrepreneurs and investors, have long since ceased to be notably profitable. In most cases the companies have either been taken over by the cities or have gone out of business. Although the very large cities could scarcely function without transit systems, the systems in these cities too have over the past decade suffered a decline in riders. The share of total commutation accountable to the automobile has risen at the expense of the transit systems.

The difficulties of urban transit companies have been the subject of many studies and need not be recapitulated here. Some of these are difficulties of the systems themselves; others are problems of urban growth and development only slightly related to the systems. The three major difficulties posed for transit by the pattern of growth of our cities are (1) the collection problem, (2) the delivery problem and (3) the "peak" problem.

The collection problem arises largely from the diffuse pattern of urban "sprawl" made possible by widespread ownership of automobiles and ready access to highways. Density of settlement is one of the most important variables in accounting for urban transit use, and for the performance and profitability of the systems. The New York subways are made possible by the heavy concentration of riders in areas served by the system, just as the system itself makes possible the aggregation of population at these densities. It is obviously difficult for a fixed-route system to collect efficiently in a highly dispersed settlement pattern. Not only is a commuter train unable to collect people door-to-door; the number of stops required to accumulate a payload is increased by a dispersed residential pattern. More stops in turn slow down the performance of the system and hurt it in terms of both operating costs and attractiveness to the rider. The operating disadvantages of the fixed-rail transportation system—relatively low efficiency at low operating speed, the high cost of braking and acceleration, the problems of scheduling, the minimum profitable payload required by fixed costs—all create conflicts between efficient service and low collection densities.

The problem of delivery has been exacerbated by changes in the scale and distribution of activities within the downtown areas as well as the general dispersal of places of work. Within metropolitan areas industries have moved increasingly toward the outskirts in search of larger sites; this movement has tended to disperse places of work and so reduce the usefulness of the highly centered, radial transit systems. Circumferential systems moving through predominantly low-density areas have been less attractive to the transit companies. Within the downtown areas dispersal of places of work and of central points of attraction (brought about by changes such as the shift of a department store to the fashionable fringe of the area) has greatly lengthened that portion of the trip between arrival at the terminal and arrival at the final destination. The lengthening of the walk or taxi ride from station to destination has made the whole transit ride less attractive. These developments can be summed up in the observation that the general dispersal of activities and functions within metropolitan areas has made the fixed-rail system less efficient in point-to-point delivery of passengers.

The "peak" problem arises almost entirely from the organization of journeys in time. For many transit companies 80 percent of the volume of travel is concentrated in 20 hours of the week. This results in the underutilization of rolling stock and other equipment necessary for meeting peak loads. The source of this difficulty is the fact that mass transit is increasingly confined to serving commuter journeys. The concentration of journeys in narrower bands of time has been a steadily evolving phenomenon, accompanying the movement toward fewer workdays in the week and less work in shifts.

It is axiomatic to the performance of any system—transportation or otherwise—that sharp peaks lead to high operating costs. The capacity needed for meeting peak loads without breakdown of the system is far in excess of the average capacity required by the system. The need for excess capacity is aggravated by the fact that in transportation accounting the obsolescence cycle and the amortization cycle are out of phase: mass-transportation systems in cities are rarely able to amortize investments in rolling stock and equipment before they are obsolete as a result of technical competition, of shifts in land use or of changes in employment patterns.

