Toward a Systems Level Approach to Sustainable Urban Arterial Revitalization: A Case Study of San Pablo Avenue

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ABSTRACT

Many cities in the United States face challenges associated with antiquated urban arterials whose purpose has drastically changed since their development. Once considered the main streets of the city, with thriving businesses and attractive residential development, many of them have deteriorated over the decades for a number of reasons, including shifting demand for housing and retail development and heavy through traffic. Because of the complexity of the problems associated with these arterials, a great challenge of transportation and land use planners is to develop an integrated land use-transportation systems level approach to revitalize and reinvent these arterials in a matter that encourages environmental, economic and social sustainability. This paper presents a methodology for analyzing strategies that could help revitalize multimodal urban arterials that includes land use planning, traffic and transit operations management, street redesign, and community participation. The methods are demonstrated for the case of San Pablo Avenue, a major arterial in the San Francisco Bay area. Land use and transportation recommendations are made that will facilitate sustainable development along this corridor.

OBJECTIVES

Urban arterials serve a variety of purposes in cities throughout the country. Some are high capacity, high speed thoroughfares, whose main purpose is to move vehicles a large distance across an urban area. Other urban arterials are more complex. They are multimodal arterials that serve neighborhood communities and act as a dense retail and residential corridor through the urban area, while also providing a high level of capacity for vehicle movement. Many times, these arterials were developed around transit, before urban expressways and high levels of motorization. As a result, the development patterns do not cater to private automobile use and there is often a conflict between providing a high level of service to auto users on the arterial and serving neighborhood scale shopping, residential land uses, and high quality transit, pedestrian and bicycle options. Often, there is a disconnect between city planning and transportation engineering strategies for these multipurpose arterials, and differing recommendations by staff members of the two disciplines proposals can lead to stalemates or conflicts. .

To develop a sustainable corridor, several goals must be met. Sustainability implies developing a system that is economically viable, environmentally friendly, and equitable across income and racial spectrums, now and in the future. Specific tasks that can be developed to achieve sustainability on a multipurpose urban arterial include retail zoning that encourages economic vitality, development of affordable housing through incentives or relaxed zoning ordinances, traffic management to achieve safe and efficient movements for multiple modes, reducing vehicle miles traveled through transit improvements and mixed use development, and developing infrastructure for disadvantaged populations. While these goals could be pursued in ways that conflict with or counteract each other, urban arterials of the sort considered here must find a way to accommodate all the goals. The challenge is to search out the strategies where the multiple goals can compliment each other.

This paper provides a multidisciplinary, land use-transportation systems level framework through which to analyze a complex urban arterial that must serve multiple purposes. The first part of this paper outlines principles associated with urban arterial revitalization and redevelopment. These principles include land use and transportation coordination as well as multimodal transportation operations and street design, all grounded in strong community involvement in development, design and operation decisions. The second part of this paper applies these principles to a case study of San Pablo Avenue, an urban arterial that runs along the eastern shore of the San Francisco Bay. Local elected officials have joined together to seek out ways to revitalize San Pablo Avenue; this study was conducted to support that larger effort. The case analysis begins with a discussion of the results of community outreach including developer interviews, merchant interviews, community surveys and focus groups. It then explores deficiencies in existing land use plans that inhibit development. The next part discusses sustainable street design that encourages transit use through improvement of pedestrian amenities. Geometric and operational improvements are simulated that improve transit performance. Finally, recommendations are presented based on the analysis performed.

LAND USE-TRANSPORTATION SYSTEMS ANALYSIS

When developing a strategy to improve a multipurpose urban arterial, it is important to consider all aspects that have a connection with the arterial. Transit investments can be

much more effective if they are coupled with land use improvements near transit stations. Conversely, transportation investments can be rendered ineffective if contradictory land use improvements are implemented. Both transportation and land use improvements can be blocked if there is inadequate community outreach and active involvement in the planning process.

The systems approach for a multi-purpose arterial therefore must consider the system to be the land use-transportation system, not just the transportation system. Planning for land use and transportation must be coupled in a way that works for both functions.

Community Outreach

Perhaps the most important aspect of urban arterial revitalization is community outreach. Local interest groups have the power to make or break development or transportation improvement projects and their perspectives must be considered in the conceptualization of any project. Otherwise developers or public agencies could spend large sums of money designing projects, only to have them rejected and defeated by community members. It is essential that a visioning process take place prior to a redevelopment plan that identifies key goals of the community and finds ways to form those goals into sustainable projects. Developers, public agencies, and community groups should have a predictable channel through which to communicate.

Focus groups with stakeholders, residential surveys and merchant interviews are effective ways to determine the needs and viewpoints of interest groups. Once a specific plan has been agreed upon, the development process can be expedited, reducing costs to developers and agencies, and ultimately residents and users of the corridor.

