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Advancing Bus Rapid Transit and Transit Oriented Corridors in California's Central Valley

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1. Project Overview

Bus Rapid Transit (BRT) has gained attention as a potentially cost-effective form of high-capacity public transportation. This is particularly the case in small to medium-size cities that do not have high enough densities or serious enough peak-period traffic congestion to justify fairly expensive fixed-guideway transit investments. BRT is widely embraced for providing potential rail-like services at a fraction of the cost (Wright, 2011).

This study explores possibilities for advancing BRT systems and associated higher density land development in the Central Valley of California. It uses photo-simulations and stakeholder reactions to visual images to gauge public attitudes toward what would be a fairly radical transformation of urban environments in traditionally car-oriented settings. Due to the comparatively low development densities found in the Central Valley relative to California's larger metropolitan areas, the kinds of transformations that would be needed to economically justify higher quality BRT services will likely require more than better and more frequent bus services. What will also be needed to complement and perhaps even offset the traditionally negative connotations of higher densities are more amenities, in the form of street trees, attractive landscaping, street furniture, improved building facades, bike lanes, and the like. By eliciting views and responses from local stakeholder interests about BRT service design and surrounding development patterns, the work sought to provide a platform for stimulating open public dialogue on factors that could be vital to successful project implementation.

We chose the city of Stockton as a case context. This was in good part because Stockton has an existing BRT-like service in place. Extending this to a higher-quality dedicated-lane service matched by higher accompanying urban densities was viewed as less of a stretch in Stockton than other Central Valley cities that we considered. To investigate the possibility of a BRT-based transit-oriented corridor in Stockton, photo-simulations were created for two locations: one downtown and the other in a more residential setting. For each location, three levels of density matched by enhanced amenity packages were photo-simulated and presented to local stakeholders, along with background information on assumed costs and possible ridership impacts. Participants were asked to express what they liked and did not like about the BRT scenarios that were presented. This analysis built upon prior work using photo-simulations to gauge public sentiments toward TODs in California by Cervero and Bosselmann (1998).

Besides visually simulating BRT-related transformations that could take place in Stockton, estimates of costs related to various improvements were compiled, as were estimates of ridership increases based on the higher densities of each transit-oriented corridor. The results presented in this paper are just a first step toward designing and implementing a sustainable transportation program for fast-growing, medium-size cities of California where BRT investments could function as a backbone investment toward reshaping community growth.

2. Transit-Oriented Corridors

Transit-oriented development (TOD), while widely embraced as a desirable urban form, has largely failed to produce the benefits — e.g., traffic congestion relief, land conservation, improved air quality – that proponents extol (Cervero et al., 2004; Dittmar and Ohland, 2004; Curtis et al., 2009). While TOD — compact, mixed-use, pedestrian-friendly growth around major transit stops — is a sensible and widely accepted form of "smart growth", its limited scope and scale has proven a shortcoming. In the U.S., what one often finds is an island of TOD in a sea of auto-oriented development. An alternative model is a transit-oriented corridor (TOC) (Cervero, 2007). TOC aims to create multiple TODs that synergistically benefit from their co-presence, mainly in the form of one mixed-use, transit-oriented node being linked to and served by other similar nodes. Metaphorically, TOCs take on the appearance of a necklace of pearls, as found in great transit metropolises of the world like Stockholm, Copenhagen, and Singapore (Cervero, 1998). Rather than focusing development around a single transit node in the hopes of encouraging greater transit ridership, TOC focuses development along a natural travel corridor to develop balanced travel flows along the corridor and enable as many activities as possible within the travel shed of the corridor.

In contrast to TOD, TOCs enable a hierarchy of uses to take form, including local-serving uses (such as coffee shops, cleaners and small scale shopping), community uses (movie theaters, restaurants, retail), and larger citywide/regional uses (large retail stores and offices, entertainment venues, government facilities, etc.). An example of this style of development is the Rosslyn-Ballston Corridor in Virginia which has multiple nodes serving different purposes throughout the day. However, it is important to emphasize that while each node may specialize in a particular land-use, the entire corridor allows for a mixture of uses. For example, the Rosslyn corridor nodes are commonly surrounded by single-family residential, allowing residents who prefer a "typical residential" living to remain within walking-, cycling- or transit-distance of the main corridor. This mixing of uses results in stations that function as both trip origins and destinations during peak hours. This can result in more efficient, bi-directional flows. Rather than having trains and buses jam-packed in on direction and half-empty in other, mixed-use, transit-oriented corridors ensure a more event, balanced distribution of travel flows.

Another advantage of corridors is that they can geographically cover the distance range of trips where public transit enjoys a natural advantage. Transit often grabs the largest market share of trips that are made over a distance of 2 to 8 miles in length (Seskin and Cervero, 1995). If too much shorter, it is not worth the effort of waiting for a bus to arrive – one can just as soon walk to the destination. If the trip is too far, on the other hand, the large number of intermediate stops will deter many from taking transit. The 2-to-8 mile distance, which matches the spatial extent of TOCs, is transit's "sweet spot".