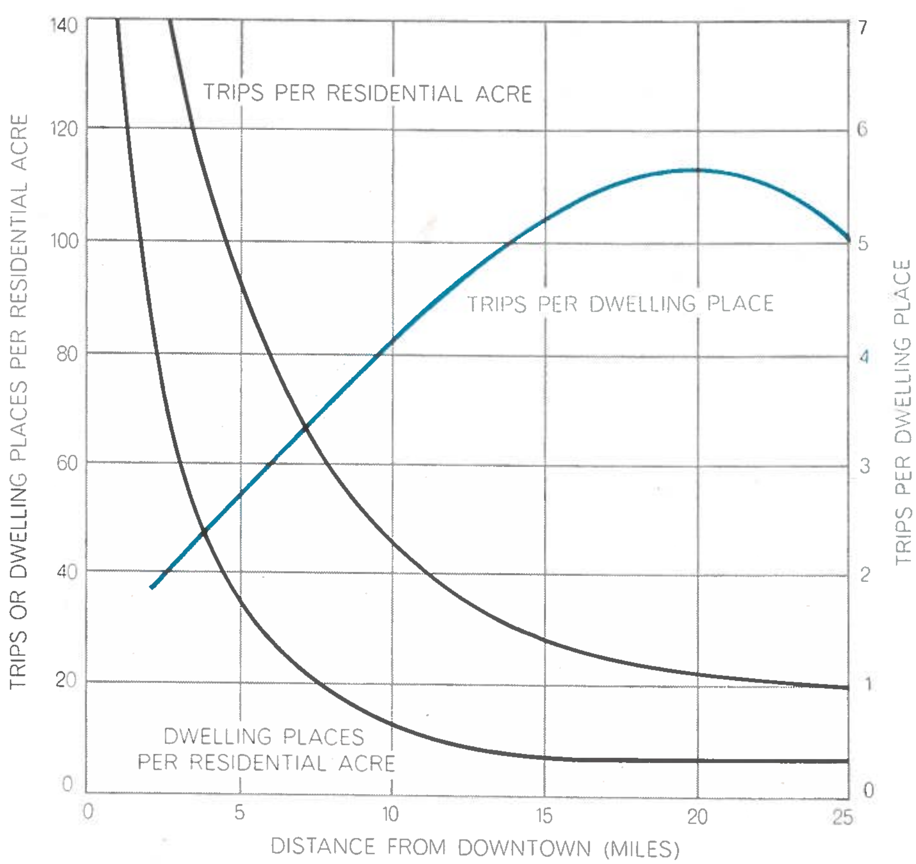
Finally, a whole set of factors arising from changes in consumer tastes and expectations have worked to the disadvantage of the fixed-rail system. Comfort, convenience, privacy, storage capacity, guaranteed seating, freedom from dependence on scheduled departure times and a number of intangible satisfactions all favor the use of private automobiles.

In view of the marked advantages of the automobile over other types of carrier, what can the public-transit system be expected to do to alter the present drift in commuter habits? Under what conditions would the transit system be able to compete with the automobile? The engineering efficiency of trains, which can move many times more people and much more cargo for a given road space and energy output than automobiles can, has persistently held out the promise that mass transportation would lower costs. One may ask, however: Costs for whom? Real costs, out-of-pocket costs to users and public costs have all been cited from time to time to make points for and against mass transit. It is particularly important to distinguish the public costs of the respective operations from the private costs and the average costs from the so-called marginal costs.

A recent study by economists at the RAND Corporation concluded that the automobile is competitive with other available modes of travel to work in large American cities. Under the assumptions made by these economists—including a relatively high rate for the driver's or passenger's time—it appears that the one-way hourly cost is lower for the automobile than for most competing modes of travel up to about 15 miles of commuting distance from door to door. In the framework of this analysis the behavior of commuters who choose to commute by automobile is rational.

When one compares the average cost per mile of automobile operation against the cost of transit fares per ride, the comparison may be misleading. The average cost of operating an automobile driven about 10,000 miles a year is close to 10 cents per mile. The marginal cost (the daily out-of-pocket operating cost) is much lower. A sizable fraction of the cost of operating an automobile lies of course in depreciation, insurance, registration, taxes and other fixed-cost items. Gasoline and oil account for only about 15 percent of the total cost. The cost of parking, which might be significant if it were entirely passed on to the consumer at the point of destination, is frequently subsidized by private merchants and public authorities or is provided free by the community on the street. Similarly, the rights-of-way provided in highway programs are financed by gasoline taxes paid by all users, so that long journeys help to subsidize the shorter in-city trips.