Land Use

The development along multimodal, multipurpose arterials is often infused with many types of uses, either through unplanned historic development patterns or through deliberate planning strategies that have changed over the years. For example, in different eras the land use plans may have promoted housing, retail, auto-serving, and transit-oriented uses. As a result of organic development patterns, many of the infill opportunities for development or redevelopment along such corridors may be on small, irregularly shaped lots that are hard to develop. Sometimes the land use plans and zoning ordinances for these corridors are not developed specifically for the parcels along the arterial and specific mandates such as setbacks and minimum parking requirements may make development even more difficult. As a result, many developers may prefer to develop on more unconstrained parcels on the urban fringe and only specialized developers may be available for the parcels along the arterials.

In order to develop a transit oriented corridor, bus stop or station areas must be developed with easy connections to an assortment of trip attractions; including residential, retail and service land uses. This mixed use development should be centered around major transit stations or transfer points, but not necessarily along the entire corridor. Land use control is a very powerful tool to influence the effectiveness of transportation investments. If transit oriented development is allowed near transit stations, increases in ridership can be experienced. However, land use controls that allow

suburban style development along urban corridors can effectively negate the effects of any public transportation investment.

Traffic Operations and Street Design

In order for a major arterial to be a vibrant place where people would like to live and shop, traffic and transit must operate in an efficient manner. There must be high levels of accessibility for both automobiles and transit; however many aspects of these two modes conflict. Transit must operate with high levels of service, with minimum delay due to traffic signals or congestion. The pedestrian environment must be conducive to walking and bicycling. Sidewalks and bus stops must have adequate amenities to encourage connectivity between trip generators.

Traffic must flow smoothly and high speed traffic must be calmed in order to improve the pedestrian environment. Congestion should be limited wherever possible or priority treatment should be given to transit in order to reduce the adverse effects of auto congestion on mixed flow transit modes. Optimization of signal timing to account for buses and simulation of geometric changes to improve bus performance can be powerful tools to evaluate prospective level of service changes from different priority treatment strategies. Pedestrians should have adequate crossing opportunities and signals should be timed to allow adequate crossing time. Lastly, traffic should be managed to limit the negative externalities of noise, pollution, and congestion.

A CASE STUDY OF SAN PABLO AVENUE

Background

San Pablo Avenue is an urban arterial near the east shore of the San Francisco Bay. The study area spans eight miles and runs through five cities, Oakland, Emeryville, Berkeley, Albany, and El Cerrito; and two counties, Alameda and Contra Costa (Figure 1). The avenue lies parallel to and within a half-mile or less of I-80, and before the interstate was built it was the main North-South thoroughfare through the five cities in the study area.

Land uses and urban design vary substantially along San Pablo Avenue. Along the Oakland stretches of the avenue are many four to six story apartment buildings interspersed with one to three story commercial buildings with housing on upper floors. In Berkeley and downtown Albany, two to three story buildings, again with first floor retail and upper story housing, are interspersed with small-scale single story retail, auto dealers, and auto repair shops. El Cerrito's downtown is along the avenue, with single story retail and a small mall as the predominant land uses. Through these three cities most of the retail and housing units are oriented to the street with little setback and only occasional off-street parking. Farther north along the avenue the older single story retail is interspersed with mini-malls, fast food drive-ins and big box retail, each with its own parking lot. In the past decade or so, multifamily housing developments have replaced older retail and parking at locations scattered along the avenue.

For most of the length of San Pablo Avenue the road is two lanes in each direction with turning lanes at major intersections. Sidewalks line both sides of the street for its entire length, and on-street parking is permitted in most locations. In Berkeley, a tree-lined median developed in the 1960s divides the thoroughfare and limits cross-traffic at

many intersections. The City of El Cerrito has recently installed a median as well. Other areas include a two way left turn lane.

Average daily traffic (ADT) ranges from about 15,000 at the northern terminus of the study area to 27,000 around its busiest intersection *(1).* Thirty-seven bus routes are operated on at least part of San Pablo Avenue by four different transit properties including AC Transit, WestCAT, Vallejo Transit, and Golden Gate Transit. Many of these routes also connect to BART and AMTRAK stations. During peak periods, as many as 20 buses per hour travel on key San Pablo Avenue blocks. The most significant recent investment in transit has been the implementation of the 72 Rapid bus service operated by AC Transit. This bus serves the length of the study corridor from Oakland to Richmond and provides high speed, high quality, limited stop service to the corridor. The study area of San Pablo Avenue is a complex corridor where five cities, two counties, and the state DOT all have authority over their particular jurisdiction.

