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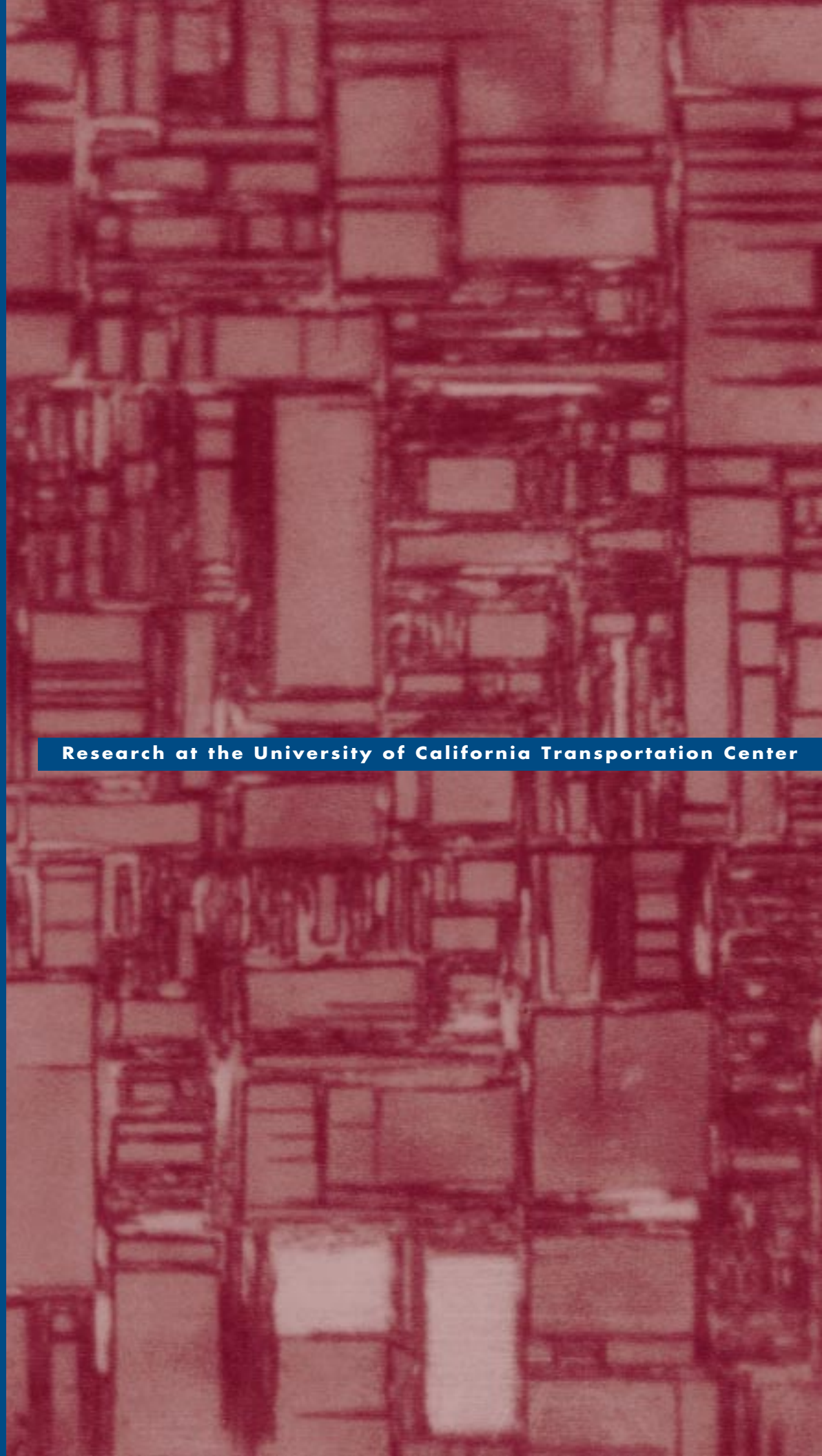

Research at the University of California Transportation Center

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The University of California Transportation Center, founded in 1988, facilitates research, education, and public service for the entire UC system. Activities have centered on the Berkeley, Davis, Irvine, Los Angeles, Riverside, and Santa Barbara campuses.

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The Land Use/Transportation Connection (cont'd)

BACK IN THE 1950s and 1960s, a basic aim for the newly proposed BART system was to curb urban sprawl. The trick was to reinforce major metropolitan centers and create new suburban subcenters. Because land adjacent to BART's station sites would be highly accessible, its planners expected they'd be powerful magnets attracting offices, shops, and high-density housing. Those concentrations would make for culturally enriched residential life and a more viable local economy. In turn, they'd attract riders to BART and thus help reduce traffic congestion.

Our mid-'70s assessments of promised land use effects were pessimistic, but probably premature, because land use changes are slow to show up. Now, some two decades later, it is possible to assess BART's influence on Bay Area development with greater precision and confidence.

John Landis and Robert Cervero have conducted a new series of land use studies around BART lines and stations, and they summarize their findings here. Their conclusions confirm those of the earlier assessment: Downtown San Francisco's office employment has indeed expanded dramatically near BART stations, but there has been only modest development around other stations—whether urban, suburban, or exurban. They find BART has had little influence on the location of either population or employment. Indeed, growth rates were lowest in those suburban corridors served by BART, and suburban office construction favored places that lack BART service.

Patronage has also fallen short of expectations. Initial forecasts expected 258,500 daily riders in 1975. Now, 24 years later and after a 30 percent increase in population, there may not yet be even that many riders on the original lines.

Metropolitan areas around the country have been building or extending rail systems and, with some notable exceptions, experiencing similarly disappointing patronage and urbanization effects. One exception is Washington's Metro, whose Orange Line route into Virginia is now a rapidly urbanizing corridor with a series of new, high-density subcenters surrounding stations. Although BART is several years older, nothing resembling such dense concentrations has emerged near its suburban stations (see photos on page 12).

Four explanations may account for the differences.

(1) At the outset, more auto ownership and an extensive network of highways and freeways endowed the Bay Area with a higher level of region-wide accessibility. The additional accessibility at BART stations was but a small increment and hence largely inconsequential.

(2) In the absence of numerous transit riders living or working at stations, these sites are less attractive to real-estate investors than are dispersed and spacious sites readily accessible by automobile.

(3) Unlike Metro's complex network of intracity lines, BART is essentially a suburban commuter railroad with two main lines reaching to outlying stations. Those stations are largely surrounded by paved lots offering free parking and occupying much of the adjacent land.

(4) As Jonathan Levine explains in his accompanying article, so long as land use regulations continue to limit locational choice for families and businesses, the land market can't respond to induce desired urban and travel patterns.

Suburban centers along Washington Metro's lines are direct products of active engagement by local governments collaborating with private land developers. Together, they changed land use regulations, exploited urban-redevelopment options, created joint-development enterprises, and forged tax and other financial incentives that encouraged high-density housing and high-rise office buildings. Metro thus became an effective instrument for city-building.

In contrast, it seems that BART saw itself primarily as a railroad rather than as an agent of urban development. So it didn't actively work with local governments to change the zoning, or with real-estate developers and financial institutions to build at stations. The absence of intensive suburban centers then translated into too few riders. In turn, BART's low patronage was little inducement to concentrated suburban development. In further turn, continued low density meant continued low patronage.

Our experience here suggests it's not enough just to install rail transit. It should now be apparent that we can't rely on trains alone to restructure the land market so that it spontaneously induces desired urban forms or attracts sufficient riders. Once again, events have exposed the intrinsic interdependencies between land use and transportation, showing that we can't treat the one without the other.

Melvin M. Webber

MIDDLE AGE SPRAWL:

BART and Urban Development

BY JOHN LANDIS AND ROBERT CERVERO

BART was the first American rail rapid transit system to be built in modern times, and its arrival was greeted with worldwide attention. BART is famous. Its fame is attached to its favorable image as the answer to the problems of the modern American metropolis. And the extent to which it has succeeded, or failed, to live up to expectations is an important lesson for other cities wanting to emulate it.

BART is now middle-aged and certainly widely recognized as a part of the San Francisco Bay Area, but is it an important part? Do people in the Bay Area live and work in different locations and in different ways than they would if BART were not there? Can we point to housing projects, office buildings, shopping centers, or public buildings that would not have been built, or neighborhoods that would not have been revitalized but for BART's presence? Does BART provide more people with more accessibility to economic and social opportunities than they would otherwise enjoy? Would the Bay Area without BART be the same place it is today?

The answers to these questions may be more important today than in 1962, when BART's construction was approved by voters in Alameda, Contra Costa, and San Francisco counties. If, as many city planners and transit advocates believe, transit investments like BART can substantially alter metropolitan development patterns, then transit's role as "growth shaper" should be explicitly considered when making transit investment decisions. If, on the other hand, transit's effects on growth and urban form are only marginal, then decisions regarding transit investments should be primarily made either to relieve congestion or to enhance accessibility.

We wish here to summarize the results of a series of inquiries into BART's effects on Bay Area growth and urban form, undertaken as part of the BART@20 project. (Similar studies were undertaken in the mid-1970s as part of the initial BART Impact Study.) We review BART planners' initial expectations regarding the system's effects on the Bay Area and ask how transit investments influence urban development. We explore BART's effects on regional population and employment patterns, residential and office-construction activity near BART stations, the quality of BART's influence on land use change and redevelopment, and BART's effects on home prices, office rents, patronage, and retail sales volume.

John Landis and Robert Cervero are professors of city and regional planning at the University of California, Berkeley, CA 94720-1850 (jlandis@uclink.berkeley.edu and robertc@uclink.berkeley.edu). Research assistants on the BART@20 and related projects were Carlos Castellanos, Bruce Fukuji, Wicaksono Sarosa, Will Huang, Subro Guhathakurta, David Loutsenheiser, Sourev Sen, and Ming Zhang.

INITIAL EXPECTATIONS AND PROCESSES OF CHANGE

Initial Expectations

The politicians, planners, and business and civic leaders who advocated building BART in the 1950s and 1960s did so expecting that BART would affect Bay Area development patterns in three related ways. First and foremost, BART would relieve mounting congestion problems on the Bay Bridge and major freeways, thereby insuring San Francisco's continuing dominance as the economic and political center of northern California.

Second, they hoped BART would serve as a structure for the inevitable outward suburbanization of the Bay Area. Rather than decentralizing willy-nilly, as Los Angeles was doing, the Bay Area would evolve into an efficient hierarchy of interdependent urban centers and subcenters, each specializing in some activity essential to the economic life of the region. Downtown San Francisco would stand at the apex of this hierarchy. One level down, Oakland and San Jose would serve as regional centers. One level further down were various subregional centers: Berkeley, San Mateo, Palo Alto, San Rafael, and Walnut Creek. BART would support this structure by linking these centers to each other and to suburban residential areas, creating points of high accessibility that would attract offices, high-density housing, and commerce. In doing so, BART would discourage leapfrog development and urban sprawl, which were regarded as economically and socially wasteful.

Third, BART would serve as a catalyst promoting redevelopment and reinvestment in older areas of Oakland, Berkeley, and Richmond, while promoting higher-density residential and mixed-use development in growing suburban jurisdictions. BART's success in meeting this last objective would depend on supportive land use and redevelopment policies at the local, neighborhood, and station-area levels. In the absence of such policies, BART's effects on the prospective built form of the Bay Area would be minimal.

Processes of Change

The processes through which transportation investments like BART affect urban development patterns are reasonably well understood. The principal effect of metropolitan transportation investments is to make previously distant sites more accessible, thereby adding to the supply of developable land within the metropolitan area. Able to purchase land more cheaply and still maintain their prior level of accessibility, households, stores, and businesses respond by moving outward. The resulting competition for suburban land causes site prices to rise above previous agricultural levels but below central city levels. If and when new agglomeration economies arise, usually among complementary land uses, land prices may increase further. Alternatively, rail transportation investments may serve to relieve congestion, ➢

thereby *maintaining* regional accessibility levels amidst continued growth.

Because accessibility is typically high near the sites of transportation facilities, rates of decentralization, land use change, and land price hikes should all be highest at the locations closest to the facility itself. For freeways, these high-value locations are at on-ramps, off-ramps, and interchanges; for rail transit systems, such as BART, they are at or near stations.

This simple theory lends itself to several testable propositions regarding BART's influence on Bay Area activity and development patterns. All else being equal:

- Activities requiring high levels of regional accessibility should concentrate around BART stations.
- To the extent that sites around BART stations are in limited supply, land prices, housing prices, and office rents near BART stations should be bid upward.
- Competition for sites around BART stations should cause development densities to increase.

POPULATION AND JOB GROWTH

As the foregoing suggests, one would expect population and employment growth to favor sites served by BART. To what extent has this actually been so?

Population Growth

Contrary to expectations, we found that population has grown faster away from BART than near it (Figure 1). The Metropolitan Transportation Commission divides the nine-county San Francisco Bay Area into 34 transportation planning superdistricts. In the twenty years since BART opened, population grew 35.2 percent in the 25 superdistricts not served by BART and only 17.1 percent in the nine BART-served superdistricts. In Alameda and Contra Costa counties, the population grew three to five times faster, in percentage terms, in areas not served by BART than in served areas.