As long as private incomes continue to rise, some substitution of private automobile travel for transit is probably inevitable under present competitive conditions. In analyzing the findings of the Detroit Area Transportation Study, John Kain, then at RAND, related much of the change in transit use in Michigan to changes in median family incomes of Michigan residents. His findings disposed him to the view that changes in income were more important in the decline in transit use than deteriorating service. In sum, although the automobile is not a technically elegant solution to the urban transportation problem, it



RELATION between density of dwelling places and trips generated by a given acre of land varies according to distance from the central business district, or downtown, of a city (in this case the Loop in Chicago). Why more trips are made to dwelling places that are at greater distances from the downtown area is not completely understood. One explanation may be that the proportion of income spent for travel rises slightly as income rises. It may also be cheaper and is probably easier to make trips in low-density areas, because of greater congestion and difficulty in parking in high-density areas. Families are also larger in suburban areas and so create a greater potential of trip-taking per dwelling place.

BAY AREA RAPID TRANSIT DISTRICT (BARTD) currently embraces three metropolitan Bay Area counties: San Francisco, Alameda and Contra Costa. Although early studies envisioned five inner Bay counties in the system, San Mateo County withdrew from the plan by 1962 and Marin County, joined to San Francisco by the thin thread of the Golden Gate Bridge, was judged too difficult to serve under present conditions. The 75 miles of track expected to be in operation by 1971 are indicated by the solid colored line; surface or elevated sections are in light color, underground sections in dark color. Possible future extensions of the system are indicated by the broken colored line. Squares denote stations with parking facilities; circles denote stations without parking.

is a socially engaging one because of its adaptability, social prestige and acceptability.

Given these realities, what strategies are being developed for dealing with the overall problem of urban transportation? The two "pure" strategies are (1) all-out accommodation of the automobile and (2) a strategy of banning the automobile from the center city and replacing it on a large scale with rail transit as a mode of journey-to-work travel. Between these two positions are numerous mixed strategies.

Europeans, who are on the verge of entering the automobile age that has enveloped the U.S., have not as yet reacted so strongly to the automobile and are given to accommodative strategies. A firm statement of this view, albeit one tinged with ambivalence and irony, is to be found in the report entitled *Traffic in Towns*, prepared for the British government by Colin Buchanan. The Buchanan report proposes a general theory of traffic based on separation of express and local motor traffic, pedestrian traffic and certain freight movements. Buchanan holds that potential urban amenity is measured by the volume of traffic, since traffic is a measure of the use of buildings and spaces. His proposal for downtown London is based on a vertical separation of traffic: expressways are sunk below street level or are completely automobile subways, the street level is chiefly given over to the storage of vehicles, and pedestrians are lifted to a mezzanine level above the storage level. The principle is the same as the old architectural notion of arcaded shops above the major service lanes.

Although the presuppositions of the Buchanan report, as much as its analyses, lead to a drastic reshaping of cities to accommodate the automobile, similar efforts on a more modest scale are already to be seen in many of the large cities of the world. The downtowns of major U.S. cities have been attempting to adjust to the increasing number of automobiles by various internal adaptations. The process of adaptation has been going on for many years, with the widening of streets, the construction of garage spaces, the building of expressways to speed the exit and entry of cars, and alternating permission to park with restrictions on parking. Large investments in underpasses, bridges, tunnels and ramps have been made in order to integrate the local street systems with the high-speed expressways and to reduce local bottlenecks in the increasing flow of cars.

Calculations made by Ira Lowry of RAND and the University of California at Los Angeles on the basis of the Pittsburgh Transportation Study suggest that gains in transportation efficiency resulting from improved routes and automobile-storage capacity are almost immediately absorbed by the further dispersal of places of work and particularly of residences. This dispersal enables the consumer to indulge his preference for more living space; it also increases the advantage of the automobile over the fixed-route system, and it does not significantly relieve the center-city traffic problem. To borrow a concept from economics, in motoring facilities there is a "Say's law" of accommodation of use to supply: Additional accommodation creates additional traffic. The opening of a freeway designed to meet existing demand may eventually increase that demand until congestion on the freeway increases the travel time to what it was before the freeway existed.