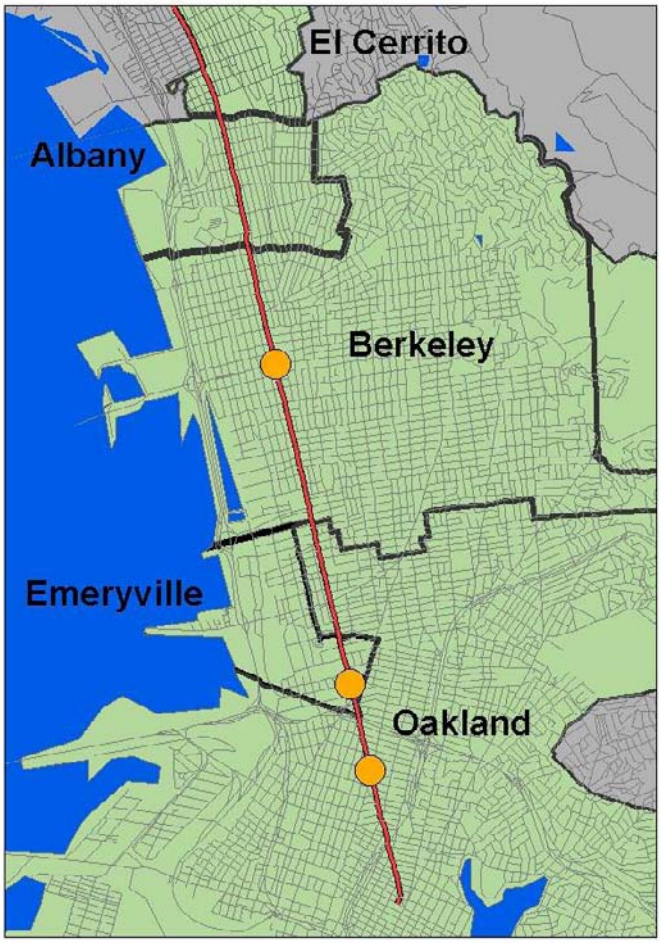


Figure 1: Map of San Pablo Avenue Study Area

Community Involvement

The San Pablo Avenue study was conducted at the request of the local state assemblywoman, who is working with the mayors of the cities along San Pablo Avenue to find ways to revitalize the corridor. The elected officials have organized a variety of

outreach efforts to encourage community involvement in the planning efforts, including public meetings, walking and bus tours of the corridor, and discussion sessions with community leaders and stakeholders. To help support the community involvement effort our study team conducted interviews with developers and merchants as well as a survey and focus groups with local residents.

Developer Interviews

Developers can offer tremendous insight into land use markets as well as some of the hurdles that must be overcome to construct a successful development. In the case of San Pablo Avenue, developers who specialize in infill development were interviewed to elicit their views on problems and opportunities along the corridor as well as some of the market influences currently in place *(2)*.

Some cities along San Pablo Avenue are redevelopment areas (in which development is subsidized) and some are not. Further, some of the redevelopment cities are more responsive to developer views than others. One result has been very rapid development in the redevelopment/responsive cities and slower development elsewhere. However, whether the area is in redevelopment or not, some general themes about zoning provisions emerged.

Currently most planning agencies have been zoning San Pablo Avenue for mixed use development with first floor retail and upper story residential uses. Developers cited the tremendous housing demand and the low retail demand along many sections of San Pablo Avenue as a major difficulty such a policy imposes. Retail space is often vacant long after all of the residential units have been sold or rented. Unless the retail space is subsidized by the local government, then, developers must charge more for the residential uses to make up for the unprofitable retail component. This increases the cost of the residential development in an already expensive housing market. Rather than requiring mixed use development along all sections of San Pablo Avenue, developers would prefer that nodal centers be designated where retail activity could be concentrated into a small retail district. Each of these nodes could have its own identity and reflect the socioeconomic situation of the neighborhood. Major transit stops and transfer points could be incorporated into these nodes to connect them with other nodes along the corridor.

Most developers stated that parking minimums were too high along the corridor. Currently most jurisdictions require at least two spaces per residential unit and up to five spaces per 1000 sq. ft. of retail development, parking ratios that show little acknowledgement that the corridor is served by both bus service and three BART rail transit stations and has many pedestrians and bicyclists. However, developers also noted that some developments have a higher demand for parking than others and they fear that overly restrictive parking policy also could reduce the marketability of some developments. Developers would prefer that parking be determined by the market (e.g. themselves and their lenders) rather than specified in zoning codes.

