Suburban Living

Public Transportation for Environmentally Sustainable and Healthy Communities

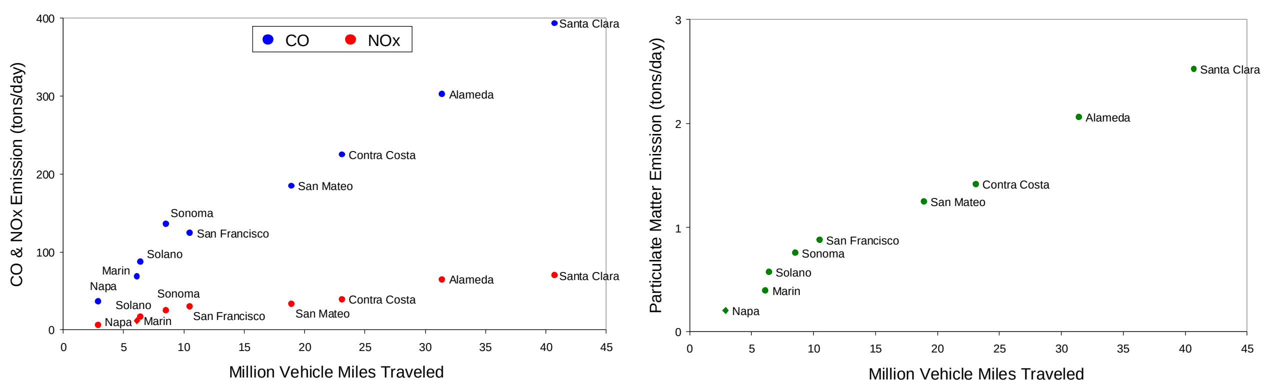
Kitae Jang

PhD student, Institute of Transportation Studies

Civil and Environmental Engineering,

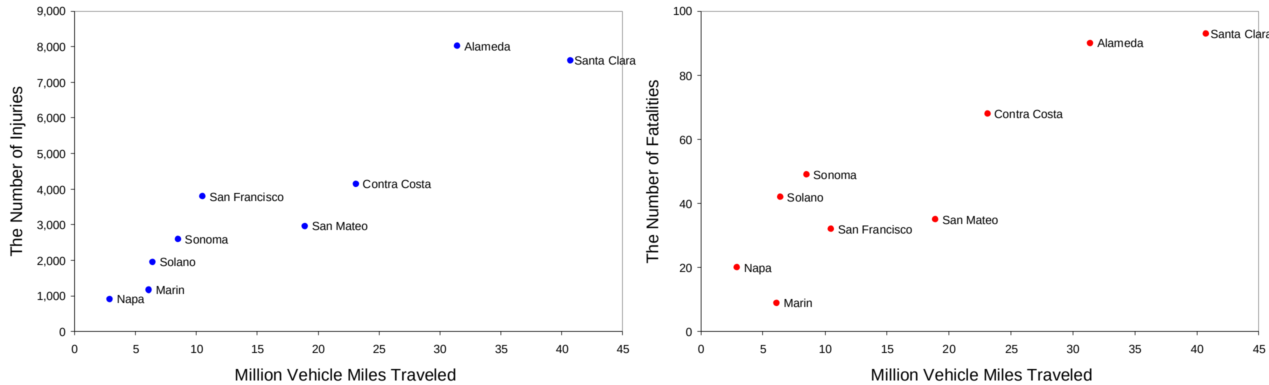
University of California, Berkeley

The San Francisco Bay Area's increasing population and residents' preference for a suburban lifestyle have shaped the rapid and sprawling expansion toward rural areas at the periphery of urban regions. As areas such as those in Contra Costa County have been developed in sprawling, low density patterns, they have become more isolated from the city and from industrial and commercial zones. Without effective transportation policy and planning appropriate to these communities, most activities continue to require the use of motor vehicles due to the impracticality of walking, biking and other methods of public transit. As a result, residents in such environments drive more frequently and longer distances, and the subsequent increase in Vehicle Miles Traveled (VMT) results in a rise in pollutant emission by consuming more fuel and also causes traffic injuries and fatalities, as shown in Figures 1 and 2. Figure 1 displays the relationship between million daily VMT and emission pollutants from major on-road vehicles; (a) Carbon Monoxide (CO) and Oxides of Nitrogen (NOx), and (b) Particulate Matter (PM). Figure 2 presents the association between million daily VMT and traffic collision injuries and fatalities.