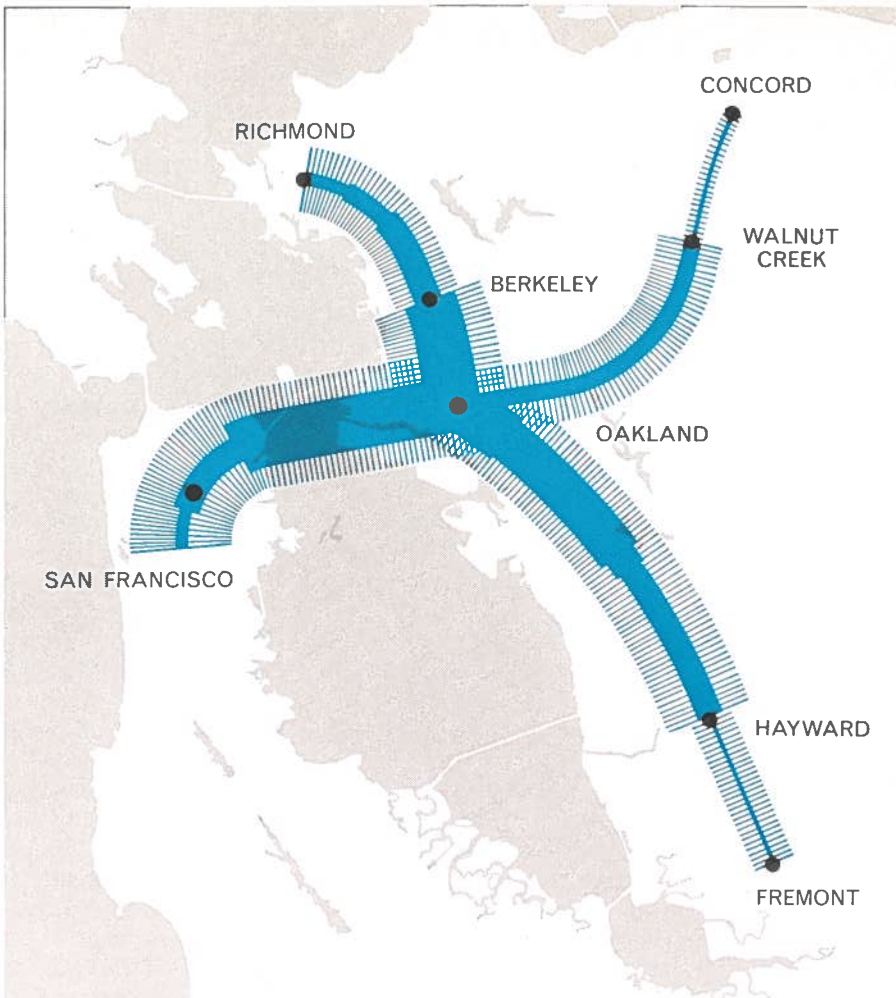
The case for supplementary transportation systems, such as mass transit, arises from the conviction that measures to accommodate the demands of the automobile are approaching the limit of their effectiveness. The primary aim of improved transit systems is to relieve the conditions brought about by the success of the automobile. The issue for many years to come will not be trains v. automobiles but how to balance the two systems, and it may lead to new designs in which both systems complement each other.

The very scale of the effort to transform our cities to accommodate the automobile has, in view of the problems created by such investment, raised serious doubts in the minds of public officials and transportation experts about the efficacy of making further investments of this kind. The cost of building urban freeways in the interstate system has averaged $3.7 million per mile. This is not the entire real cost, however. Freeways are prodigal space-users that remove sizable tracts of land from city tax rolls. Among other costly consequences are the need for storage space for vehicles brought by freeways to the center city, for elaborate traffic-control systems and for the policing of vehicles. Freeway construction frequently displaces large numbers of urban residents; the freeway program accounts for the biggest single share of the residential relocation load resulting from public construction in the U.S. Moreover, automobiles are a prime contributor to air pollution, which can be viewed as the result of private use of a public air sewer over a central city by motorists from the entire metropolitan area [see "The Metabolism of Cities," by Abel Wolman, page 178].