Developers also believe that streamlined permit approval processes and effective community involvement also could significantly reduce the cost of development along the avenue. They noted that lengthy public involvement processes on a project by project basis added to the risk of the projects and thus to their costs. Many would prefer a community planning process that actively engages residents and other stakeholders,

reaches an effective agreement on a plan for the corridor, and then expedites the approval of individual projects consistent with the agreed upon plan

Merchant Interviews

Interviews were carried out with merchants at key activity centers on San Pablo Avenue. Their perspectives on the avenue, key problems and reasons for locating on San Pablo Avenue were investigated. Most merchants enjoy the amount of activity on the avenue as it is one of the busiest north-south corridors in the East Bay. While they dislike the traffic and congestion, they appreciate the exposure it brings. Merchants had mixed feelings about bus investments. Most did not think that it improved the business in the area and they were of the impression that few of their employees or customers use the service. Most felt that the supply of parking is inadequate (especially those without their own lots) and they would like more available parking. Few, however, had done surveys of customers or even of their own employees and so their views were impressionistic rather than data driven. As later community surveys revealed, the merchants often had misconceptions about their own customer bases that more active planning and community involvement could help to correct.

Resident Surveys

Surveying residents of the immediate neighborhoods surrounding San Pablo Avenue was carried out to determine what uses residents made of the avenue and what changes they would like to see along it. Over 500 residents were surveyed, spanning all demographic groups.

Most residents had chosen to live on or near San Pablo Avenue because the neighborhoods are relatively affordable and have convenient transportation access. Most people use the avenue as a transportation corridor; over 54% of residents choose to commute to work by transit, walking or biking and the remainder use the corridor as a commute route or use it to access the freeway. Residents also use the corridor for its shops and restaurants and would like to see even more restaurants and cafes along it.. Very few people think that the avenue has an attractive design, however. The greatest problems they see are related to appearance, as residents feel that many areas are dirty and rundown. Traffic noise, speed, and safety concerns are also major issues.

Focus Groups

In order to identify some of the more subtle interests of communities, focus groups were conducted. Some interesting insights came from these meetings. Focus groups reinforced the survey reported desire for more neighborhood serving retail and restaurants. The focus groups also noted that one of the problems along the avenue is a large amount of auto uses (garages, gas stations, etc.) however, most residents use those services on a regular basis. While some cities' planning departments have recommended phasing out these uses, residents rely on them and would prefer that they improve their façade and operating procedures, minimizing noise and other annoyances. Interestingly, in the survey many people mentioned that their favorite places along the avenue are big box shopping developments, but the focus groups clarified that they like the shopping opportunities of but dislike the design.

Land Use on San Pablo Avenue

Zoning

Zoning requirements along San Pablo Avenue are similar to zoning along many urban corridors throughout the United States, however, because San Pablo Avenue runs through several different cities, there are subtle differences that make development along the avenue quite heterogeneous. Much of the avenue is zoned for high density residential, retail or mixed use development. The maximum floor area ratio along the avenue varies from 3.0 to 7.0 in its densest areas (at the southern portion near downtown Oakland). One of the major issues arising in redevelopment along San Pablo Avenue is the lack of integration of the dense new development fronting the avenue with the low density single family dwellings immediately behind those high developments. Community opposition has stopped several dense developments and has discouraged developers *(3)*. Figure 2 shows a mixed use development that elicited a negative response; adjacent residents complained that it was a "shoebox design" that "crowded the sidewalk and blocked views".

Figure 2: Example of Mixed Use Development on San Pablo Avenue

Form Based Zoning

Under current zoning practices, interest groups agree on land use plans based on generic building envelopes and uses. This often results in conflict when development occurs, because it is not what the interest groups had in mind. Much of the conflict surrounding

new development is centered around the building dimensions themselves, and less about use. An overwhelming majority of residents along San Pablo Avenue recognize a need for more high density housing in the area. Likewise, they want more neighborhood serving retail development along the avenue. However, the zoning ordinances and land use plans place a large emphasis on the land use and institute generic building envelopes that allow the scale and setbacks of buildings along the avenue to be discontinuous and heterogeneous. Buildings that are designed to conform to the zoning ordinances often do not take into consideration the needs of the immediate neighborhood. As a result, developers risk defeat when their plans are approved by the planning agency, but the form of the building is not consistent with the needs of the neighborhood.

Form based zoning ordinances have been developed and successfully implemented in several cities in the United States, which focus on a standard building design, that is agreed upon in advance by all interested parties. These zoning ordinances include standard setback requirements and building lines to ensure continuous street frontage. They also include standard height and step down requirements to ensure that the building fits into lower density neighborhoods, without constructing large blank walls or privacy invading windows into neighbor's yards. The most powerful feature of form based zoning is that once all interested parties have agreed upon a design, the approval process of development plans can be streamlined to expedite development. Figure 3 shows an example of a form based zoning requirement in Virginia; several of the cities along San Pablo Avenue are considering such zoning.