(a) Million daily VMT vs CO & NOx (b) Million daily VMT vs PM

Figure 1 Million daily VMT[1] vs Major on-road vehicle emission pollutants[2]
(San Francisco Bay Area, 2005)



(a) Million daily VMT vs injuries (b) Million daily VMT vs fatalities

Figure 2 Million daily VMT vs traffic collision injuries and fatalities[3]
(San Francisco Bay Area, 2005)

The associations exhibited in Figures 1 and 2, in which VMT is almost linearly proportional to pollutant emission and traffic collision injuries and fatalities, imply that a reduction in VMT can consequently improve neighborhoods' environment and health[4] [5]. However, current sprawling urban expansion and its low density obstructs the implementation of alternative transportation modes other than personal vehicles and results in increased VMT. Conversely, a reduction in VMT can be achieved by providing residents with efficient public transportation which can be successfully operated within the current spreading urban layout. The present paper proposes public transportation policy and planning strategies that suitably facilitate the development of convenient and efficient public transportation and eventually delivering environmental sustainability and health to the neighborhoods.

[1] Source: http://www.baaqmd.gov/pln/emission_inventory.htm
[2] Source: http://www.arb.ca.gov/app/emsinv/fcemssumcat2006.php
[3] Source: http://www.chp.ca.gov/switrs/
[4] Ewing, R., Pendall, R. Chen, D., *Measuring Sprawl and Its Impact*, Washington DC: Smart Growth America, 2002
[5] Eidlin, E., *The Worst of All Worlds: Los Angeles, California, and the Emerging Reality of Dense Sprawl*, Transportation Research Record 1902, 2005

Public Transportation Terminal

The "many-to-many" Origin-Destination (OD) pattern inherent in extensive and sparsely populated areas requires a large number of public transportation routes to meet connectivity demands. Thus, operational costs often surpass allocated transportation budgets, resulting in users' dissatisfaction with the connectivity and quality of public transportation in these areas. However, the "many-to-many" OD pattern can be modified by deploying public transportation terminals, which collect passengers from different origins and redistribute them to numerous destinations. As a result, the "many-to-many" OD pattern is converted to a pair of "many-to-one" and "one-to-many" OD patterns. Figure 3 provides a simple example comparing the number of required transit routes with and without use of a transportation terminal. For N origins and M destinations, in case of the "many-to-many" OD pattern without use of a transportation terminal as displayed in figure 3 (a), M^N transit routes are required. With the addition of a transportation terminal as shown in figure 3 (b), on the other hand, the smaller number of routes, N+M, is needed to cover the same number of origins and destinations. As the numbers of origins (N) and destinations (M) increase, M^N accumulates at an exponentially greater rate than N+M, leading to an increase in the difference between M^N and N+M. Therefore, areas with a greater number of origins and destinations require transportation terminals to decrease their large number of transit routes, which can be directly interpreted as a reduction in operating costs.