These aspects of automobile transport in our cities have intensified public interest in alternative schemes and have expanded the political appeal of such schemes. At government levels a great deal of support has been mustered for the strengthening of rail systems, both local transit systems and the suburban lines of interstate railroads. Privately, however, consumers continue to vote for the use of the automobile. In view of this tension between public objectives and private choices, the San Francisco Bay Area Rapid Transit District (BARTD) commands special attention.

At roughly the same time that the Buchanan report in Britain found no reasonable competitive alternative to the automobile, the voters of three counties of the San Francisco Bay Area committed themselves to support the largest bond issue ever undertaken for an urban transportation system. The San Francisco Bay Area Rapid Transit experiment has aroused international interest on a number of counts. Most important perhaps is the fact that this is the first wholly new public-transit system to be built in the U.S. in 50 years and the first openly to challenge the automobile-transportation system in the era marked by the ascendancy of the automobile and the freeway. Almost equally important is the fact that this project is being undertaken as the result of the decision of citizens of a metropolitan area—for the most part automobile owners—to tax themselves to bring an attractive transit alternative into existence. For various reasons one cannot assume an overwhelming consumer mandate, but the actions of the electorate of the three metropolitan Bay Area counties that finally formed the district is remarkable on the American local-government scene, where the assumption of responsibility for transit by voters is, to say the least, unusual.

The Bay Area mass-transit undertaking is the outcome of more than 10 years of major public planning and study of the transportation needs in the region. The earlier studies envisioned participation of at least the seven inner Bay counties in the system; the Bay Area Rapid Transit District created by



BARTD'S SHARE of the total daily commuter traffic along its routes is indicated for 1971, when the system will go into operation. Proportion of trips to be handled by BARTD is in solid color; all other trips are in hatched color. The BARTD system is expected to carry some 100,000 passengers a day, or half the total traffic, between Oakland and San Francisco.

the California legislature in 1957 would have allowed the participation of five counties. By the time the proposed district was brought before the voters in November, 1962, however, it had been reduced to three counties: San Francisco, Alameda and Contra Costa. San Mateo County, whose Southern Pacific commuter trains serve the older suburbs that generated the bulk of commuting to San Francisco's financial district in an earlier era, withdrew from the plan. Marin County, joined to the city by the thin thread of the Golden Gate Bridge, was judged too difficult to serve under present conditions. The district comprising the three counties was authorized by the voters of those counties to issue $792 million in bonds.

The BARTD system, which is expected to be in operation by 1971, is to be an electric rail system with elevated tracks over some of its routes and subways over others. It is hoped that it will provide technically advanced, comfortable, high-speed commuting that will divert peak-hour travel from automobiles to its trains. To do this it will stress comfort and speed (notably speed; unless the commuter can save appreciable amounts of time he will not easily be diverted). Existing mass-transit systems find it hard to achieve average speeds exceeding 20 miles per hour over the whole of their run; the Bay Area trains will aim at average speeds of 40 to 50 miles per hour and maximum speeds of 80 miles per hour. To attain such average speeds BARTD will operate what is primarily an express system with widely spaced stations fed by buses and automobiles.

In order to be convenient, the express service must be frequent. At present a maximum interval between trains of 15 to 20 minutes at any time of day is contemplated. The proposed interval between trains during hours of peak traffic is 90 seconds. Although slightly less frequent than some rail lines (for example parts of the London subway system at peak), this is very frequent service by American standards; it will be aided by fully automatic controls. A critical factor in the interval between trains is the length of station platforms; this length limits the speed of loading. The BARTD planners hope to have platforms 700 feet long, the longest in the world with the exception of the continuous platforms in the Chicago subway. The maximum interval of 15 to 20 minutes, maintained by varying the number of cars to match anticipated loads, will reduce the number of trains less markedly than would be the case in other transit operations. The BARTD planners believe that in rapid-transit equipment the process of technical obsolescence may be so rapid as to outweigh the fixed costs of wear; thus it will pay, in terms of overall performance, to use the equipment more frequently. If waiting times ranging from 15 to 20 minutes can be maintained around the clock, the BARTD operation will in fact be a suburban rail system with some of the characteristics of local transit. This performance would enable BARTD to avoid the inconvenient schedules that plague the traditional commuter lines, while still offering the high speed and comfort needed to serve effectively the greater distances of commutation characteristic of the present pattern of metropolitan settlement.