The TOC concept, it should be emphasized, is not anti-automobile. TOC strategies can, however, reduce the dominance of automobiles through policies such as shared parking around office and entertainment uses or the relaxing of minimum parking requirements. Moreover, at the end of a corridor, parking can be provided to serve potential riders beyond the reach of a transit line.

Finally, a significant benefit of TOC is that by linking these corridors together and to the broader transportation network (such as high speed or regional rail), these transit corridors can give rise to transit-oriented cities and regions (Cervero, 1998). As development patterns shift to designs that are friendly to transit throughout a region, paired with a network of interconnected transit corridors, metropolitan areas will be on the path to truly sustainable urbanism.

3. Central Valley Context

This study focused on the Central Valley of California for a multitude of reasons. One factor that weighed in is the possibility of a high-speed rail (HSR) system being built that links the cities in the Central Valley with urban regions of Sacramento, San Francisco-San Jose, Los Angeles, and San Diego. Additionally, the large projected population growth in the Central Valley provides an unprecedented opportunity for cities that populate the spine of the state to pursue smarter development patterns so as to create more sustainable urban futures. Finally, given increased importance of sustainability in the state and the importance of agriculture in the Central Valley to the state's economy, pursuing more compact and sustainable growth allows for greater preservation of farmland and open space.

The planning of California's high-speed rail (HSR) system has provided a major opportunity to shift the form of development in California and how people travel. The development of the HSR stations in Central Valley cities creates a need to develop connections between current local transit systems and the new intercity transportation system. Encouraging a linked, tiered, multimodal system of transportation is an important aspect of transit-oriented corridors, as individuals can walk or bike to local destinations, use transit at the neighborhood and city scale, and transfer to intercity modes such as air travel or high-speed rail. By connecting these modes into one integrated system that accounts for land use, an efficient transit system can provide the convenience and access to shift peoples' mode choices to more sustainable transportation alternatives. Based on international experiences, the greatest potential for TOC lies less at HSR stations themselves and more along secondary feeder lines and distributions networks that connection to intermodal hubs (Murakami and Cervero, 2010).

Another important facet of the Central Valley is the rapid population growth expected in California. The state's population is expected to increase by 52% by the year 2050 according to the California Department of Finance. Additionally, Central Valley counties are projected to be some of the fastest growing counties in the state, with Stanislaus County's population projected to increase by 113% and San Joaquin County's by 141% by 2050. The shift in population growth from the state's coastal areas to more inland settings will likely be driven by cost-of-living differentials that make the Central Valley a more affordable place to live and run a business. Given the substantial increases in projected population, Central Valley cities are poised to face pressures on finding land to accommodate new development. TOCs offered a promising way to accommodate new growth in a sustainable format. Linking denser and interconnected land uses with higher-quality, more convenient transit services could reduce the pressures to sprawl and by reducing traffic congestion and pollution, improve quality-of-life.

Mounting environmental and sustainability concerns are another factor that favor the model of TOC. At the state level, the enactment of SB 375, California's Sustainable Communities and Climate Protection Act, and AB 32, the California Global Warming Solutions Act, mandate reduced VMT and greenhouse gas emissions. The California Air Resources Board has proposed GHG reduction targets for the Central Valley of 5% by 2020 and 10% by 2035. These emission reductions are directed at passenger vehicles and light trucks, thus as each region puts together its own Sustainable Communities Strategy to meet its targets, increased transit use and more compact development patterns are promising strategies of reducing emissions and vehicle miles traveled. Additionally, at the regional level, the *San Joaquin Valley Blueprint* plan has emphasized the need for more compact growth and increased residential density in the region. Finally, as traditional development in the area has continued to sprawl outward, pressure has mounted to develop in a more compact, land-conserving manner. Only by limiting car-oriented sprawl will it be possible to preserve farmland and open space as well as the traditional agricultural character of the Valley's communities and townships. Transit-oriented corridors represent a promising tool for staving off problems associated with market-driven urban growth. The hope is to shift from a vicious cycle of sprawl and automobile dependence feeding off of each other to a more virtuous cycle of transit-oriented growth: more compact growth allows higher-quality transit services to be introduced which in turn reduces the pressure for car-oriented sprawl and draws more households and businesses to compact, mixed-use settings.

4. Why Stockton?

Stockton was selected among the various Central Valley cities that are slated for future HSR services for two main reasons. One, local officials seemed receptive to the idea of TOC and were willing to provide background information needed to prepare photo-simulations. Just as important, Stockton currently has a BRT-like service: Line 40. What might be called "BRT lite" in the sense it does not have a dedicated lane but has other BRT features such as wider spacings between stops and identity branding, Line 40 runs from Stockton's downtown waterfront to the northern suburbs along Pacific Ave (Figure 1).   Existing land uses and development patterns along the corridor could plausibly be upgraded and redeveloped at higher densities, partly due to pent-up market demand and also because of the large amount of road space allocated to surface parking. The wide road right-of-way would allow the conversion of on-street parking to an exclusive, dedicated lane, thus creating a "high-end" BRT service. Route 40 also connects a number of key nodes and activity centers in Stockton: downtown, the waterfront, University of the Pacific, northern residential zones, Miracle Mile shopping corridor, and the San Joaquin Delta College. These trip generators are the building blocks of a potentially success BRT-based network of transit oriented corridors.