Only in San Francisco was the pattern different. Population grew in the BART-served part of the city while the western half lost some four thousand residents.

FIGURE 1

Percent population growth in BART-served and non-BART-served superdistricts in Alameda, Contra Costa, and San Francisco counties: 1970–80, 1980–90

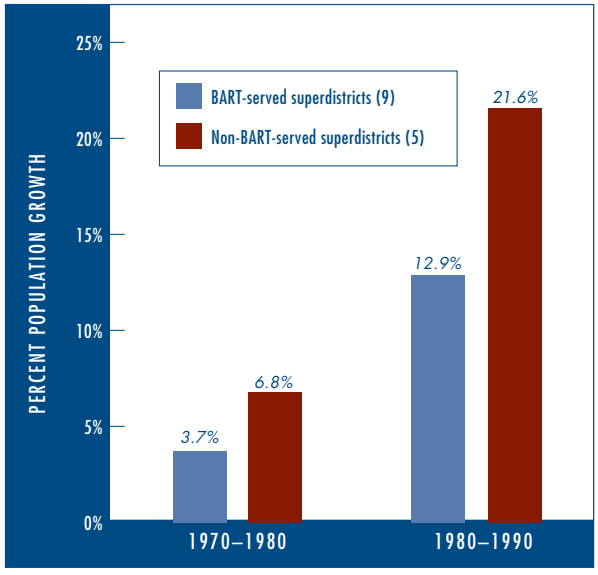
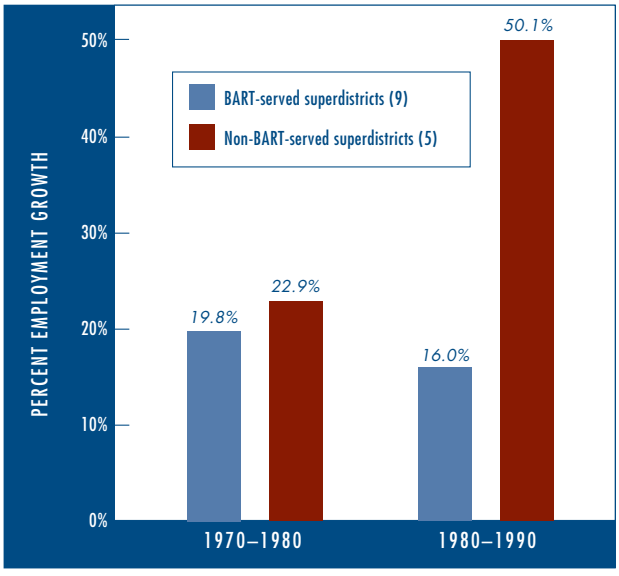


FIGURE 2

Percent employment growth in BART-served and non-BART-served superdistricts in Alameda, Contra Costa, and San Francisco counties: 1970–80, 1980–90



Employment Changes

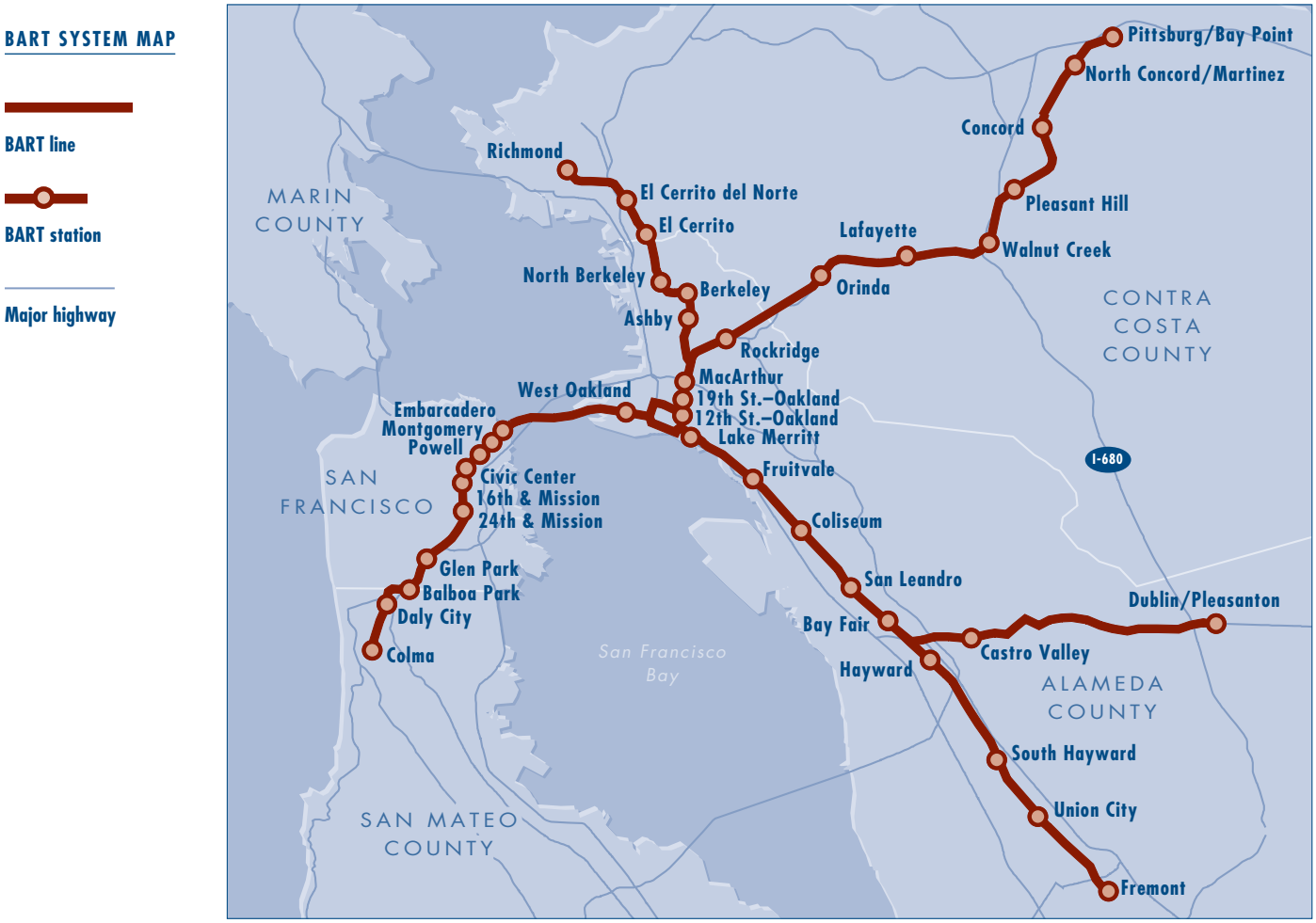
Outside San Francisco, a similar pattern emerged in employment changes (Figure 2). From 1970 to 1990, job growth mostly occurred away from BART. Employment grew 84.5 percent in non-BART superdistricts compared to 38.9 percent in the BART-served ones, mirroring the trend of job decentralization that was occurring throughout the U.S. At the county level, employment grew seven times faster in non-BART portions of Alameda County than in the BART-served portions, and non-BART superdistricts in Contra Costa County added jobs at twice the rate of BART-served areas. Growth percentages can sometimes be misleading: in absolute terms, 153,000 more jobs were created in BART-served superdistricts of Alameda and Contra Costa Counties than in the non-BART superdistricts.

A finer-grained analysis of employment growth by zip code showed marked disparities between San Francisco and the other counties for the 1980–90 period according to data at zip code level from *County Business Patterns.* The 35 zip codes in the three counties with BART stations gained 139,400 jobs from 1981 to 1990, growing by 30.3 percent and accounting for 57.1 percent of employment growth in the three counties. Employment in the 117 non-BART zip codes increased by 110,300, or 19 percent. However, almost all the BART-related employment growth occurred in San Francisco. Jobs in East Bay zip codes by comparison increased just 1.1 percent.

We also compared BART and non-BART employment growth differentials by business sector. The two sectors in which employment growth was most consistently concentrated in BART-served zip codes were Finance Insurance and Real Estate (FIRE), and non-Business Services. Even in these two sectors, however, employment growth was hardly uniform: it most favored BART-served zip codes in downtown San Francisco and along the north I-680 corridor.

In summary, job growth has been consistently higher around BART stations in downtown San Francisco than elsewhere in the region. In the East Bay, job growth has generally been faster away from BART, especially in the south I-680 corridor. ➢

BART SYSTEM MAP



DEVELOPMENT ACTIVITY IN AND AROUND BART STATIONS

Residential Construction

We estimate that approximately four thousand housing units were demolished during construction of BART and related redevelopment projects. Once construction was completed, planners hoped these units would be replaced, and indeed, added to. But it didn't quite work out that way: disinvestment in housing near BART stations continued well after BART was completed. Between 1970 and 1990, housing units within a quarter-mile of BART stations declined by nearly four thousand units, or roughly –11 percent. In contrast, the number of housing units in BART-served cities grew by 20 percent, and Alameda, Contra Costa, and San Francisco counties together experienced a 25 percent increase. The loss of housing units around BART stations was mostly a downtown phenomenon in Berkeley, Oakland, and San Francisco (Figure 3).

Additions to the housing stock, where they have occurred, have been concentrated at suburban stations, along the Fremont line, and near the end of the line. Most gains—as, indeed, most losses—have been apartment units. Property values and congestion levels near BART stations are generally too high, and neighborhood services and amenities too low, to attract single-family homebuilders.

FIGURE 3

BART station areas: change in single- and multi-family housing units, 1970–1990

Just about everyone agrees that developing housing near BART stations is a good idea. In practice, it has always been a tough sell. Until recently, Bay Area apartment developers were more interested in suburban properties than older urban neighborhoods. Local general plans and development policies were—and to some extent, still are—indifferent to multi-family housing development. In addition, residents of established single-family neighborhoods around BART stations like North Berkeley and Rockridge have long opposed residential densification of any form. Except at a few isolated stations like Fremont, Pleasant Hill, and now Fruitvale and Castro Valley, opportunities for large-scale residential development have been sparse.

Thus, notwithstanding thirty years of demolition and construction, most near-BART housing is what it was and where it was two decades ago. In 1990, apartments comprised about three-quarters of the housing stock at BART station areas, about the same as in 1970.

Office Construction

In contrast to housing, BART has had a significant concentrating effect on office development, but only in San Francisco (Figure 4). In 1962—the year local funding for BART was approved by voters—the supply of office space in San Francisco stood at 18.8 million square feet. About half this total was located in the downtown area, within a quarter-mile of what would be ➢

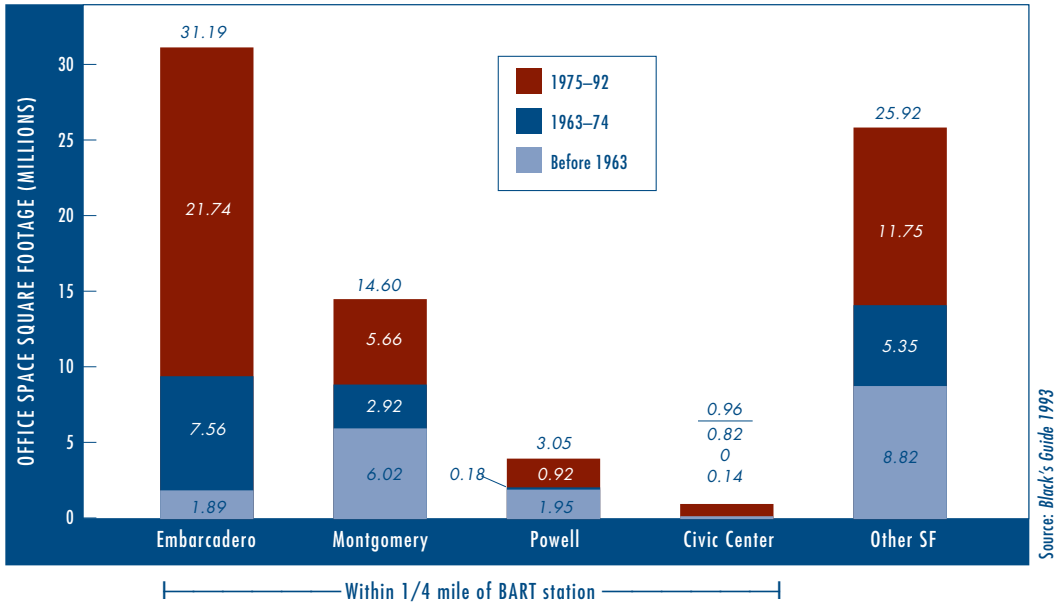
SOME HOUSING SUCCESS STORIES

There have been some notable exceptions to the tepid performance of housing around BART. BART's greatest housing success story is at the Pleasant Hill station, on the Concord line. Until 1988, the Pleasant Hill station was surrounded by a mix of modest single-family homes and open fields. Between 1988 and 1993, over 1,900 housing units were built within a quarter mile of the station—despite the station's being enveloped by BART's largest parking lot and lying in an unincorporated part of Contra Costa County. In many situations these conditions would have suppressed land development.