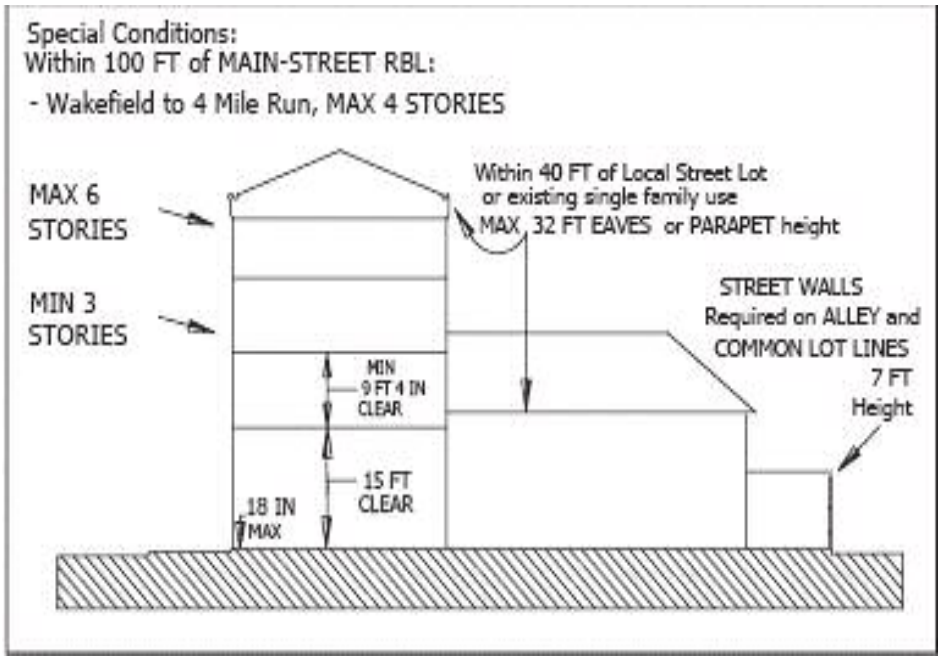


Figure 3: Arlington, VA Form Based Zoning Requirement

One aspect that form based zoning does not consider explicitly is parking and trip generation. Generally, parking and trip generation rates are defined by use and floor area, not size or shape of the building. However, there has been criticism on applying these rates in all settings. Empirical estimation of parking and trip generation rates of can be

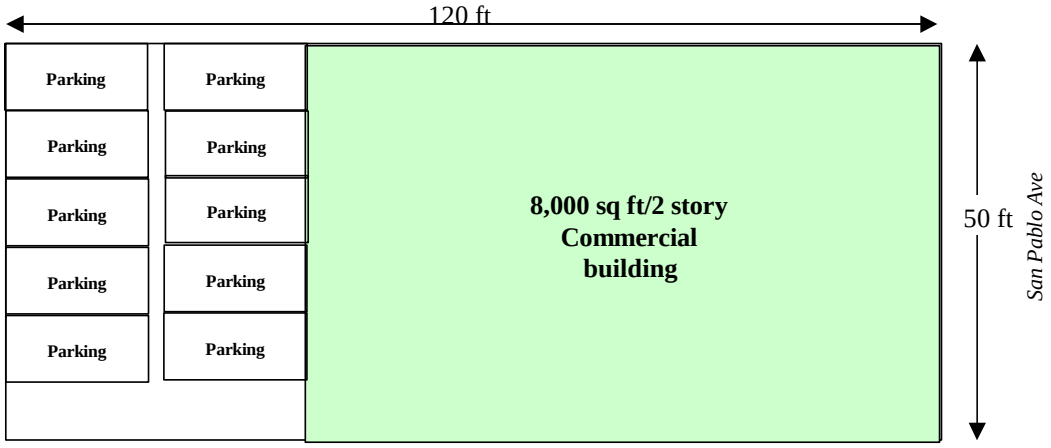
determined based on site specific trip generation along sections of a corridor where form based zoning is to be implemented and those rates can be used to develop transportation infrastructure. Much more research must be conducted to develop techniques to determine adequate parking and trip generation rates for all types of zoning schemes.

Parking

Parking availability is one of the most powerful demand management tools that is available to a transportation planner. "Plentiful free parking can counteract the total benefits achieved by virtually all other trip reduction tactics, frustrating efforts to mitigate transportation problems through such programs"*(4)*. Researchers have found that workers generally will change modes when encountering stricter parking regulations, but shoppers will generally change their destination to shopping centers with better parking *(5-7)*. Thus, the strategy should be to provide adequate short term parking for shoppers and good transit service for long term shoppers or commuters.

Parking requirements are one constraint that makes it difficult to develop vacant lots on San Pablo Avenue. Planning agencies have generally adopted parking generation rates based on the ITE parking generation manual *(8)*, which has been criticized for its presentation of statistically insignificant parking generation rates *(9)*. Most of the parking generation rates are based on suburban land uses where personal automobile use is much higher and all parking generation rates are based on the assumption of unlimited free parking. Multimodal urban arterials do not exhibit the same level of personal automobile use, but in some of the cities along the corridor, developments are required to provide the suburban levels of parking. For instance areas along the corridor have census tracts with 50-77% zero vehicle households, but all of the corridor cities' zoning requirements still require new development to have one or more parking spaces per new residential unit.