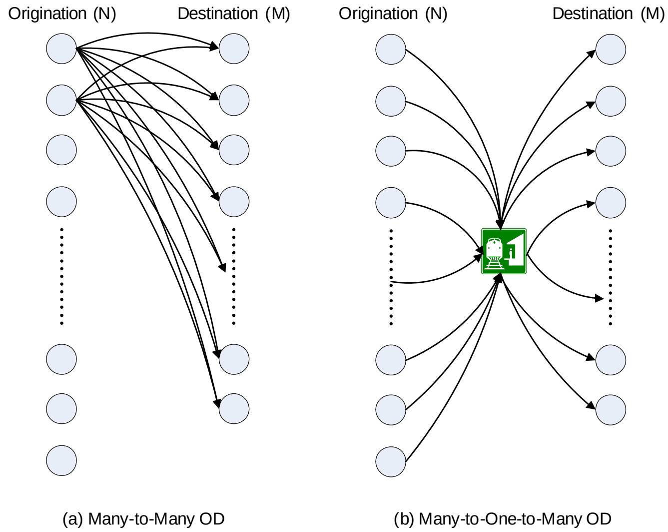


Figure 3 Schematic Diagrams of Two Different OD Patterns

To maximize the efficiency of public transportation terminals, their locations must be carefully planned based on three conditions. First, transportation terminals need to be located at existing public transportation infrastructures to avoid extensive fixed construction and implementation costs (cost effectiveness). Second, the terminals must be located in proximity to areas of higher population to serve more people at the same budget level (proximity to origins). Third, the terminals must connect the public to desired destinations and activities with efficient transportation modes (connectivity to destinations). One good example of facilities satisfying these conditions is Bay Area Rapid Transit (BART) stations. Figure 4 shows a map of Contra Costa County, including streets, locations of BART stations, and population density according to the 2000 Census. BART has already connected 43 stations in major Bay Area cities, including ten stations in Contra Costa County. According to the 2000 Census, approximately 50% of a total of 950,000 residents live within three miles or less from BART stations in Contra Costa County. Additionally, planned extensions of BART lines in both east and west areas of the county will further improve proximity to more of the population and connectivity to more destinations.[6]

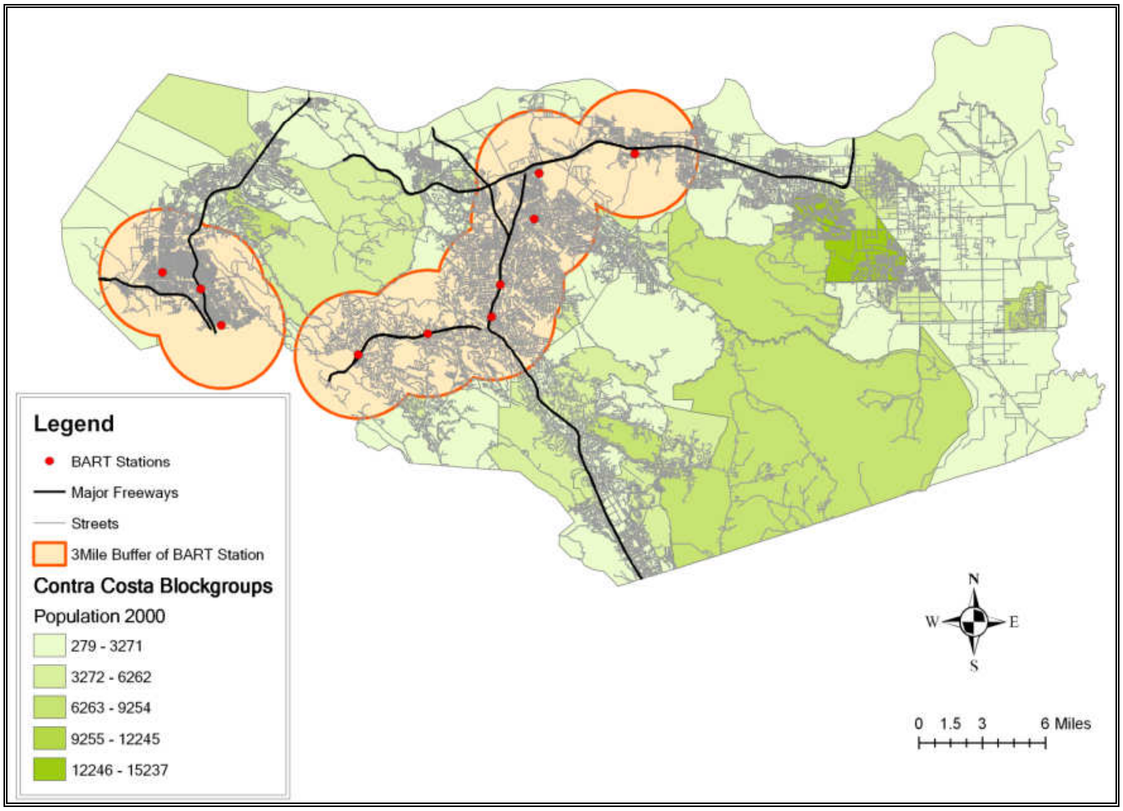


Figure 4 Map of Contra Costa County (2000 Census)

Although BART stations are recommended as candidates for terminal locations based on profitable combinations of cost-effectiveness, connectivity and proximity, additional locations with the potential to collect and connect large populations may also be considered. Terminals should be situated at locations satisfying these alternative conditions where BART service is not provided.