Three factors contributed to Pleasant Hill's turnaround. First, a cogent, specific plan created in the early 1980s served as a blueprint for guiding growth. Second, a proactive redevelopment authority aggressively sought to implement the plan by assembling irregular parcels into developable tracts, seeking out private co-ventures, and investing in supportive public infrastructure. Third, a local elected official became the project's political champion, working tirelessly and participating in numerous neighborhood meetings to shepherd the project through to implementation.

FIGURE 4

San Francisco office space construction by period



the locations of the Embarcadero, Montgomery, Powell, and Civic Center BART stations. Between 1963 and 1974, when BART was being built, San Francisco's office inventory expanded by 16 million square feet, two-thirds of which was located within a quarter mile of the same four BART stations. (Nearly half the office space built in downtown San Francisco between 1962 and 1974 was located close to the Embarcadero BART station.)

During the next eighteen years, another forty million square feet of office space—more than double what was already there—would be built in San Francisco. Nearly three-quarters of this amount would be built in downtown areas, within a quarter-mile of the downtown BART stations, and again with more than half the new supply near the Embarcadero BART station.

BART also facilitated development of larger office buildings. The average size of all San Francisco office buildings prior to 1962 was 72,000 square feet. The average size of office buildings constructed between 1963 and 1974 was 365,000 square feet for buildings located within a quarter-mile of future BART stations, but only 208,000 square feet for buildings located beyond the downtown area. As a result of public policies favoring smaller building footprints, office buildings constructed since 1975 have tended to be smaller than buildings constructed in the 1960s and early 1970s. This trend notwithstanding, the average size of new office buildings constructed since 1975 outside BART station areas is only 108,000, less than half the size of office buildings of a similar age located within a quarter-mile of a BART station.

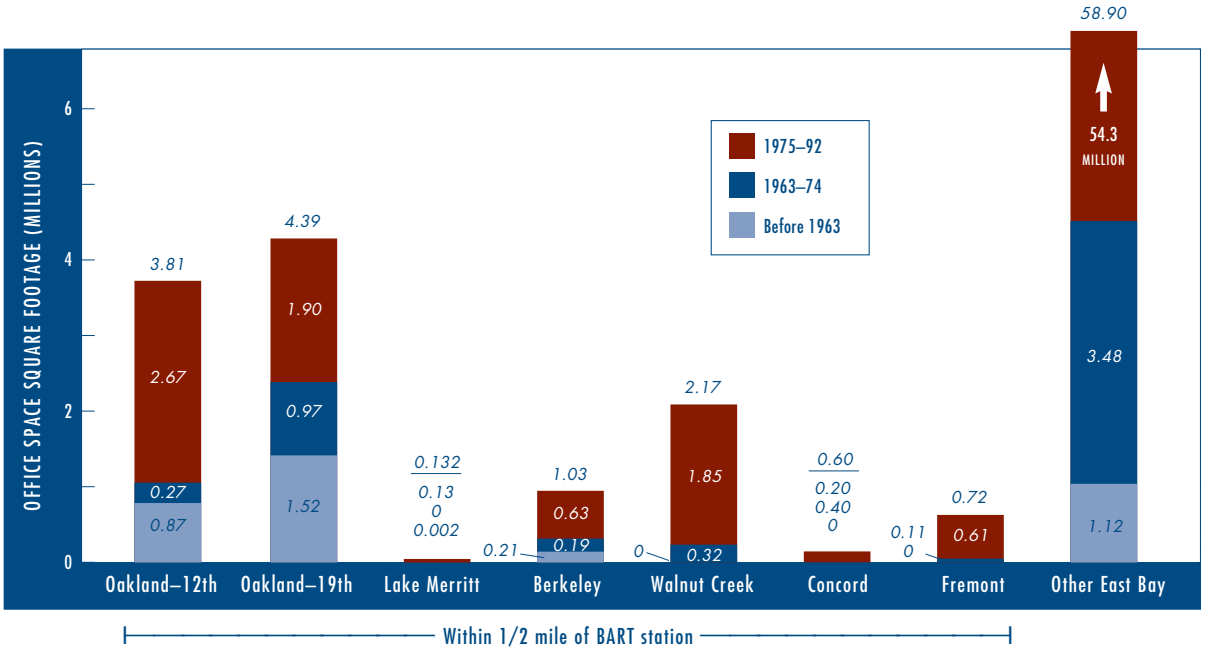
BART's concentrating influence on office development has not extended to the East Bay. In fact, as Figure 5 shows, East Bay office construction during the last thirty years has favored cities lacking BART service. As of 1962, the East Bay office inventory totaled about 3.7 million square feet. Of this total, about two-thirds was located within a half-mile of proposed BART stations in downtown Oakland, Berkeley, Walnut Creek, Concord, and Fremont. Of the 5.4 million square feet of new East Bay office space built between 1962 and 1974, only about a third was located within a half-mile of proposed BART stations. Of the sixty million square feet of new office space constructed in Alameda and Contra Costa counties between 1975 and 1992, only 15 percent was located within a quarter-mile of a BART station. Indeed, most of the new office space constructed in the East Bay since 1975 is located adjacent to freeway interchanges.

The Land Use Planning Connection

Why did BART help concentrate office development in San Francisco, but not in the East Bay? The answer to this question illustrates the crucial role of local planning and development policies in shaping the effects of transit on urban development. Remember that San Francisco political and business interests had always viewed BART's development as a tool for maintaining the city's regional primacy. The San Francisco Redevelopment Agency has long worked toward the same end. As part of its ongoing redevelopment efforts, it cleared vast amounts of land

FIGURE 5

East Bay office space construction by period



along the Embarcadero during the 1950s and 1960s. Large parcels suitable for modern office buildings were thus available for development right at what would become San Francisco's premier BART station.

More recently, San Francisco officials and citizens have adopted a succession of public policies aimed at concentrating office development in the downtown area and preventing its intrusion into residential neighborhoods. The first such policy was the Downtown Plan, adopted by the Board of Supervisors in 1985 and subsequently followed almost to the letter. The Downtown Plan was followed in 1986 by the passage of Proposition M, a citizen initiative limiting annual office construction to 400,000 square feet, thereby forcing office developers to compete for allotments. The ratings system adopted by the city for evaluating competing office development proposals strongly favors downtown locations. This has had the effect of making downtown sites even more valuable.

Taken together, these three policy initiatives: site clearance and land assembly, downtown-oriented commercial zoning (later augmented with development incentives), and the construction of a supporting transportation infrastructure (BART) have successfully prevented office development from decentralizing within San Francisco.

Ironically, these same policies helped to promote office decentralization outside of San Francisco. As downtown San Francisco office rents rose, partly in response to Proposition M construction caps and partly because of the inconvenience and high cost of development downtown, more and more office tenants began looking elsewhere in the region for office space. These tenants found cities with excess highway capacity, plentiful supplies of developable land, relatively liberal zoning and land use policies, and a yen to become a suburban office center. In the absence of a regional growth-coordinating agency, cities began competing with each other for commercial development.

Oakland, the one other city in the region well-positioned to use BART to catalyze downtown development, was unable to attract significant new office development. Instead, office developers and office tenants turned their attention to the Interstate 680 corridor in central Contra Costa County. The northern part of this corridor, the area between downtown Walnut Creek and downtown Concord, was served by BART. The southern part, from Danville to Pleasanton, was not. Except in downtown Walnut Creek—and even there, not until the mid-1980s—BART service was not a significant inducement to office developers.

BART AND OAKLAND

While BART has clearly helped downtown San Francisco maintain its economic vitality, its relationship with downtown Oakland is more complicated.

During BART's first ten years, virtually no new buildings were built around downtown Oakland's three stations. Things changed markedly since the early 1980s, thanks mainly to the construction of Oakland City Center, an ambitious office-retail complex built atop and linked to the 12th Street BART station that has received several design awards. Credit for City Center belongs jointly to the Oakland Redevelopment Agency, which provided a combination of land assemblage, tax increment financing of public infrastructure, securing federal urban renewal grants, subordination of loans, and equity participation (including majority ownership of a downtown convention hotel); and Bramalea-Pacific, a private development company that is headquartered in Toronto and thus familiar with transit-oriented downtown development.

Altogether, more than 1.6 million square feet of new office space (about 30 percent of the city's inventory) has been constructed in downtown Oakland since 1983. While this is certainly less than the volume of office space constructed in downtown San Francisco, it is probably more than would have been constructed in the absence of BART.

PATTERNS OF LAND USE CHANGE

Although BART has clearly had *some* localized influence on development activity at *some* stations, how far that influence extends and whether it has been systematic remain open questions. To gain a clearer understanding of BART's influence, we developed a series of statistical models of land use change in Alameda and Contra Costa counties between 1985 and 1995. (There were too few instances of land use change in San Francisco County.) The models track ten-year changes at the one-hectare (100m by 100m) site level.

We evaluated five types of undeveloped land use change and four types of redevelopment: no change in undeveloped land; change from undeveloped land to single-family residential use; change from undeveloped land to multi-family use; change from undeveloped land to commercial use; no change in developed land use; redevelopment from nonresidential to residential ➢

The changing downtown San Francisco skyline, looking toward Embarcadero station. **1958**

use; redevelopment from noncommercial development to commercial use; and redevelopment from nonindustrial development to industrial land use. These changes were compared with more than twenty predictive factors, such as the distance from each one-hectare site to the nearest BART station and freeway interchange. Altogether, more than 13,000 hectares of land in Alameda and Contra Costa counties changed use between 1985 and 1995.

BART's influence on 1985–95 land use change in the two counties turned out to be minor and uneven. In Alameda County, proximity to a BART station reduced the likelihood that a vacant site would be developed in either single-family use or commercial use and had no effect on multi-family or industrial development. In Contra Costa County, the closer a vacant site was to a BART station, the less likely it was to be developed in any use. BART's effect on redevelopment activity was even more varied. In Alameda County, proximity to a BART station increased the likelihood that a site would be redeveloped to commercial or industrial use, but not residential use. In Contra Costa County, proximity to a BART station had no effect on redevelopment.

BART's lack of influence stands in marked contrast to the effect of freeway interchanges. Among undeveloped Alameda and Contra Costa sites in 1985, proximity to the nearest freeway interchange exerted a strong negative effect on single-family development, a strong positive effect on commercial development, a strong positive effect on industrial development in Alameda County, and a weak negative effect on Contra Costa County industrial development. Proximity to a freeway interchange exerted a negative effect on residential redevelopment in Alameda County, a positive effect on Alameda County commercial redevelopment, and a negative effect on Contra Costa County industrial development.

PRICE AND RENT EFFECTS

The process by which transportation investments influence property values is known as *capitalization*. To what extent has BART service been capitalized into residential property values and commercial rents?

BART and Housing Prices

Proximity to transit is only one of many possible factors affecting housing values. Others include the size, age, and structural characteristics of the individual house; the location of the house *vis-à-vis* regional employment and service centers; the quality of the neighborhood and neighborhood services (especially schools); and accessibility via automobile.

Proximity to any sort of transportation facility is a double-edged sword. On one hand, properties located near or adjacent to highways and rapid transit lines usually have excellent accessibility. On the other, homes located right next to major transportation facilities also suffer from noise, vibration, and, with highways, localized concentrations of pollution. Homes located away from transportation facilities can avoid such problems, but must sacrifice accessibility.

The photo at left is at the same scale as the one above. **1992**

To test these propositions, we compared 1990 prices and characteristics among a sample of 2,360 home sales in Alameda and Contra Costa counties. We used a geographic information system (GIS) to address-match each transaction to its street address, and then measure its distance to the nearest BART station and the nearest freeway interchanges, and determine whether or not it was within 300 meters of an above-ground BART line or freeway.

All else being equal—that is, controlling for house size, age, number of bedrooms and bathrooms, income in 1989, neighborhood ethnic makeup, and being directly adjacent to a BART line or freeway—homes near BART stations in Alameda and Contra Costa counties sold at a premium, while homes near freeway interchanges sold at a discount.

For every meter closer an Alameda county home was to the nearest BART station (measured along the street network), its 1990 sales price increased by $2.29. For Contra Costa homes that sold in 1990, the sales price premium associated with the nearest BART station was $1.96 per meter. The opposite effect held for freeway proximity: Alameda and Contra Costa homes near freeway interchanges sold for less than comparable homes elsewhere. For every meter it was closer to a freeway interchange, the 1990 sales price of an Alameda county home declined $2.80. The per meter discount associated with highway accessibility was even greater in Contra Costa County: $3.41.