Because of the widespread adoption of these parking generation rates, many urban development projects become fiscally impossible because a large portion of a small lot would have to be devoted to parking or small scale developments would have to invest in structured parking. Moreover, because a large number of vacant lots on San Pablo Avenue are long and narrow, the only possible way to build a parking lot is to build the building at the back of the lot and build the parking lot in front of the building. This exacerbates the problem of discontinuous building frontage, degrading the pedestrian environment. A typical vacant lot on San Pablo Avenue is about 50 feet wide and about 120 feet deep. Figure 4 illustrates the infeasibility of developing urban structures with suburban parking requirements.



C-W West Berkeley Commercial
Parking Requirements: 2 spaces/1000 sq ft
16 spaces required for 8,000 sq ft building
-5 feasible parking spaces *or*

Figure 4: Example of Parking Requirements of Typical Infill Lot

This figure illustrates the difficulty building high density retail, commercial or residential development with the parking on-site. In order for this building to be feasible, the building footprint would have to be reduced to occupy only half of the lot or about 5000 square feet, thus reducing the parking requirement, while providing more space for parking cars. Additionally, if there was no back entrance, the parking lot would have to be developed in front of the building. This parking ordinance only discourages potential development. When form based codes are added to the picture, the parking requirement can be doubly problematic. Because there is a desire to maintain a continuous street frontage, form based zoning often requires that parking be located at the rear or side of the building, or underground – something that simply does not work for many lots.

Forcing developments to devote half of their already small lots to parking is unreasonable, especially on a corridor with high levels of mixed use development and transit service. Simply eliminating the parking requirement (as some developers urged) is probably not the best answer, however. Adequate parking protects neighborhoods from parking spillover and is directly related to the regional competitiveness of a retail district. Merchants along the corridor cite parking shortages as one of the major deficiencies of the avenue already. Convenient and appropriate levels of parking must be provided for employees and shoppers.

Several strategies have been developed that hold large potential for some of the difficulties of providing parking on San Pablo Avenue. These include the construction of shared parking lot(s) at shopping or commercial districts, in-lieu parking fees for construction of public parking lots, parking exemptions and reductions, and parking maximums *(10,11)*. These strategies can reduce the demand associated with overabundant parking, reduce parking supply by sharing space and utilizing parking more fully throughout all periods of the day, and enable development of more pedestrian accessible environments by reducing the amount of land devoted to parking, thus reducing parking demand even more.

Traffic, Transit, and Pedestrian Improvements

San Pablo Avenue in the study area is a state highway and is under Caltrans' jurisdiction. However the street design varies slightly from city to city. On-street parking lines all sections of the avenue, two lanes run in each direction and major intersections have designated left and right turn lanes. Sections of the street along the study corridor have two-way left turn lanes, while others have raised medians. All sections of the study area have sidewalks of varying width and quality.

Pedestrian and Transit Amenities

Pedestrian In order for a transit corridor to be successful, the pedestrian environment must be accessible and pleasant. Most of the sidewalks along the corridor conform to the Americans with Disabilities Act *(12)*; with adequate sidewalk widths, ramps, and limited obstructions *(13)*. Some areas of the corridor have very long cross street crossings, particularly in southern parts of the corridor where cross streets intersect San Pablo at acute angles. Adequate crossing time must be given at these signalized intersections or

pedestrian refuges or bulb-outs must be provided to assure safe passage of pedestrians across and along the corridor. Based on sidewalk width, lateral separation, on-street parking utilization, and vehicle speed and volume counts; a pedestrian level of service (LOS) analysis *(13)* gives most major nodes along the corridor an average LOS of C. This indicates that the area is adequate for pedestrians but does not attract as many pedestrian trips as possible. The major deficiency, based on this analysis is the high volume of traffic at busy intersections.

Transit The investment in the San Pablo Rapid Bus service has provided high quality bus shelters and transit information including real time arrival information at many of the stops. Many sections of the avenue, particularly the more recently developed areas of Emeryville and El Cerrito have adequate pedestrian scale lighting. The Rapid Bus service provides appropriate lighting at some of its stops but very inadequate lighting at several other stops. All San Pablo Rapid stops should have the same amenities unless there are physical constraints to providing those amenities. Several Rapid stops have been poorly placed and obstruct the sidewalk, creating a more hostile pedestrian environment. Innovative shelter design should be implemented to fit the shelter into the exiting pedestrian environment and reduce obstructions.

Optimizing Traffic Flow-Passive Transit Priority Signal Optimization

Signal timing schemes are often developed to minimize vehicle delay and vehicle stops. Vehicle delay is an appropriate proxy for delay imposed to a person in many urban areas where average vehicle occupancy is close to one. However, in transit corridors, such as San Pablo Avenue, one should weight buses more heavily than automobiles because of their high load factors. To achieve the highest people moving capacity of the arterial, which minimizes delay to all people, TRANSYT-7F was used to develop and demonstrate a passive transit priority signal optimizing scheme *(14)*.