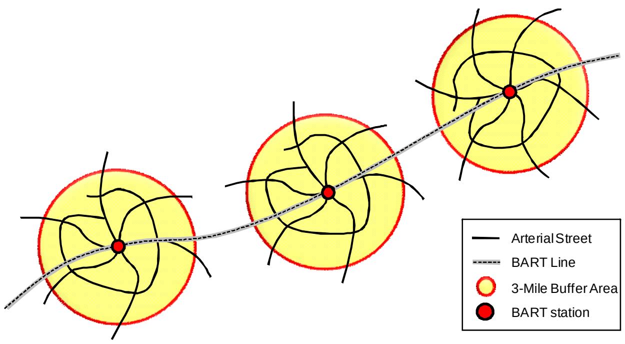
[6] http://www.ebartproject.org/

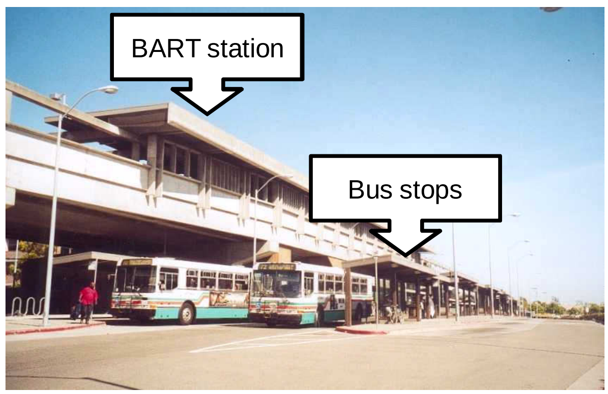
Improving Accessibility from Origins to Terminals

Despite of potential qualifications in proximity and connectivity, many residents in the vicinity of BART stations often have poor accessibility to BART service, which results in relatively low utilization of BART[7]. According to San Francisco Bay Area Travel Survey in 2000[8], among survey respondents in Contra Costa County, two thirds of BART users access BART stations via personal vehicles. Since BART users are already in favor of using public transportation, they are highly likely to shift from personal vehicles to public transportation to access BART stations if equivalent alternatives were provided. Moreover, auto access to BART stations is accompanied by inconvenience and expense including cost of parking, time spent on finding a parking space, walking time, and distance between the parking space and the station. This inconvenience and expense pushes some people to commute by personal vehicle, avoiding BART. Reliance on personal vehicles caused by poor accessibility as well as inconvenience and expense could be minimized by providing public bus service to spatially distributed BART users. The purpose of this bus service would be to connect individual households with BART stations at a minimum cost and inconvenience. To be effective, the bus service would need to assure passengers of substantially short waiting times and easy connections between bus stops and BART stations. Short route bus service is an appropriate option for the present purpose. As shown in Figure 4, 50% of the population lives within three miles of a BART station. Compared to regular full bus service, short route bus service covering small areas such as three-mile regions could reduce passengers' waiting time by diminishing bus cycle time, given the same number of buses, which is equivalent to shortened bus headways. A short route bus service could meet the demands of

[7] Landis, J. and Cervero, R., *Middle Age Sprawl: BART and Urban Development*, Access, 14, 1999
[8] In 2000, the Metropolitan Transportation Commission (MTC) conducted travel survey in nine-county Bay Area. BATS2000 collected travel information from residents of the nine-county Bay Area for weekday and weekend travel both inside and outside of the region. In the present study, public data sources released by MTC were analyzed for more detailed information.

each area located in proximity to each BART station, as represented by the shaded area in figure 5 (a). Figure 5 (b) illustrates the direct and easy connection between bus and BART that has been already implemented at many BART stations. This short route bus strategy could capture the sporadically distributed demand for BART in the region and efficiently transport passengers to BART stations, further facilitating transportation between origins and terminals.