These findings are subject to three caveats. First, as significant as they are, these transit premiums are not large enough by themselves to promote redevelopment or increased residential densities. Supportive land use policies and, where appropriate, subsidies and incentives, are also necessary to encourage residential upgrading. Second, the existence and magnitude of a station-access capitalization effect is by no means a sure thing. A similar analysis of houses near Sacramento and San Jose light-rail stations and San Mateo CalTrain stations failed to identify any such premiums.

Furthermore, the fact that a BART-access premium existed in the East Bay in 1990 does not mean that home values were correspondingly higher in every home in every neighborhood near a BART station. In neighborhoods suffering from weak housing demand, or where the quality of the housing stock is poor, there may well be no additional value associated with transit access.

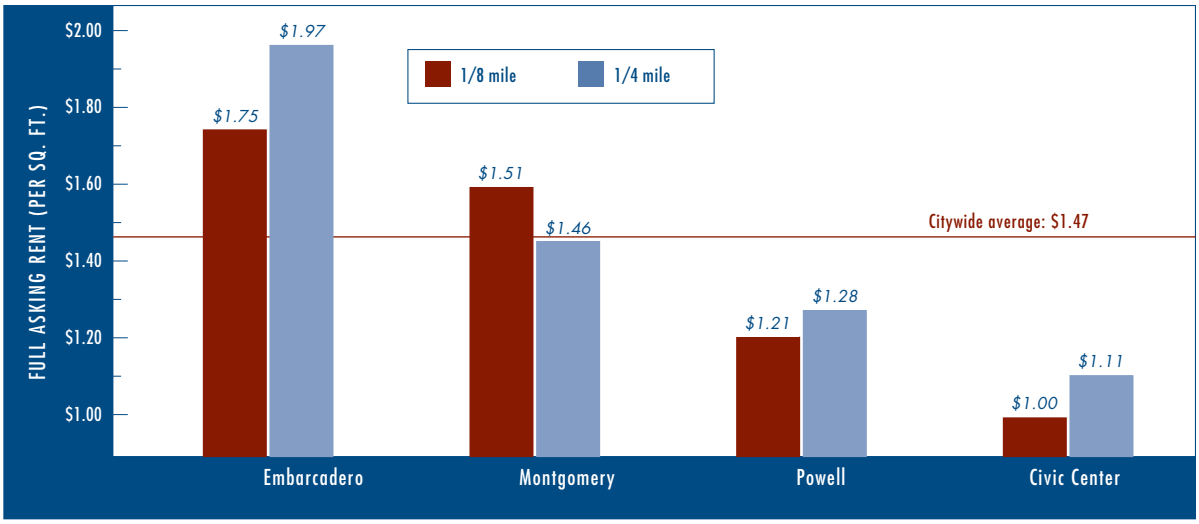
BART and Office Rents

We used a similar approach to investigate the influence of BART service on office rents. We compared differences in 1993 office-building rents and vacancy rates in Alameda, Contra Costa, and San Francisco counties as a function of proximity to the nearest BART station. We culled listings for individual office buildings from *Black's Office Leasing Guide: 1993* (San Francisco Bay Area edition), and matched addresses to their appropriate street locations. BART proximity was measured using concentric rings of 1/8, 1/4, 3/8, and 1/2 mile around each BART station, except in downtown San Francisco, where it was measured using 1/8 and 1/4 mile rings only. ➢

A tale of two efforts to build suburban centers at suburban rail stations. Top, Ballston, Virginia, on the Washington Metro's Orange Line, one of several similar subcenters there. Bottom, Pleasant Hill, California, on BART's Concord Line, the largest new development at a previously greenfield station site.

FIGURE 6

Average 1993 office rents in 1/8-mile distance rings from downtown San Francisco BART stations



If indeed office tenants do value accessibility to BART, then one would expect to find higher office rents for buildings closer to BART stations. Figure 6 shows that no such pattern is evident.

If proximity to BART makes a building more attractive to potential tenants, then one would also expect to find higher occupancy rates for buildings closer to BART stations. To a limited extent, this was indeed the case in 1993—especially for the two BART stations in San Francisco's financial district. When we looked more closely we found the higher occupancy levels associated with BART instead reflected improved building quality, not access to BART. These results confirm the observations of many commercial brokers: that office space is increasingly becoming a commodity and that rents follow the ever-changing balance of supply and demand and building characteristics more than location.

RETAIL ACTIVITY NEAR BART

BART was planned and constructed before the idea that transit stations should serve as neighborhood retail centers, or "transit villages," became as popular as it is today. Food is not allowed in BART stations or on BART trains, and no BART station includes significant internal retail space. Even at El Cerrito Plaza and Bayfair, the two BART stations which directly serve regional malls, station-shopping access is not as good as it could be.

These problems notwithstanding, there is a substantial amount of retail activity close to many BART stations. Major new retail projects have been developed adjacent to the Rockridge, Oakland-12th Street, El Cerrito del Norte, and Powell Street BART stations, and others are currently planned for the Fruitvale and Pleasant Hill BART stations.

How have the stores located at or near BART stations fared? Does being near a BART station boost customer traffic or sales? And are there any disadvantages to locating near a BART station?

Lacking area or retailer-specific information on retail sale volume, we developed and administered a brief questionnaire to all retailers located within a quarter-mile of twelve BART stations. The majority of respondents (54 percent) were long established at their current near-BART locations. Only 14 percent had been in business at their current (BART) locations for less than a year, while another 32 percent had been in business at their current locations for one to five years.

Close proximity to BART had been a very important consideration in their initial location decision, said 23 percent of respondents. Another 32 percent reported that BART proximity had been somewhat important. But an even larger number—45 percent—said that being near BART had not been a major consideration in their choice of location.

Opinions also varied widely regarding the contribution of BART to retail sales. Sample-wide, 14 percent of survey respondents believed BART contributed positively to their sales. Another 51 percent cited BART proximity as being only somewhat important to their business and sales, and one-third cited BART as having no effect. Furthermore, the longer retailers had been in business near BART, the less positively they viewed BART's contribution to sales.

Few weekday BART riders actually shop near BART stations—at least according to the survey respondents. Some 55 percent calculated that fewer than one in ten BART riders actually shopped at their stores. Only 7 percent thought that local BART riders comprised more than half their customer base. ➢

Restaurants and food stores were more likely to capture BART patrons than service businesses.

Forty-four percent of respondents cited customer and employee convenience as the primary advantage of being located near a BART station. Another 39 percent listed more customers as a major advantage. Greater visibility, additional pedestrian traffic, and BART's role as an area landmark were listed as major advantages by 20 percent, 15 percent, and 11 percent of respondents, respectively. Merchandise retailers perceived more advantages to being near BART than did restaurants, food stores, or service businesses.

On the other hand, almost a third of the survey respondents didn't list any disadvantages associated with being located near BART, although one-third cited the presence of "unwelcome people," and 22 percent cited reduced safety and security as key concerns. Merchandise retailers perceived more disadvantages from being located near BART than did other businesses—just as they also perceived more advantages. Retailers who had been in business a long time were neither more nor less likely to find specific faults than were retailers who had just opened up.

All in all, most respondents were happy with their locations. Sample-wide, 69 percent of respondents identified their current near-BART location as an ideal business location. Only 14 percent wanted to be located closer to a BART station, while only 10 percent preferred to be located farther away. Seven percent of respondents cited their ideal location as "nowhere near BART."

CONCLUSIONS

The story of BART and its effects on the metropolitan landscape of the Bay Area is complicated—composed of one very big achievement, several smaller successes, and many missed opportunities.

BART's major achievement has been to link downtown San Francisco with the growing suburbs of central Contra Costa County. This has allowed San Francisco to maintain its preeminence as the business and financial center of the Bay Area, even as regional auto use and traffic congestion have increased many times over. On a more modest scale, BART has helped spark new commercial and residential development around several suburban stations, most notably Walnut Creek, Pleasant Hill, Concord, and Fremont.

There have also been some notable failures. So far, BART has not triggered hoped-for levels of reinvestment in downtown Berkeley, Oakland, or Richmond. BART's land use effects on the Richmond and Fremont lines as a whole have been much less than were expected. Except for the Rockridge station in Oakland, BART has done little to encourage new retail development.

There are many reasons why BART's land use and development effects have to date been so modest. BART is essentially a commuter railroad, and the fact that most suburban BART stations are either surrounded by parking lots or in freeway medians has made nearby development difficult. In Berkeley, El Cerrito, and parts of San Francisco, neighborhood groups have long opposed more dense development around BART. Site assembly and financing difficulties combined with a lack of commercial demand have stifled station-area development along the Fremont line. BART has long insisted that new station-area developments provide free replacement parking, but that renders many projects economically infeasible. In short, the accessibility benefits from BART as capitalized into station-area land values have not been sufficient to overcome either weak local real estate markets or entrenched opposition to development.

Might things be different in the future? The success of the BART Rockridge station as well as recent evidence from Portland

FIGURE 7

BART station area retailer survey: advantages and disadvantages of near-BART locations

ADVANTAGES OF BEING LOCATED NEAR BART	Percentage of respondents answering	DISADVANTAGES OF BEING LOCATED NEAR BART	Percentage of respondents answering
Employee and customer convenience	43.2	Unwelcome people	32.2
More customers	38.7	Reduced safety and security	21.7
Greater visibility and exposure	20.0	Parking problems	13.0
More pedestrian traffic	14.8	Reduced sales volume	7.8
Near landmark	11.0	Lack of cleanliness	5.2
Easy and available parking	1.3	Congestion	5.2
Greater safety and security	1.3	Noise	2.6
Advertising	0.6	Image problems	0.9
None	12.9	None	30.4

indicate that there is a large untapped market for quality, mixed-use residential development within walking distance of regional rail transit. Successful experiences in metropolitan areas like Washington, D.C. and San Diego suggest that transit can be a catalyst to development where local governments, imaginative private developers, and transit agencies are able to work cooperatively together to overcome site assembly, design, financing, and entitlement barriers.

Overall, our findings confirm that the land use benefits from investments in rail transit are not automatic. Rail transit can contribute to positive change, but rarely creates change by itself. The hardware needs software—supportive land use policies such as density bonuses and ancillary infrastructure improvements—if it is to reap significant dividends.

BART is presently embarking on the largest expansion program in its history, with some 25 miles of suburban extensions at various stages of planning and completion. The degree to which Bay Area localities attempt to leverage BART's gift of improved accessibility will determine the land use effects of both existing and future investments over coming years. We trust there will be a BART@50 study to see if we are right. ◆

FURTHER READING

Blayney Associates/David M. Dornbusch & Co., Inc., *Land Use and Urban Development Impacts of BART* (San Francisco, CA: Metropolitan Transportation Commission, 1979).

Robert Cervero, "Rail Transit and Joint Development: Land Market Impacts in Washington, D.C. and Atlanta," *Journal of the American Planning Association* 60 (1): 83–90. 1993.

Robert Cervero and John Landis, "Twenty Years of BART: Land Use and Development Impacts," *Transportation Research* 31 (4): 309–333. 1996.

John Landis, Subrajit Guhathakurta, Ming Zhang, and William Huang, "Rail Transit Investments, Real Estate Values, and Land Use Change: A Comparative Analysis of Five California Rail Transit Systems," UC Transportation Center/ Berkeley Institute of Urban and Regional Development, Monograph 48. 1995.

Melvin Webber, "The BART Experience: What Have We Learned?" *The Public Interest* 45. 1976.

Access to Choice

BY JONATHAN LEVINE

A LONG TRADITION IN URBAN PLANNING seeks land use arrangements that reduce the need for travel, especially drive-alone travel. Current variations on this idea in the United States include jobs-housing balancing (locating jobs and housing nearby one another), transit villages (dense, mixed-use urban development with medium to high-rise housing concentrated near transit stops), and New Urbanism (a less dense, neighborhood form focusing on pedestrianism, transit, and mixed land uses).

Despite differences among these approaches, their common cornerstone for land use transportation policy is a focus on accessibility (the ability to reach valued destinations conveniently) rather than mobility (the ability to travel fast). Where valued destinations are nearby or accessible by transit, the reasoning goes, they can be accessible even without rapid and unconstrained travel. Thus traditional roadway construction and widenings, with attendant increasing travel distances and low densities, are de-emphasized in favor of development in areas of high accessibility, even at the cost of reduced travel speeds.

These ideas are controversial on two grounds. First, critics argue that implementation of these land use alternatives imposes undue limitation on people's choices about where to live and how to travel. Second, they suggest that transportation payoffs from these alternative development forms are illusory, because any major reduction in vehicle miles traveled (VMT) is caused by household sociodemographic factors, not urban design. Moreover, they argue, it is reasonable to believe that households select residences to match their travel preferences. Once self-selection is accounted for, they say, the independent effect of urban design on travel behavior becomes virtually undetectable. In addition, where origins and destinations are close together, the reduced cost of trips may lead people to take more frequent trips, leading to an increase in VMT.

Randall Crane summed up these policy implications of New Urbanism in the Spring 1998 issue of ACCESS, calling this alternative "a wobbly foundation indeed for current transportation policy." Crane goes so far as to say, "We must strive to avoid new urban and suburban developments that, although pretty and ambitious, might unintentionally cause more traffic problems than they solve."