The BARTD system will necessarily be expensive. The basic rider's fare has been set in advance planning at 25 cents, with increments based on distance and an average commuter cost of $1 per trip. Fares are expected to cover the operating costs, although the district has some flexibility in case of shortfall. The cost of tunneling under San Francisco Bay will be met by funds diverted from the automobile tolls of the Bay Bridge Authority, under the reasonable expectations that (1) the transit system will help to relieve the overload on the bridges at peak hours and (2) the transit system will not result in a diversion of automobiles so great as to impair revenues from the bridge tolls. With the exception of certain improvements that will be paid for by the cities affected, and some Federal grants for planning and testing new equipment, the remainder of the capital cost will be met from the bond issues. With the bond vote the property owners of the participating counties made themselves available for such additional taxes as would be necessary for building the system. Over a period of time, as costs rise and the system encounters unforeseen difficulties, taxpayers in the member counties could conceivably be saddled with high annual costs. In spite of the fact that at least some property owners will benefit greatly from the existence of the system and that all commuters, drivers as well as riders, will share in a more efficient transportation operation, the real estate taxation base is likely to provoke future political reaction. In this event the more equitable Federal tax base may offer the most promising relief.

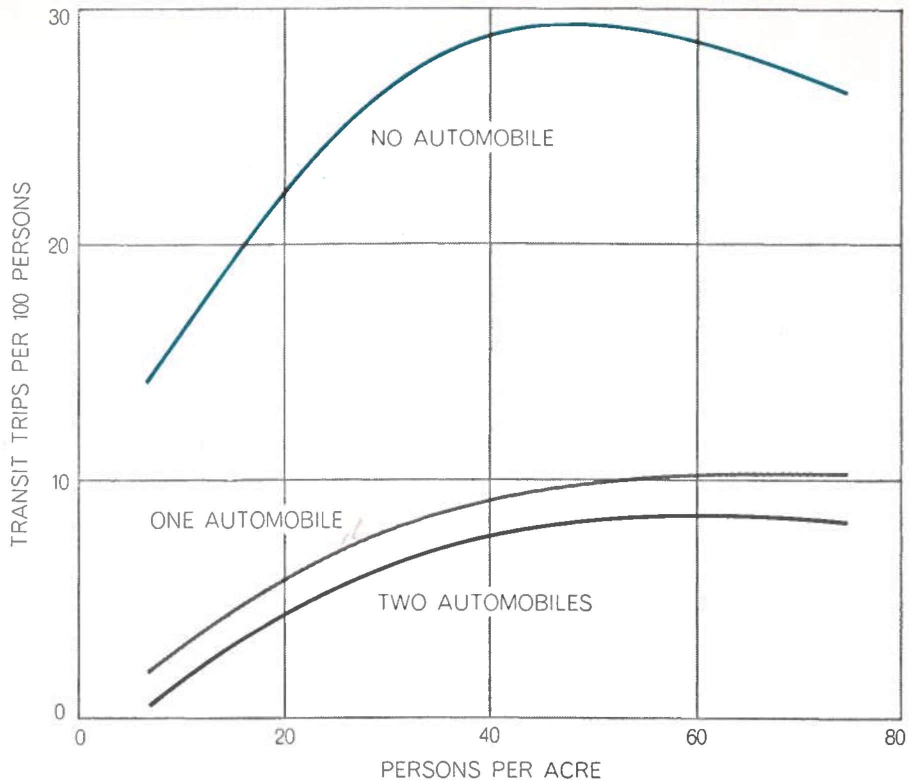
BARTD is staking much on the enthusiasm of its future riders. Its case for that support rests on speed, frequency of service, comfort and convenience resulting from attractive cars, easy ticket handling and other "human engineering" factors. It hopes to make commuting by train as pleasurable for some riders as surveys of commuters tell us driving is for others. As an answer to the general problem of urban transportation, however, it has grave shortcomings to match its great promise.