(a) Schematic diagram of short route bus service (b) Direct connection between bus and BART

Figure 5 Diagram and photograph illustrating short route bus service

Short route buses accommodate more passengers per vehicle than personal vehicles and encourage mode shift from auto to bus by eliminating existing inconvenience and expense, leading to a decrease in the actual number of operating vehicles and resulting in a reduction in VMT. Additionally, fewer vehicles traveling in a neighborhood also lead to traffic calming, generating a more desirable walking and biking environment.

Improving Connectivity from Terminals to Destinations

Although BART reaches multiple destinations, it is difficult to address continuously varying levels of demand from scattered destinations, due to inherent features of heavy rails such as extended distance between stations and inflexibility in expanding and diverting existing routes. Bus service is more flexible than BART in its ability to manage dynamically varying levels of demand. Providing connectivity to more destinations, express bus service should be added to the current BART system. However, buses are usually slower and less convenient than BART or personal vehicles as they need to travel through freeway congestion and stop more frequently to load and unload passengers. Such inconveniences and time disadvantages related to bus service tend to discourage utilization and result in continued reliance on personal vehicles. Without elimination of these disadvantages, the level of bus use is unlikely to increase.

Express bus service offers the advantages of bus service while compensating the disadvantages of BART. Unlike short route bus service near BART stations, the proposed express bus service should have fewer stops to decrease travel time caused by frequent stops. Since short route bus service aggregates the demand from widely dispersed origins, making fewer stops is plausible while satisfactorily accommodating demand. In order to further minimize travel time, the express bus travels in High Occupancy Vehicle (HOV) lanes on freeways. California Department of Transportation has expanded its HOV lanes and toll systems in order to allow vehicles with multiple passengers, including buses, to bypass congested freeways as well as to be exempted from tolls. Recently, HOV lanes and toll systems have been introduced on most major freeways and at all bridge entrances in the San Francisco Bay Area. Hence, most daily trips using freeways pass along HOV lanes or through toll areas. Operating buses in HOV lanes and on toll segments could benefit passengers in both travel time savings and toll exemptions. The express bus service can play an important role of efficiently transporting people from terminals to their desired destinations. At the same time, improved quality of bus service is attracting more people away from personal vehicles, increasing the level of bus utilization and decreasing VMT.

Conclusion

The strategies proposed herein address aggregating demand from dispersed origins to nearby public transportation terminals via short route bus service, and distributing aggregated demand to their destinations via BART and express bus service. In the short term, the terminals convert "many-to-many" OD pairs to applicable OD forms for public transportation, and facilitate operation of public transportation in suburban areas. Hence, more people could commute and travel efficiently through the terminals. Commercial districts naturally tend to be formed in the vicinity of terminals in order to take advantage of the potential for additional customers. In the long term, the developed commercial areas around the terminals could transform the land use patterns to be more compact, condensing locations of activities, allowing people to simultaneously access their desired activities without making additional trips or traveling longer distance. As the areas near the terminals develop more vigorously, utilization levels of public transportation would grow and the public's transportation needs could be satisfied while VMT would continue to decline. Consequently, the proposed strategies, paired with public transportation, could lead to the emergence of more environmentally sustainable and healthy neighborhoods.

The goal of this study is to propose a feasible framework for transportation policy and planning solutions, which can steer sprawling and spreading urban expansion toward more environmentally sustainable and healthy communities. To be ready for implementation in practice, operational details at micro levels must be fine-tuned and tested. Future research should focus on optimizing bus schedules and route designs associated with optimal operation of public transportation terminals. Moreover, public transportation policy and planning cannot be successful based solely on the efforts of a single city or county, because public transportation crosses multiple regions and involves a variety of transportation modes. Unless there is collaboration among many regional transportation agencies, effective transportation policy and planning will remain elusive.