I contend that critics of these land use alternatives are ignoring existing regulatory constraints on choice. They forget that the primary aim of these proposals is to expand households' choices in how to live and travel, not to reduce VMT. Nevertheless, neighborhood self-selection, an expression of expanded choice, can actually work to reduce VMT. ➢

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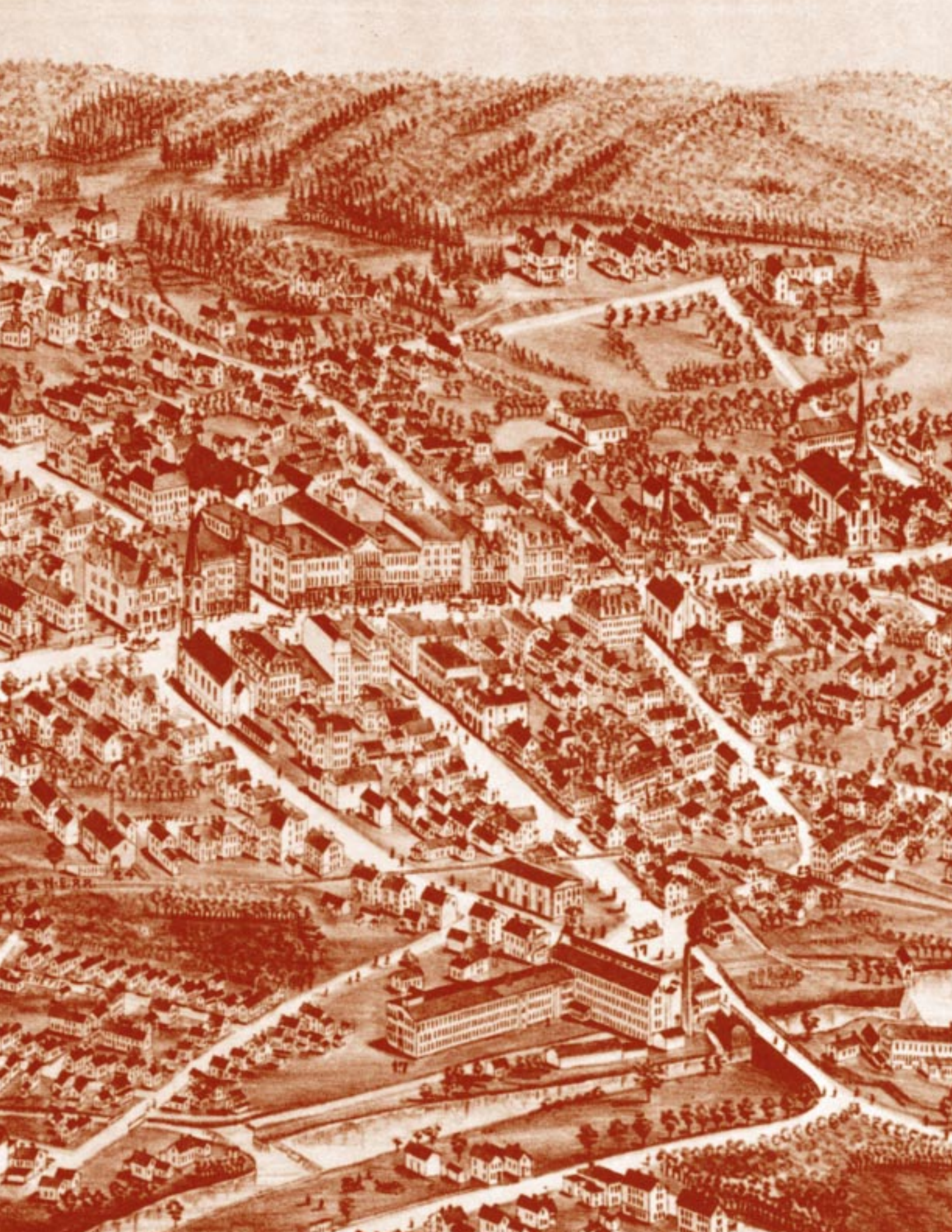

Current municipal planning practice typically seeks to lower development densities.

Expanding Choice

Researchers seem to agree that local government regulation works to shape metropolitan development patterns. Local policies include zoning that limits densities and mandates land use separation, transportation standards that call for wide streets and generous parking requirements, and fiscally motivated practices that restrict development of alternatives to the large lot and single-family house. But there is less acknowledgement of one implication of this regulatory regime: these policies prevent some households from getting the transportation and land use options they prefer.

Advocating accessibility-based land use alternatives does not mean more regulation forcing these designs on an unwilling market. Instead, local government regulations that currently preclude these alternatives need to be loosened, permitting the market to provide them where economically viable. Local government can prevent, allow, or facilitate higher-density development, but it is ultimately unable to *require* such development. A city council may desire development of a transit village at a particular site, but without a developer who sees the potential for profits the development will not occur.

Higher density development forms are typically portrayed as the products of planning and regulation of the land market, but the reality is actually the opposite: current municipal planning practice typically seeks to lower development densities. Reducing regulatory constraints is a prerequisite to the accessibility-based land use alternatives discussed here.

This argument is not intended to criticize land use regulation per se. Such intervention arose from early reformist activism aimed at unhealthful urban conditions, a concern that remains relevant today. But, reformist roots aside, the tools are broadly misused to exclude some development forms (and the population groups that would inhabit them) from selected neighborhoods. Moreover, they preclude innovation in metropolitan land use patterns. They are not the only barriers. But, as tools implemented by the planning profession, these regulations and their potential choice-constraining effects deserve more critical scrutiny by transportation and land use researchers than is currently evident.

VMT Reduction?

Many land use and transportation researchers judge alternative development forms by their capacity to reduce VMT, spur transit use, or encourage walking. These yardsticks seem reasonable tests for evaluating specific transportation claims, and such outcomes would be welcome side benefits from developing these land use forms. But scientific evidence of their likelihood must not be a precondition for removing regulatory barriers to choice.

Crane's article in ACCESS shows how land use policies designed to bring origins and destinations closer together might actually increase VMT as the total cost per trip is reduced. Alternative development forms might well cause some congestion, if for no other reason than that population density can lead to automobile density. Is that sufficient reason to avoid them? Only if one thinks free-flow automobility should take precedence over other competing goals such as encouraging pedestrianism, improving the effectiveness of transit, or expanding the range of land use and transportation choice.

Moreover, the claim that New Urbanism might increase VMT is only speculative in the absence of empirical evidence, and it should not be employed to exclude such alternatives in areas where market demand might support them. In areas where insufficient demand exists, one hardly needs policy to keep these development forms out; the absence of profits will accomplish this much more effectively.

Neighborhood Self-Selection

Some researchers have been concerned that processes of neighborhood self-selection might lead to overestimates of the effects of urban form on travel behavior. They say that people who already wish to drive less may choose to live in areas where that is easier to do. If one accounts for this tendency in statistical analysis, it appears to be the major cause for changes in travel behavior. That is, urban design by itself seems to have little effect and should therefore not be credited.

In contrast, I want to argue that such self-selection is the prime process by which alternative development forms might affect travel. Aiming to use urban design tools to induce unwilling auto-oriented households to drive less is probably futile. It is much more promising to accommodate people whose preferences for less auto-dominated environments have been inhibited by zoning and other exclusionary regulations.

Consider, for example, the elderly household with the capacity to drive but a preference for alternatives to the car. Where transit-oriented neighborhoods are not available, this household has no choice but automobile dependence; but were transit-based settlements allowed to develop, they could reduce car use.

Thus self-selection is hardly a problem invalidating the transportation relevance of alternative development forms. On the contrary, transportation planners should hope for the greatest possible self-selection into transit-oriented neighborhoods to expand the desired effects on VMT and transit use.

Of course we should try to estimate self-selection effects, but they should be interpreted differently. Where prospects of alternative development forms are restricted by regulation, reducing the regulation and thus allowing those forms will enable people with preferences for transit use, walking, or limited automobile reliance to exercise their preferences. The relevant question is not how much transportation-behavior modification can be forced by means of mandated land use changes, but rather what travel-behavior changes can occur once barriers to land use and transportation choices are lowered.

Conclusion

The debates I refer to have been shaped by the broadly held view that alternative land use and transportation proposals can be realized mainly through governmental regulation and control and are to be justified (if at all) by demonstrable reduction in VMT. But, to adopt this view, one must ignore the intricate latticework of current governmental land use and transportation regulation that imposes a development template inimical to alternative accessibility-based land use forms. Where the workings of the market might generate the sorts of land use arrangements the proponents seek, those inhibiting regulations preclude them.

Accessibility-based land use policies should be assessed in a different light. Are such approaches a "shaky foundation" for transportation policy? To the extent that transportation policy focuses on the singular goal of mitigating traffic congestion, concepts like New Urbanism, jobs-housing balancing, or transit villages will probably be of little assistance. But transportation policy should be aimed at broader objectives. Among other goals, policy should seek to ensure that households are able to match their land use and transportation environments to their needs and preferences. With or without benefits of reduced highway congestion, lowered barriers to household choice would be a worthy aim indeed for U.S. transportation policy. ◆

FURTHER READING

Marlon G. Boarnet and Sharon Sarmiento, "Can Land Use Policy Really Affect Travel Behaviour? A Study of the Link Between Non-Work Travel and Land Use Characteristics," *Urban Studies*, vol. 35, no. 7, pp. 1155–1169. June 1998.

Randall Crane, "Travel by Design?" *Access*, no. 12, pp. 2–7. Spring 1998.

Robert Cervero, "Jobs-Housing Balance Revisited: Trends and Impacts in the San Francisco Bay Area," *Journal of the American Planning Association*, vol. 62, no. 4, pp. 492–511. Spring 1996.

Wenyu Jia and Martin Wachs, "Parking and Affordable Housing," *Access*, no. 13, Fall 1998

Jonathan Levine, "Rethinking Accessibility and Jobs-Housing Balance," *Journal of the American Planning Association*, vol. 64, no. 2, pp. 133–149. Spring 1998.

Rolf Pendall, "Do Land Use Controls Cause Sprawl?" *Environment and Planning B: Planning and Design*. Forthcoming.

Splitting the Ties:
The Privatization of British Rail

BY JOSÉ A. GÓMEZ-IBÁÑEZ

MOST RAILROAD COMPANIES around the world own and maintain all the necessary facilities and equipment to provide rail transportation service. Different railroads often serve different regions, so a long distance movement might involve the cooperation of two or more railroads. A freight container moving from the port of Los Angeles to Atlanta might be transferred from the Union Pacific Railroad to the CSX Railroad, for example, while a passenger coach from Paris to Frankfurt would be transferred from the French to the German national railways at the border. But within its respective service area, each railroad usually owns all or most of the needed locomotives, wagons, tracks, yards, and stations. In the parlance of economists, railroads are often horizontally separated in that different railroads serve different regions, but they are almost always vertically integrated in the sense that they provide all the functions needed to offer rail service within their region.

In the mid-1990s, the British government began a radical experiment in vertically restructuring rail services when it privatized its national railroad, British Rail. The government broke British Rail into approximately seventy different companies and sold them to the private sector. The most important of these is Railtrack, which owns and maintains all of the tracks, yards, stations, and other railroad infrastructure in the country. Twenty-five separate private passenger train-operating companies, nicknamed TOCs, pay Railtrack to use its facilities. In addition, there are separate companies that operate freight trains and lease locomotives and rolling stock to the TOCs. They also bid to maintain infrastructure for Railtrack as well as locomotives and rolling stock for the TOCs.

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The aim of British Rail's vertical separation was to improve service and reduce costs by introducing more competition into train services. Rail infrastructure is usually considered a natural monopoly because the most economical way to serve most rail corridors is with a single set of tracks and stations. But train operations alone (without responsibility for infrastructure) is not a natural monopoly, so there would be no cost penalty if several TOCs competed with one another in the same corridor.

Vertical separation has long been common in other forms of transport, and it is increasingly popular in many other types of infrastructure and in utilities. The firms or agencies that own and maintain most highways, airports, and seaports, for examples, are not the same as those operating the vehicles, planes, and ships that use those facilities. Recently many countries have vertically restructured their telephone, electric, and gas utilities to introduce competition to certain parts of the business. In the mid-1980s, for example, the United States divided its national private telephone company, AT&T, into a long-distance company, an equipment company, and twelve separate local telephone companies (the "Baby Bells").

The reforms to British Rail remain the most ambitious attempt to apply vertical restructuring to railroads. The most important prior example in the United States involves Amtrak, the public corporation created in 1970 to revive long-distance rail passenger services. Amtrak owns its own rights-of-way only in the Washington-New York-Boston corridor; elsewhere it must pay private freight railways to operate passenger trains over their tracks. The private railroads agreed to this arrangement in 1970 in return for being released from the obligation to offer their own passenger services, but the number of Amtrak trains involved is relatively small.