Perhaps the most significant feature of the BARTD approach is its concentration on the portion of the problem it considers to be crucial: the diversion of some of the peak-hour, longer-range commuters. This is certainly an important part of the urban transportation problem in many large cities, particularly in California. It is not the whole problem, however, and some features of the Bay Area system raise doubts about its impact on the total transportation problem of the area.

BARTD must improve its prospects for solving the distribution and collection problems that are the persistent vexations of fixed-rail systems. For its door-to-door service the system depends on connections with the private automobile. A "car park" system, which is proposed to encourage park-and-ride trips, is BARTD's answer, but as it is presently planned this system may not be adequate. Unless the commuter is certain of a parking place at the station, he must either depend on "kiss and ride" assistance—a ride with his wife—or make an earlier decision to park downtown if the station car park is full. Delivery of passengers in San Francisco, Oakland and other business and industrial districts is a similarly serious problem. San Francisco has traditionally been favored by the limited physical scale of its downtown area; the area is compact and densely populated, and it has high intensity of urban activities within a short walk of central points. Oakland, however, is less concentrated. In general two factors work against an easy solution of the delivery problem. One is that downtown areas are spreading; the other is that, as industries seek lower-density sites away from the downtown area, there is a sizable volume of reverse commuting.

The local-transit portions of the BARTD system and its subsidiary feeder-distributor arrangements have thus far received the least consideration. The majority of the downtown workers live

FULL-SCALE MODEL of a BARTD train was photographed at the test station near Concord, Calif. The detachable forward pod has space for an attendant and automatic-control equipment. The attendant will monitor the train's performance and will be able to exercise control if necessary. Normally, however, the BARTD trains will be operated automatically with the aid of a central computer.



AUTOMOBILE OWNERSHIP, a function of personal income, appears to be more important in the decline of transit use than deteriorating service. This graph, based on data from the Pittsburgh Area Transportation Study, relates density of an area to transit use by residents of the area, according to the number of automobiles owned per household.

in the cities, on the local-transit part of the system, and a sizable number of middle-income and lower-income factory workers commute from moderately priced rental areas in the center city to jobs in suburban areas. The latter are likely to find the trip from the downtown end of the BARTD line to their jobs a difficult one, and the former are likely to find the spacing of the stations inconvenient for the length of trip required. Within the downtown areas there is as yet too little attention to the devices needed to get passengers from the debarkation platform to their destination. Moving sidewalks, local bus connections, jitneys and other devices may have to be carefully integrated into a planned distribution system. At present the most effective distribution systems at downtown terminals are vertical ones making use of high-speed elevators, as in the Pan Am Building above Grand Central Station in New York. The fast, free elevator ride, however, is made possible by the real estate values of the location; as far as the rail system is concerned it is simply a device for capitalizing on the "point to point" features of the fixed-rail line.

If it is not necessary to move passengers too great a distance to and from the station, the passenger conveyor belt —an elevator turned on its side—may prove to be an important adjunct to the rail system. The continuous conveyor belt is a most efficient transportation device (whose possibilities for the movement of freight have not yet been fully tapped in the U.S.). In passenger use its efficiency depends on the length of the trip and, to a lesser degree, on the route and on the means of getting on and off the belt. Belts currently in operation carry as many as 7,000 persons per hour in a 42-inch lane. When one considers that a contemporary expressway lane carries only a third of that number, the performance of the belt is promising. Present conveyor belts, however, go only one and a half to two miles per hour. At this low speed it is necessary to keep the ride short in order to hold down total travel time.