There are two distinctly different kinds of transit priority that can be modeled with TRANSYT-7F. Passive priority relies on inexpensive geometric and signal timing changes that can significantly decrease the delay and number of stops for transit vehicles while minimizing negative effects on the normal traffic flow. Active priority uses different detection techniques to give extra green time to the transit movement when the transit vehicle comes at the end of its green phase.

Active priority takes green time from undersaturated cross streets. However, many of the intersections on San Pablo Avenue are highly saturated on all approaches. This reduces the effectiveness of active priority because it imposes more delay on cross street traffic and buses.

Passive priority simply requires optimizing the signal timings while properly weighting the transit movements to account for the fact that they carry many more people than do cars.

In this analysis, we selected the congested AM peak hour as our study time. For the AM peak, we have developed a fixed-time signal timing plan, making the assumption that the north and south thoroughfares already get the maximum allotment of green time. Assuming that the arterial is already allotted its maximum green time allows us to eliminate active priority strategies since their effectiveness is limited when the side

streets are already receiving their minimum green and there is no green time to spare. Additionally, we have made the assumption that all of the cycle lengths will be the same in order to create a corridor with good progression and good passive transit priority. The existing cycle length varies from 60 seconds to 120 seconds while the optimized signal timing plan will have a fixed cycle length of 100 seconds.

The base case was modeled and then the new cycle length was modeled without bus weighting, then weighting was added to buses for a third case. The improved signal timing plan does not provide a large disadvantage to the normal traffic flow while providing significant benefit to the flow of buses. The optimized conditions with weighted buses reduce bus passenger delay by 33% from the existing conditions. The total stops were reduced substantially, by 41% while the travel time was reduced by 9%. These improved measures of effectiveness come at the expense of cross street and single occupant vehicles, but the total system wide person-hour delay, number of stops and travel time are reduced significantly (Table 1).

TABLE 1 Comparison of Measures of Effectiveness Between Alternatives TRANSYT-7F

Performance Measures	Total Travel Time (veh-hr/hr)			Total Delay (veh-hr/hr)			Total Stops (veh/hr)		
	Buses	Other	System Total	Buses	Other	System Totals	Buses	Other	System Totals
Existing; No Bus Weight	23	1505	1528	6	794	800	884	91970	92854
Optimized; No Bus Weight	22	1307	1329	5	596	601	578	64521	65099
Optimized; Bus Weight	21	1340	1361	4	629	633	519	69278	69797
Percent Difference From Existing Conditions									
Optimized; No Bus Weight	-4%	-13%	-13%	-17%	-25%	-25%	-35%	-30%	-30%
Optimized; Bus Weight	-9%	-11%	-11%	-33%	-21%	-21%	-41%	-25%	-25%
Benefit of Bus Weight	4%	-2%	-2%	17%	-4%	-4%	7%	-5%	-5%

Geometric Changes to Improve Bus Performance-Microsimulation

Microsimulation models give analysts the ability to investigate the effect of geometric changes on traffic operations. A Paramics model was developed to simulate the AM peak traffic conditions along both San Pablo Avenue and the parallel freeway, I-80, using data provided by Caltrans and ACCMA *(15,16)*. Hourly traffic counts, continuous speed, and travel times were provided for San Pablo Avenue and I-80. Using these data, a network was developed that included San Pablo Avenue, the I-80 freeway, and all interchanges along the segment and those portions of major arterials that connect San Pablo Avenue with I-80. The existing signal timing as well as the optimized signal timing schemes were modeled *(14)*.

Once the network was fully built, an express bus route was inserted into the network. This route follows the San Pablo Rapid bus route (72R) operated by AC Transit from Downtown Oakland to Contra Costa County Community College in the City of San Pablo. The route and associated bus stops were entered into the model so that improvements could be measured in terms of travel time improvements to the bus service, in addition to the vehicle travel time.

The model was calibrated following procedures documented in the literature *(17-20)*. The calibrated network was used to produce base case measures of effectiveness, and then simulated several alternative infrastructure and signal operation improvements for San Pablo Avenue.

Although the travel time for the buses improves slightly under the new signal scheme, the passive priority timing alternative does not give the express bus any advantage over cars because the bus still operates in mixed flow lanes. In order to give the express bus an advantage, we simulated geometric alternatives in which we added a queue jumper lane at each intersection with long queues during the peak period. These are the intersections where the bus stands to gain the greatest increase in travel time.