In the 1980s, Sweden divided its government-owned railway into separate infrastructure and train-operating companies. The idea was that private train-operating companies would then be able to provide service using government-owned infrastructure, but the private sector showed little interest in entering the railroad business on these terms. Other countries that have recently privatized their railroads—such as Japan, Argentina, and Mexico—have broken them up horizontally (into regional railroads) rather than vertically. ➢

Interest in Britain's experiment is intense because the entire European Union may soon follow suit. The European Commission wants to promote competition in EU railway services and has issued directives requiring railways of member countries to offer access to other carriers on equitable terms. At the very least, the directives require railways to separate their infrastructure costs from their train-operation costs and to determine fair rules and charges for track access. Some countries, such as Germany, are establishing separate infrastructure and train-operating companies that they may eventually privatize.

The Origins and Design of Britain's Railway Reforms

British Rail was created in 1948 when Britain's private railroads were nationalized. It provided four main types of services throughout the nation: freight; regional (medium distance) passenger trains; intercity (long distance) passenger trains; and commuter railroad services, particularly in and around metropolitan London. British Rail's market share declined rapidly from the start, especially on the freight, regional, and intercity services, which faced serious competition from trucks, buses, and private automobiles. Commuter railroad ridership declined less drastically, largely because London's traffic congestion made auto and bus alternatives less attractive. Although the government cut many unprofitable and lightly used tributary lines in the 1960s and modernized track and rolling stock on many remaining lines during the 1970s, British Rail continued to require substantial public subsidies.

The railroad was one of the few public utilities and transport firms to escape privatization during the 1980s, after the Conservative Party led by Margaret Thatcher won control of Parliament in 1979. In that decade, electricity, gas, water, and telephone utilities were all privatized. British Rail may have been left out because of the sheer complexity of its services. By 1992, however, there was little left to privatize; and the Conservative Party, then led by John Major, finally announced its intention to sell off British Rail.

The government divided passenger services into 25 separate TOCs, each specializing in a particular area or route. It offered franchises to operate the services for terms of between seven and fifteen years through competitive bidding and expected negative bids—that is, requests for subsidies. Passenger TOCs were obligated to maintain at least the level of services British Rail had provided, and they were not allowed to increase fares on those services by more than retail-price inflation. But TOCs could provide additional passenger services on their assigned routes if they wanted to, and gradually they could also offer services on the routes of other passenger TOCs.

Perhaps because British Rail's share of freight carriage was small, freight services were not protected the way passenger services were, and the government did not accept negative bids for those franchises. A single company (English, Scottish and Welsh Railways, Ltd.) eventually acquired most of the seven newly created freight TOCs.

Railtrack was supposed to be financially self-supporting from the track- and station-access fees it charged the passenger and freight TOCs. Because Railtrack has a monopoly on Britain's rail infrastructure, the government set up a new public regulatory authority, the Office of the Rail Regulator (ORR) to oversee the conditions Railtrack sets and the fees it charges TOCs for access. Another new agency, the Office of Passenger Rail Franchising (OPRAF), supervises the awarding of passenger TOC concessions and monitors TOCs to ensure that they provide the promised services.

Performance Since the Reforms

Both taxpayers and rail users seem to have benefited from the reforms so far. The burden on the taxpayer for supporting rail service appears to have declined, although such calculations are complex and subject to criticism. Bids for passenger TOCs show a fairly dramatic reduction in subsidy over time, and some TOCs actually promise to pay OPRAF in the later years of their franchises. Rail services and usage have grown, despite cuts in rail subsidies. Train miles have increased, and so have reliability and punctuality. As a result, both passenger trips and passenger miles increased by approximately 15 percent in the first two years. Freight traffic has increased even more than that.

But there have been controversies over whether the government is getting good value for its money. Critics contend that the government either sold Railtrack for too little or has been too lax in regulating it, an argument that seems to be supported by the nearly fourfold increase in the price of Railtrack shares within two years of the initial public offering. Critics also complain that service quality has been uneven. In the first year, OPRAF assessed large fines on several passenger TOCs for not operating scheduled trains. In the second year, reliability improved but punctuality declined, although it was still above the levels of British Rail's last year of operation. Some observers blame the decline on the increase in train frequency, which is causing some critical sections of track to operate too close to capacity.

The Benefits of Vertical Separation

One key benefit of vertical separation—added opportunities for competition—has been deliberately delayed. There was competition for TOC franchises when they were auctioned off, and vertical separation also offered the possibility of competition among them after the auctions. Some proved unavoidable where territories or routes overlapped; for example, where separate intercity, regional, and commuter TOCs all served the same corridor. But the government feared that, if TOCs were to invade each other's territories from the outset, the uncertainties would discourage bidding for franchises. As a result, ORR decided not to allow passenger TOCs to establish any competing services until April 1, 1999.

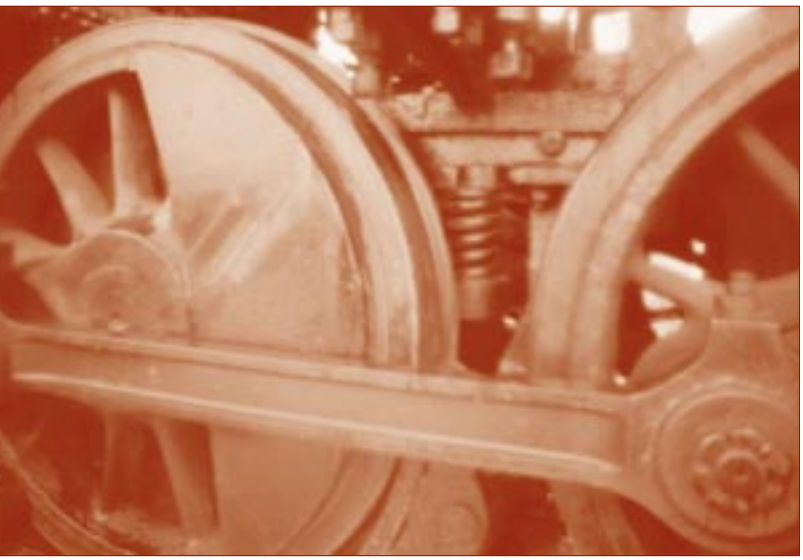
A second benefit, already apparent, is managerial focus. British Rail was an enormous organization, so some of the smaller and more specialized of its businesses suffered from lack of attention. By creating separate companies for different activities, the restructuring focused managerial attention in a new way. This benefit seems most obvious with freight service, which had languished under British Rail. The turnaround in freight traffic would not have happened if freight TOCs were not single-mindedly concentrating on freight as their sole source of revenue. Many of the passenger TOCs are exhibiting similar energy in developing their businesses. ➢

The Costs of Vertical Separation

The major disadvantage of vertical separation is increased difficulty in coordinating design and maintenance of infrastructure with train operating plans. Before restructuring, coordination was entirely within a single organization—British Rail—all of whose units were ostensibly dedicated to the common good of the enterprise and at least nominally under its central control. Now coordination has to take place through contracts negotiated at arm's length by autonomous enterprises that have different and often conflicting objectives.

In theory, the track- and station-access charges set by ORR could provide strong incentives for Railtrack and the TOCs to coordinate their activities sensibly. Access charges for each TOC include two components: a variable charge per train-mile, intended to cover the cost of accommodating an additional train on the route, and a fixed annual charge, intended to recoup Railtrack's fixed costs. In addition, a system of penalties provides incentives for day-to-day reliability and punctuality. Under the penalty scheme, a TOC must pay Railtrack a fine if one of its trains blocks a track or station at a time when it's not scheduled to be there. Railtrack, in turn, must pay a fine to the TOC if it cannot provide access for a train that's on schedule. Penalties are not intended to generate substantial revenues for either the TOCs or Railtrack but simply to encourage reliable daily service. ORR reviews and revises the access charges every five years.

In practice, it has proved difficult to set access charges that provide incentives. In its first attempt, ORR set charges so that 90 percent of Railtrack's revenue would come from the fixed component and only 10 percent from the variable component. This decision was based on an early and not very sophisticated study of Railtrack's costs and assumed Railtrack tracks and stations were not operating close to their capacity. But the very small variable component of the access charge seems to have encouraged a substantial increase in train mileage, since it is relatively inexpensive for TOCs to run additional trains. In turn, this has caused excess capacity to disappear in many places. Worse, there is little incentive for Railtrack to invest in increased capacity if it can't make much money on it.



ORR may change the fee structure in the future to approximate Railtrack's current costs more closely. However, as long as ORR relies primarily on access charges to provide investment incentives, it has to establish a very complex system of charges that vary significantly by location, time of day, direction, speed, axle weights, traffic volumes, and other factors that affect Railtrack's capacity costs.

In the absence of such a complex access-charge system, the main method of improving Railtrack's capacity has been through negotiations between TOCs and Railtrack over specific investments the TOCs want. ORR must review any agreements between a TOC and Railtrack to be sure that Railtrack is not abusing its monopoly position in the negotiations.

The primary example of a negotiated agreement to date has been the West Coast Main Line (WCML), a key four-track route connecting London, Birmingham, Manchester, Liverpool, and Glasgow that is heavily used by intercity passenger, local commuter,

and freight trains. Tight curves and an obsolete signal system on the one-hundred-year-old line limit its capacity.

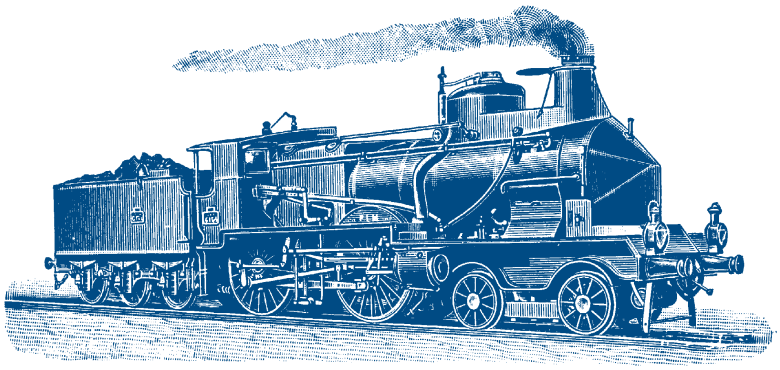
Richard Branson, the founder of Virgin Airways, won the TOC franchise in 1996 for long-distance passenger service on the WCML. Branson's bid was extremely aggressive, requesting subsidies of around £60 million per year in the beginning of the fifteen-year franchise but promising payments in excess of £200 million per year by the end. This financial turnaround could be achieved only if service were significantly improved. Branson's company, Virgin Trains, immediately began negotiating with Railtrack for improvements to increase the planned maximum speed to 140 mph.

It took over two years of negotiations to sort out the financial responsibilities and competitive interests of the different parties involved in the WCML. Virgin's proposal for 140-mph service created conflicts with other TOCs operating 80-mph commuter trains and 30-mph freight trains on the line. Operating 140-mph trains would reduce the capacity of the line unless Railtrack also upgraded to in-cab signaling and improved an extra pair of tracks. But these changes would provide benefits to the commuter and freight trains as well as to Virgin by increasing capacity and reducing delays at peak commuter hours. Railtrack, Virgin, and the other TOCs using the line had to agree both on how much the improvements would cost and on how the costs and risks would be shared among the several existing TOCs, potential new entrants, Railtrack, and the government.

The difficulties in reaching an agreement on the WCML suggest that this kind of negotiation may be a cumbersome method of coordinating infrastructure improvements with train-operating plans. The WCML is an extremely ambitious project, to be sure, but the complexities of negotiating agreements probably don't decline much with the scale of a project. There are modest enhancement needs all over Railtrack's network, and many may simply never get done if the high cost of negotiating agreements outweighs the benefits from the investments.

Conclusion

It is far too early to tell whether vertical separation will prove worthwhile in railroads. While the coordination problems seem daunting, the British have only begun to work on them. And the benefits of separation—in focus and added competition—are only just beginning to be realized. One thing that is sure is that many of us in the transportation research community will be following the British experiment with great interest. ◆



FURTHER READING

Journal of Transport Economics and Policy, vol. 33, part 1 (January 1999): a special issue devoted to railway restructuring and reform in Europe.

European Conference of Ministers of Transport, *The Separation of Operations from Infrastructure in the Provision of Railway Services* (Paris: Organization for Economic Cooperation and Development, 1997).

Ron Kopicki and Louis S. Thompson, *Best Methods of Railway Restructuring and Privatization*, CFS paper series no. 111, Coordinating and Financial Advisory Services, Privatization Group (Washington, DC: World Bank, 1995).

Louis S. Thompson, "The Benefits of Separating Rail Infrastructure from Operations," Policy Note, World Bank (1977).

José A. Gómez-Ibáñez, "Office of the Rail Regulator (Abridged)," Teaching Case, Case Program, Kennedy School of Government, Harvard University (1999).