The transit-system terminal runs into trouble when the distance the passenger must walk exceeds 1,500 feet. If the passenger is not to spend more than 10 minutes on a belt (an excessive time with respect to the shorter overall journey), the speed must be pushed above 150 feet per minute, or close to two miles per hour; speeds over three miles per hour make it difficult for some passengers to step on and off the belt. With increased use of conveyor belts in airports and parking areas, however, advances in loading and unloading them can be expected.

The fact remains that the moving walkway is a point-to-point device and inherently inflexible. Given the high cost of its installation and the risk of shifting demand in the downtown area, it may be less attractive than the more flexible small bus or car. Failure to develop effective devices at the ends of the trip could jeopardize the success of the BARTD operation; a greater emphasis on securing a cheap, flexible system for quick delivery of discharged passengers at their destination will be needed as the rapid-transit portion of the system moves closer to operation.

If the problem of matching the service to points of origin and destination cannot be solved, the BARTD system may turn out to be an interim rather than a long-range solution to the Bay Area transportation problem. The BARTD lines will form a double-track system relying on third-rail power and using relatively conventional railroad cars. BARTD's principal departure from standardization—a wider rail gauge—promises a somewhat smoother ride than the conventional gauge but has the serious drawback of impeding integration with the Southern Pacific Railroad system in the event that San Mateo County is brought into the district. The BARTD decision to use wide-gauge tracks is at variance with plans in Philadelphia, Chicago and New York to push for the integration of portions of the traditional railroad commuter lines with local transit operations.

Experts who are not sanguine about the role of rail systems in moving people from door to door are advocating more drastically altered systems. Any mass-transit system depends on the principle of specialized vehicles and routes. Automobile expressways can be designed to offer specialized routes, such as separate rights-of-way and separate levels. Rail transit offers the same in addition to a specialized vehicle: the train. A Cornell Aeronautical Laboratory report for the Department of Commerce urged consideration of a system that would combine the automobile's vehicular versatility with some of rail transit's advantages for part of a typical trip. Such a system would be an automatically controlled automobile freeway; it might be able to push the capacity of the freeway close to that of the rail system without sacrificing the collection-and-distribution advantages of the individually operated vehicle.

Some of the engineers who have considered the design of an automatic freeway favor the use of small, electrically powered cars that can be automatically controlled in certain zones, coupled and uncoupled without danger or discomfort and conveniently stored at their destination. The case for electric power is made on the grounds of reducing the air pollution associated with emission of hydrocarbons by internal-combustion engines and on the grounds of the improving economy of battery-powered vehicles in stop-and-go driving. The case for a coupling device is based on the desire to secure automatic control on expressways and storage in central business districts. Since electric cars designed for intrametropolitan use would be smaller than conventional cars, less space would be needed in which to park them.

Such systems were of course not available to BARTD, although they may be useful in future planning of transportation. The BARTD system is potentially the most advanced mass-transit system in the U.S. and at the same time, in the words of the planning critic Allan Temko, "something which is patently less than the best that 20th-century technology makes possible." Perhaps the transit of the future will be automatic, coupled private vehicles; perhaps it will take the form of improvements in present train technology, with air-cushioned trains riding above the roadbed, sped by linear-induction motors; perhaps it will appear as a system of passenger or automobile carriers traveling at high speed in pneumatic tunnels [see "High-Speed Tube Transportation," by L. K. Edwards; SCIENTIFIC AMERICAN, August].

Whatever the vehicular technology, it will be well to recall Wilfred Owen's caution in 1957 that "the so-called transportation problem is only half a transportation problem. Half the problem is to supply the facilities for moving. The other half is creating an environment in which the transportation system has a chance to work." In this respect it is unfortunate that the BARTD transportation plan has, for a variety of historical reasons, preceded an effective plan of metropolitan land use. The success of BARTD will depend partly on shifts in population density and land use in the region, and the operations of BARTD (along with other elements of the regional transportation system, such