Intersections with slow approaches and residual queues were identified using data from previous studies *(15)* and those intersections were improved by widening the approach and taking width from the existing lanes. The two thru lane, 24' cross section (12' per lane) was widened by six feet to make a three thru lane, 30' cross section (10' per lane). In the northbound direction, four queue jumper lanes were added at the most problematic intersections. In the southbound direction, eight queue jumper lanes were added at the problematic intersections. The queue jumper lanes were added to the shoulder side of the roadway to facilitate easy entrance to the bus bay on the far side of the intersections. The additional space required for the queue jumper lanes can be taken exclusively from the existing right-of-way by re-striping, limiting on-street parking, narrowing the median, or widening the road (by narrowing the sidewalk). Many of the on-street parking spaces have very low levels of utilization, especially during the AM peak before retail businesses open *(13)*. Utilizing this space for queue jumper lanes could be a better use of this road space, at least for portions of the day.

The addition of queue jump lanes did not significantly improve travel time along the entire corridor, due to conflicts with the mixed flow traffic and bus stop configuration. However, looking at one intermediate trip, from El Cerrito Del Norte BART station to Broadway & 14th Street in Oakland, we find a statistically significant (99% confidence level) 3.5-minute travel time decrease when queue jumpers are added in addition to a smaller standard deviation. This time savings becomes more significant given that the destinations are two of the heaviest boarded and alighted stops on the 72R's route *(21 pg. 21)*. The smaller standard deviations observed are also of considerable importance because they imply that arrival times are more consistent when queue jumpers are added, resulting in less disparities between the bus schedule and actual bus arrivals. Previous studies looking at the performance of the 72R have pointed to the on-time performance as an area of difficulty *(21)*. Both reliability and travel time performance to highly serviced areas are of main concern to express bus operators and their patrons. While the travel time performance of the 72R may not be vastly improved by the addition of queue jumpers in our study, the time that is saved will benefit a large number of riders.

Traffic signal timing models and network simulation models can be effective tools not only in traffic operations and management but also for transit planning and street design. Using data available from the state DOTs, local governments, and simple field observations, we show that alternative bus priority schemes and simple geometric improvements can be evaluated easily, once the models are calibrated. Such

improvements can be a low cost, highly effective way to improve the performance of urban arterials such as San Pablo Avenue.

CONCLUSION

Redevelopment of an urban arterial, whose original purpose is obsolete, is a difficult task. There are many parties that have a stake in transportation and land use improvements and it is vitally important to look at the revitalization process from a systems perspective. Transportation improvements will have limited effect with inconsistent land use improvements. Expensive transit investments coupled with suburban land use requirements results in marginal increases in transit ridership. Conversely, land use improvements without adequate transportation infrastructure yields congestion and spillover effects that alarm neighborhood organizations and other stakeholders. Stakeholder input is vitally important at all stages of the development process, particularly early-on in the process so there is little at stake when negotiating the desires of stakeholders.

This paper identifies several important tools related to land use planning, transportation operations and design, and community involvement; and applies them to the analysis of San Pablo Avenue. Land use plans must be specific to a particular corridor and within that corridor, areas of activity or high transit access must have incentives or mandates to develop in a transit oriented matter. This includes incentivizing high density mixed use development with lower parking requirements that reflect high levels of transit access. Parking should be consolidated and shared between uses. Different land uses have different parking requirements at different times of the day, so parking should be utilized as much as possible throughout the day by sharing. This consolidated parking can be funded using in-lieu fees and the reduction of scattered parking lots will make access by both auto and transit easier and more efficient. The permit process should be streamlined to encourage development. This can be done by using form based zoning that the community agrees upon before hand, limiting the risk to developers and encouraging community participation at the beginning of the development process.

Streets should be designed to encourage pedestrian accessibility. Transit amenities should not be obtrusive and should be built into the pedestrian environment. Simulation tools are a very powerful resource to test and optimize traffic signal operation and geometric changes to the roadway. Improvements can be quantitatively analyzed with a minimum amount of investment and their effect on transit, traffic and the pedestrian environment can be analyzed.

Community involvement is of utmost importance. Surveys and interviews of stakeholders, including developers, residents and merchants can give unparalleled insight into the market conditions driving development and commerce as well as peoples' motivations of residence location and travel. This gives all parties a forum in which to express their opinions and needs. As community members are gaining more and more influence in the decision making process, their views are becoming more critical when developing policy.

This paper presents a set of tools that move the planning process toward a system level approach. San Pablo Avenue is an excellent example of a corridor that used to serve a very different purpose than it does today. There are tremendous opportunities for infill development and densification, but many of the opportunities are not economically

feasible because of uncertain planning processes and unreasonable requirements. As a result, the avenue is dotted with vacant or underutilized parcels that severely reduce the attractiveness of the street. Developers choose to invest in 'easier' green-field development on the urban fringe, perpetuating unsustainable growth and transportation patterns. Changes in transportation engineering and city planning practices are required for streets like San Pablo Avenue to undergo true revitalization.

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