OBJECTS IN MIRROR ARE CLOSER THAN THEY APPEAR

BY THEODORE E. COHN

Roads, bridges, gasoline, internal combustion engines, and automatic transmissions were singular advances on the way to modern automobiles. But, without goggles, the horseless carriage might have been slow to arrive. Dust in the eye was objectionable, debilitating, and dangerous at the new high speeds. Whatever access the automobile promised, a driver couldn't enjoy it if blinded, even momentarily. Developments leading to modern transport systems have been a long series of accommodations to what our eyes can and can't do. Because future developments must compensate for the limitations of human sight and take advantage of its capabilities, my laboratory has been examining various relations between vision and transportation. Here I'd like to tell about some of those relations.

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Goggles gave way to windshields, but these were no panacea because the heavy windshield frame limited the driver's field of view. It took a while before slim but strong frames overcame the problem. In 1911 a rearview mirror was fitted to a motor car. This device, an attempt to permit a backward glance, has undergone several developmental changes since then. Modern passenger-side mirrors contrive to expand the field of what's visible by the simple trick of bending the mirror. But this trick has an unintended consequence: objects in the mirror appear to shrink. Experience has taught our brains that there's a relation between the size of familiar objects and their distance from us. Shrunken, they appear to be farther away than they really are, hence the warning poem on our side-view mirrors.

Goggles, windshields, and bent mirrors were responses to manifest problems. Future systems will involve new structures dealing with newly perceived optical attributes, including a need for warning signals to alert drivers about stringent road conditions. To increase roadway efficiency, Intelligent Transportation System engineers are now studying plans to shrink lane widths and to equip cars with lane-edge sensors. But, so long as vehicle guidance is under driver control, the driver needs to know when his car crosses the lane's edge and to act on this information quickly and accurately. That requires improved visual cues.

Reduced headways can also increase efficiency, but that requires a new kind of warning signal that responds to the distance between vehicles. One ITS scheme groups vehicles in compact platoons of twenty or so. Cars in a group accelerate together, change lanes together, and in general behave in a coordinated manner. While under computer control, visual acuity is less crucial. But even then, tomorrow's drivers will need additional signals to warn that brakes or engine are not up to the demands of coordinated action.

Warning signals aren't the only media that will compete for drivers' attention. The November/December 1998 issue of *ITS International* showed the following products already available: a microwave pedestrian sensor, a corner sensor to see beyond or beside the front bumper, an in-vehicle computer that displays vehicle performance data, a navigation unit to display real-time alternative route suggestions based on current traffic, a night-vision sensor to display an augmented view of the road that transcends the capability of low beams, navigation aids with fully detailed maps, a birds-eye-view navigation aid, roadside signs with changeable messages, a lane tracker to warn of lane edge crossing, and a red-light violation recorder.

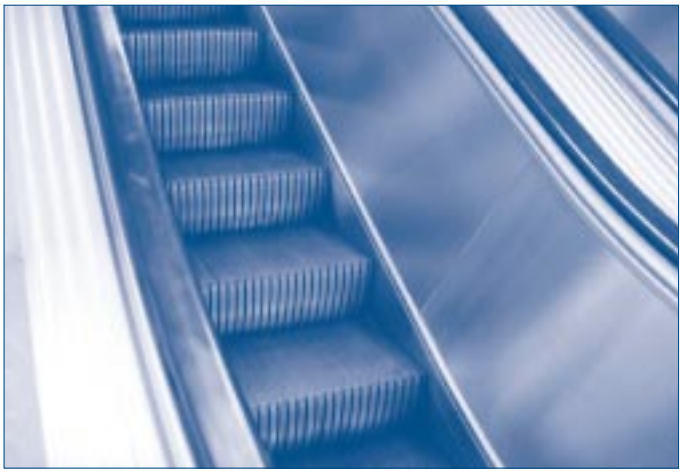
Although many of these innovations do not rely on human vision, other new gadgets will distract drivers' eyes, compelling one to ask whether the eyes can handle the increased burden. My lab has looked at one small piece of this puzzle. We developed guidelines for constructing display systems for the new warning signals, paying attention to the driving public's visual attributes, including deficient (though licensable) vision.

As one example, we recommend that *movement,* not just flickering lights, be incorporated into warning signals. Tests in our lab show that movement improves visibility and reaction time. We also recommend the use of signals in a coordinated system that shows all necessary information in one place. In one implementation, a bird's-eye view of the vehicle is continuously illuminated, and warnings appear juxtaposed on the outline. A vehicle too close to the lane edge would show an illuminated moving stripe on the appropriate side of the vehicle outline. ➢

INSIGHT ON AN ESCALATOR

I first became interested in these problems while in Australia. There I was on an escalator descending into the Melbourne airport when I experienced a phenomenon familiar to me as a vision scientist, but not, apparently, to my fellow riders. I sensed that the escalator tread was removed several inches above its actual location. This perception is easily explained as a manifestation of the well-known wallpaper illusion discovered in Europe in the nineteenth century.

Here's how the illusion works, and how it occurs on escalators. The brain decides where to point the eyes. They are directed to look at the same spot, the angle made by their lines of sight (angle of convergence) indicating the distance of the eyes from that spot. The brain knows the pointing is correct when the images seen in both eyes are essentially the same. An escalator tread looks like a series of dark and light stripes across the visual field. With a periodic pattern like that, the brain can erroneously conclude that two points which only look the same actually are the same. When that happens the angle of convergence of the eyes is misinterpreted by the brain, and the object seems to be closer to or farther from the eyes than it actually is. An adult looking at a tread underfoot might perceive it as a half-foot closer than it is.



Later measurements in the laboratory at Berkeley and on BART escalators in San Francisco confirmed that depth illusion is triggered by escalator treads and that it can be suppressed by the trick of closing one eye. Many observers find the illusion disorienting and have difficulty standing upright while looking down at the escalator.

Escalators are a principal means for access and egress at urban transit systems. When they stop, they double as stairways. As stairways they leave much to be desired because they sport an unfamiliar riser height that requires the user to look at them, bringing on the illusion.

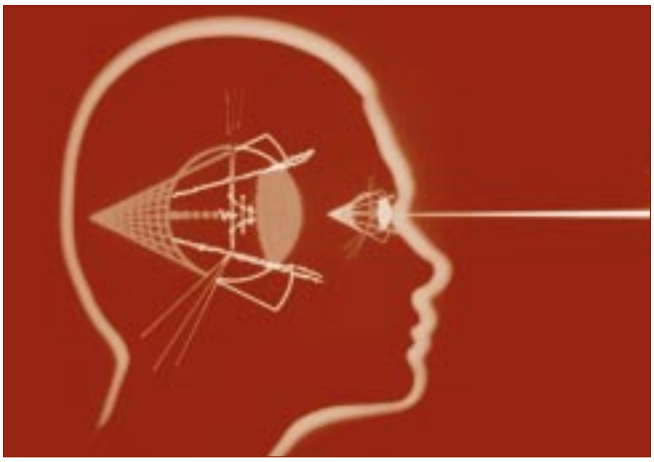
Ironically, using escalators as advertising media may lower the odds of people falling down. By providing a nonrepeating pattern for the eye to behold, ads appear to have the unintended, but valuable, side effect of reducing the depth illusion. Further measurement will help us to see whether the inadvertent promise of advertisement can be realized.

LARGE OBJECTS MAY BE FASTER THAN THEY APPEAR

Around 1984, Hershel Leibowitz at Penn State University was concerned about the alarming number of grade-crossing accidents that occurred when pedestrians or motorists tried to beat the train or simply failed to appreciate its speed. Leibowitz, a psychologist, went so far as to place himself in the engineer's seat, trying to understand the curious and tragic phenomenon. His understanding of the relation between size and perceived speed led him to conclude that the sheer bulk of the oncoming train fooled observers into thinking it was slow.

You've probably observed this phenomenon yourself at an airport. While landing, a 747 or DC-10 looks sluggish in the air compared to a smaller plane landing at a much

slower speed. Size is known to convey this misimpression, and Leibowitz concluded that at least some grade-crossing accidents could be attributed to the victims' misjudgment. In the succeeding fourteen years no evidence has refuted his hypothesis.



ILLUSION-FREE VIEWING IS NOT GOOD ENOUGH

Leibowitz also contributed important insight to the special perils of night driving. He understood that our eyes are organized around two different visual systems—an *ambient* system, specialized in processing movement patterns, and a *focal* system, specialized in detail vision and object recognition. Vehicle guidance depends mostly on the former, and it is remarkably resistant to the effects of lowered light level. Hence, we have little trouble steering a straight course at night.

But hazard recognition depends on the focal system, which becomes far less sensitive at night. Thus, upon receiving reassuring signals from the ambient system, we are lulled into thinking that our sensory system is up to the task of night driving. There is no warning light to tell us that our focal system is impoverished at night and will do a poor job picking out hazards we need to avoid.

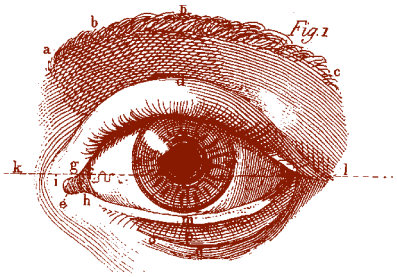
We are just beginning to understand properties of the visual nervous system that might affect matters as diverse as speed limits, driver education, and roadway lighting.

A BETTER BRAKE LIGHT?

Vision scientists now understand that, in addition to the focal/ambient dichotomy, two independent but cooperating vision systems are at work: the M and P systems. One, termed P system by neurophysiologists, (short for parvocellular, for the neurons to which these cells connect) conveys color and detail information to the brain; it is relatively slow and insensitive. The other, the M system (short for magnocellular), conveys temporal detail, including motion, and is especially sensitive and fast. Armed with this kind of information, designers of transportation vehicles should be better able to exploit the attributes of human vision. Here's an example:

We've developed a new kind of brake light that alerts a fog-shrouded driver when the car ahead applies its brakes. Our idea, which we've just begun to test, is that brake lights designed to stimulate the M system will be seen more quickly and more sensitively than lights designed to stimulate the P system. The more important possibility is that, because the M system is so insensitive to spatial detail, it will be relatively resistant to the effects of blur, whether the blur occurs because of the driver's cataracts, other optical problems like night blindness, or because of a foggy, rainy, or dusty atmosphere.

We've made a few laboratory measurements to test this idea. We asked human subjects to imagine they were driving and gave them a "steering" task to reinforce the idea. The steering task consisted of keeping a randomly moving dot within a target circle on a video screen. The dot moved of its own accord, but the test subjects could also move it with the steering wheel. While thus engaged, we asked them to push a button whenever they saw a briefly flashed target, and we interwove a sequence with two different targets for them to detect. ➢



One target was a slightly blurred single blob of light about the size of a brake light. The second consisted of two such blobs ignited in sequence, which thus appeared to move. Both were adjusted in brightness to be just above the limits of detection and so were quite hard to see. We then measured the accuracy and speed of signal detection.

The moving target was seen about twice as well. Moreover, it was seen more quickly than the stationary target, the difference averaging about 250 milliseconds for our subjects. At 65 miles per hour, a quarter of a second corresponds to a distance of more than one car length. So, if we want to signal a driver following us to stop, this moving target could trigger the stopping response a full car length sooner, perhaps soon enough to avoid a collision. And most important, this advantage is emphasized when onerous conditions of fog or dust make the leading vehicle nearly invisible.

A recent attempt to match brake lights to another aspect of the visual system was not so successful. Based on measurements of where drivers look while driving, researchers thought that a center high-mounted brake light would be likely to fall at the center of a driver's gaze, making it more easily visible. There was also the extra bonus of the light being visible through the windshield and rear window of an intervening vehicle.

Initial tests on taxicab fleets were highly successful at reducing accidents. Of the roughly 67 percent of rear-end accidents involving braking by the lead vehicle, about half were eliminated in the test fleet. The benefits were calculated to exceed the considerable cost by a factor of ten! Today, one cannot buy an automobile without this now-required apparatus. But the promise of this innovation does not seem to have paid off.

Estimates from different studies place actual reduction in accidents somewhere between 3.5 and 22 percent, still economically useful but nowhere close to initial expectations. Scientists at the National Highway Transportation and Safety Administration are presently trying to audit the entire set of tests to understand why. The lesson they extract will be an important one. Advantages of innovation, however well-planned and conceived, may, unlike objects in the mirror, be smaller than they at first appear!

LICENSING

Whether or not Intelligent Transportation Systems mature in the near future, a change in licensing requirements is almost certain. Licensing rules have been remarkable stable: there have been no changes in the vision requirements for licensure in California in over fifty years. Do we need to update these rules to reflect new findings in visual research?

Axiomatically we want licensed drivers to be able to see the road, their destination, and obstacles to their progress. In pursuing that aim, we routinely exclude candidates with visual acuity of less than 20/40. But recent research suggests we've been measuring the wrong thing. It now seems that acuity, which gauges the resolution of the eye—that is, its ability to discern fine detail—has too little relation to propensities toward

accidents or traffic violations to predict well. Varieties of other vision-performance measures are also unable to predict who will have accidents or commit violations.

Cynthia Owsley and her colleagues at the University of Alabama's School of Optometry have developed an important new tool, an indicator of vision performance that predicts better than everything else (including the visual acuity that DMVs now rely on) who the good drivers will be. This measure, termed by its inventors the "Useful Field of View," essentially quantifies the size of the visual field in which sudden events can be discerned by an observer who is already engaged in a task like vehicle guidance. It is essentially a measure of the size of the visual world that drivers are attentive to. The research section of California's DMV is even now examining the usefulness of this approach in the licensing process. It will be surprising if this does not generate a major change in the way we test vision for licensing in the future.

Vast technological developments are poised to engulf transportation modes in the near future. The changes will be shaped by travelers' abilities to see and by ways the limitations of those abilities affect their performance as drivers, transit users, or clients of information services. Many of these changes, like objects in our mirrors, are closer than they appear. ◆

FURTHER READING

T. E. Cohn and D. J. Lasley, "Wallpaper Illusion: Cause of Disorientation and Falls on Escalators," *Perception* 19: 573–580, 1990.

H. W. Leibowitz, "Grade Crossing Accidents and Human Factors Engineering," *American Scientist* 73: 558–562, 1985.

Cynthia Owsley, "Visual Attention Problems as a Predictor of Vehicle Crashes in Older Drivers," *Investigative Ophthalmology and Visual Science*, 34: 3110–3123, 1993.

R. G. Mortimer, "Center Mounted Brake Lamp: A Cause Without a Theory," *Proceeding of the Human Factors and Ergonomics Society Annual Meeting*, 955–959, 1993.

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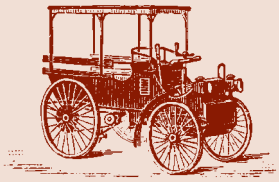

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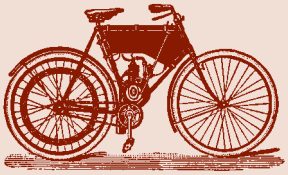

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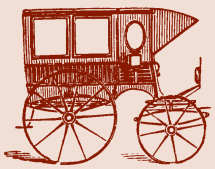

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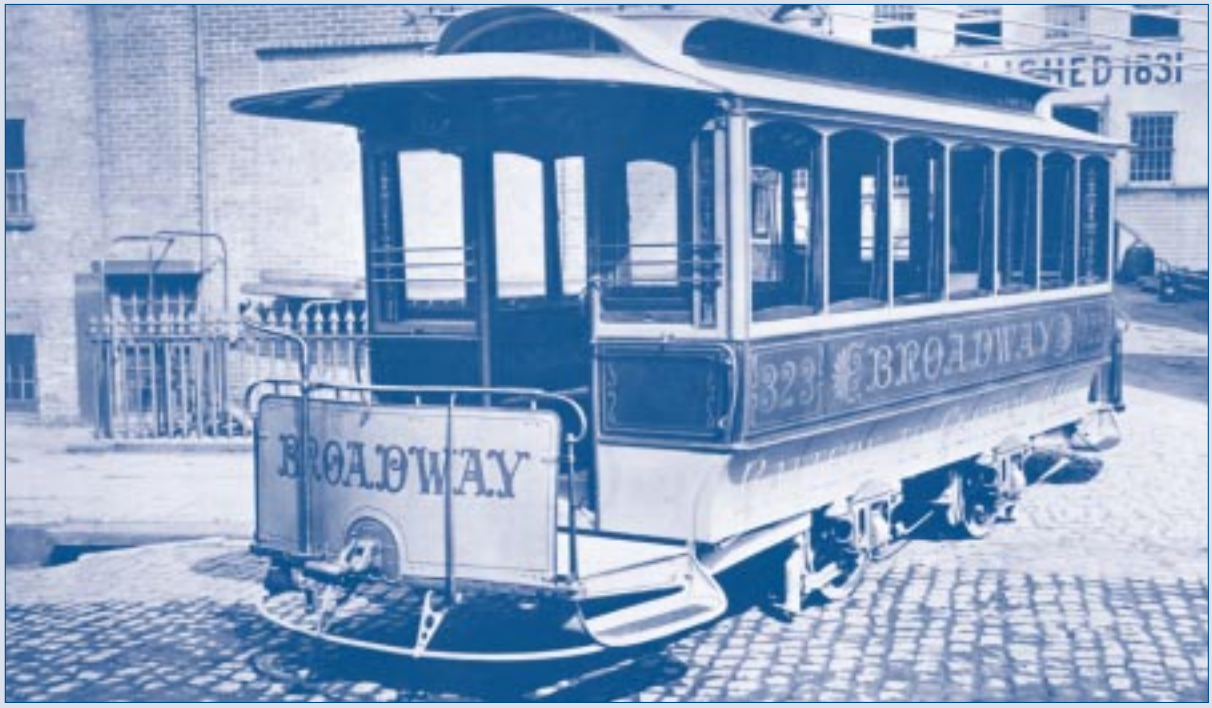

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THE ACCESS ALMANAC:

GAS TAX DILEMMA

BY MARY HILL, BRIAN TAYLOR, AND MARTIN WACHS

PRIOR TO 1923 California, like most states, financed highway construction and maintenance by issuing general obligation bonds. By the early '20s direct appropriations for highways and interest payments on the bonds had risen to more than 40 percent of the state's budget. So in 1923 California adopted a new system of highway finance using earmarked user fees, in particular the per-gallon fuel tax. Before long all fifty states had similar user taxes, as did the federal government.

This system means that highways do not compete for revenues with other programs such as education and social services, making them unique within state government. Since they are funded almost completely out of current revenues, they are far less dependent on bonded debt than many other public programs. User fees have the support of many environmental organizations who believe that those who pollute and deplete energy resources should pay in direct proportion to the extent they do so. They also offer what economists call "price signals" that encourage more efficient use of the transportation system.

Since the 1960s California has seen substantial and sustained contraction of fuel-tax buying power, and today there is again a growing sense of financial crisis. The problem is not an actual decrease in dollars collected, but rather a dramatic fall in purchasing power of the fuel tax even as highway use continues to rise. Because gasoline and diesel fuel taxes are levied on a per-gallon basis, they do not automatically keep up with inflation. The gas tax can't produce more revenue unless it is explicitly raised by act of the legislature, and legislators are understandably reluctant to raise gas taxes very often, fearing they'll alienate constituents.

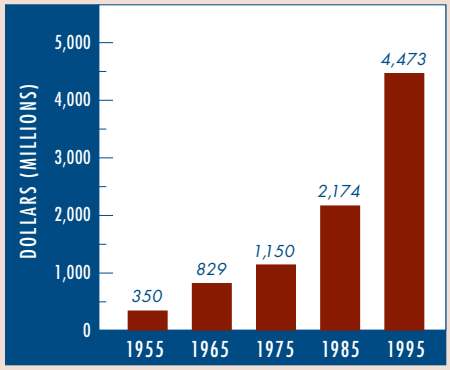
Increasing fuel efficiency is also eroding the gas tax's buying power—per-mile revenue declines as fuel efficiency rises. Fuel economy of new cars improved from 14.2 miles per gallon in 1974 to 28.6 miles per gallon in 1997. Thus, even without inflation, the average new car today generates half the revenue per mile of new cars twenty years ago.

The combined effects of inflation and fuel economy are shown in these graphs. While the sum of federal and state gasoline tax collections in California has grown from $350 million in 1955 to $4.5 billion in 1995, the "real" value of those collections has fallen dramatically. When corrected for inflation and fuel-economy changes, the gas tax per vehicle mile has fallen by more than 50 percent from 3.8 cents per mile to 1.7 cents.

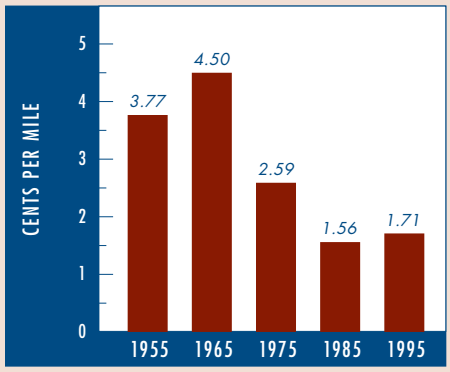
The California state fuel tax stands today at 18 cents per gallon (there is also a federal tax of about the same amount). Restoring its buying power to the 1950 level would require an increase of 25 cents per gallon to a total of 43 cents. The California legislature is reluctant to consider even a small increase in the state fuel tax and would regard as lunacy the prospect of more than doubling it. Instead, a senator has proposed placing before the voters a $16 billion bond issue backed by the general revenues of the state.

Over the next year or two Californians will engage in lively political debate over how to finance their highways. And because the fuel tax is similar in other states and at the federal level, this dilemma will recur many times during the coming decade. ◆

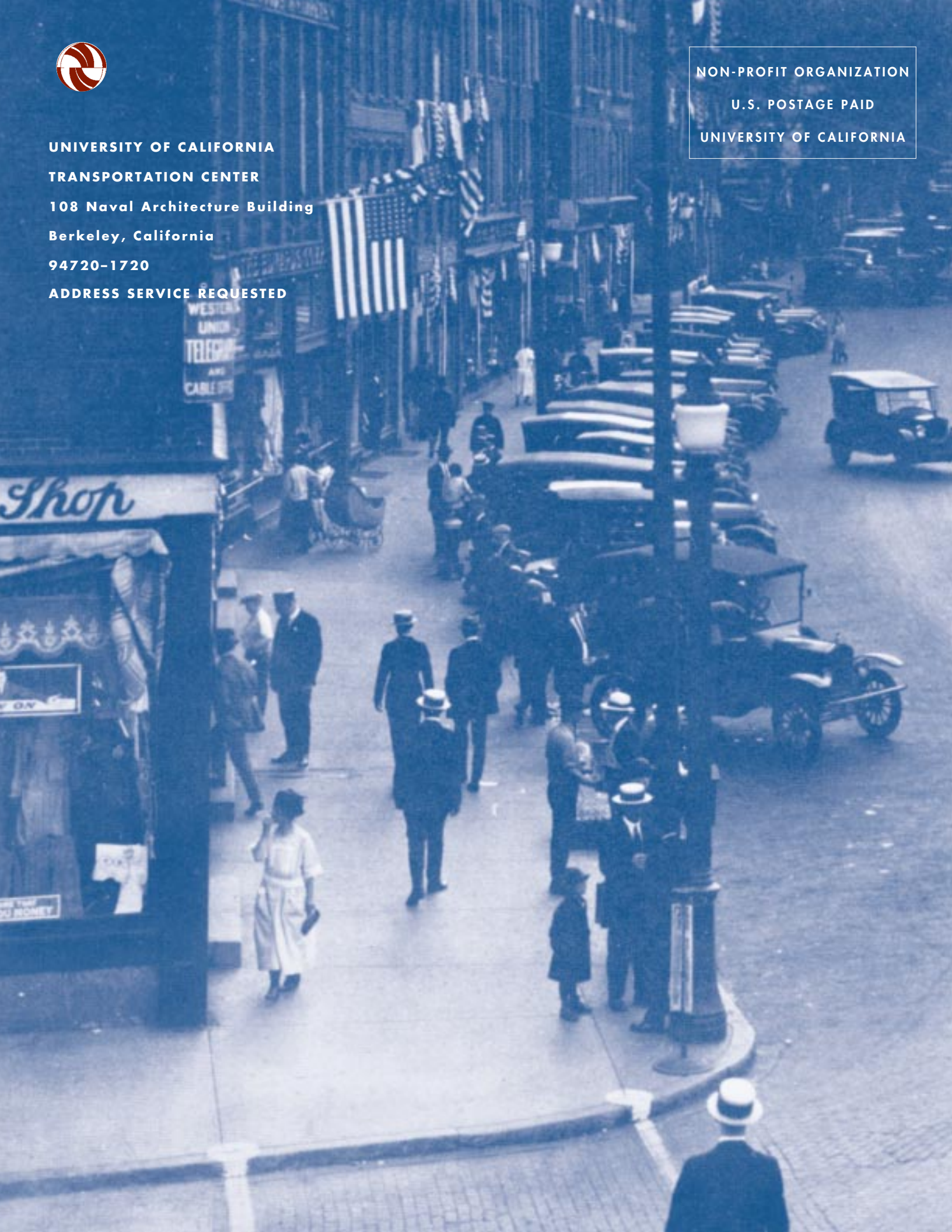
Estimated gas tax collected (not adjusted for inflation)



Estimated inflation-adjusted gas tax collected per VMT



This article is based on The Future of California Highway Finance, *by Jeffrey Brown, Michele DiFrancia, Mary C. Hill, Philip Law, Jeffrey Olson, Brian D. Taylor, Martin Wachs, and Asha Weinstein (California Policy Research Center, crr@ucop.edu, www.ucop.edu/cprc).*



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