Stockton's BRT Route 40

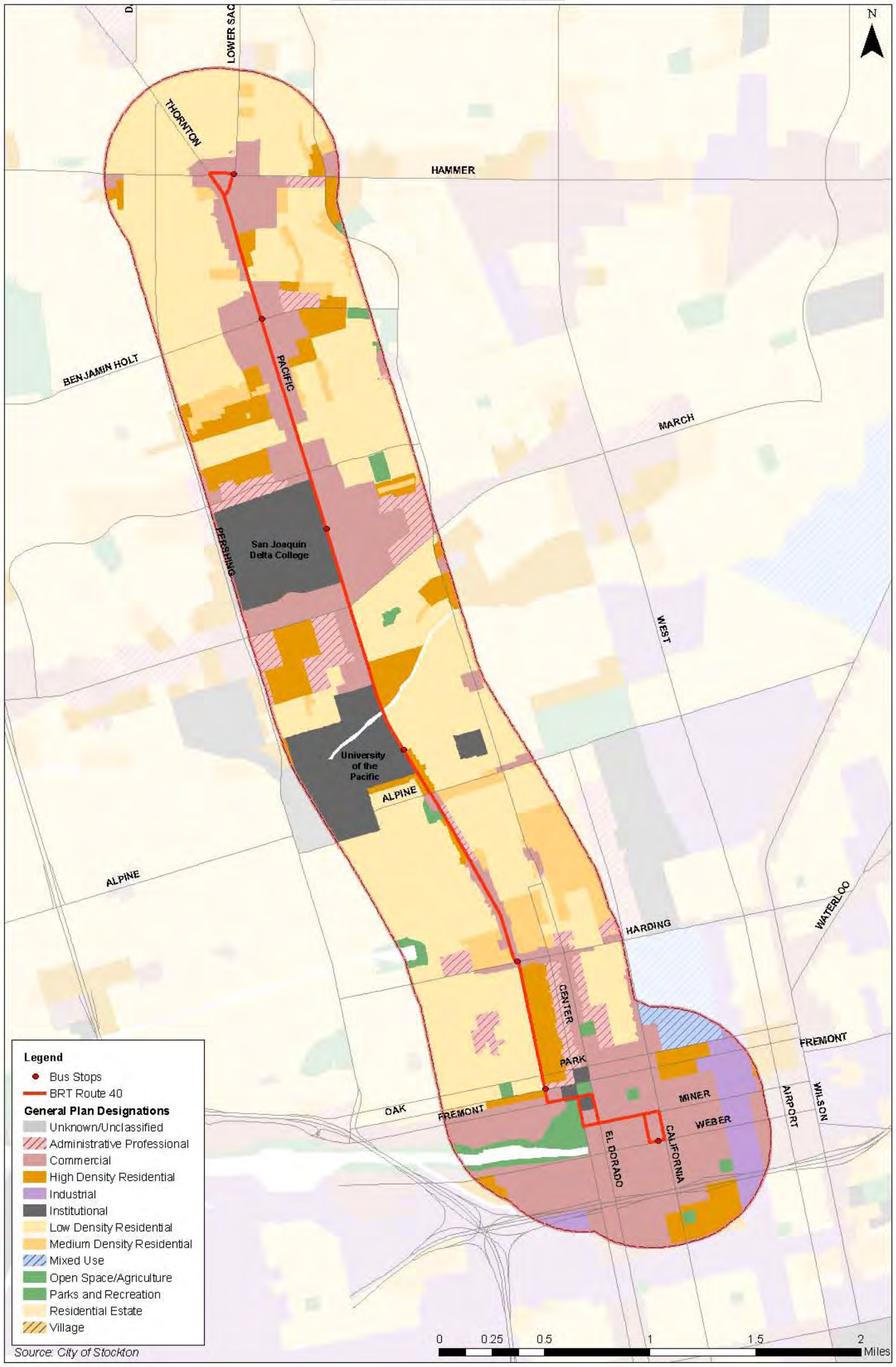

Figure 1. Stockton BRT Line 40

5. Study Approach and Photo Simulations

While TOC might have appeal from a theoretical point of view, the reality is the concept remains largely untested in the United States. To implement TOC in a traditionally low-density setting without serious traffic congestion adds even more uncertainty. For local interests and stakeholder groups, often what is necessary to move the idea forward is a sense of how TOC might look "on the ground". Thus, as a first step to potentially more in-depth analysis of expanded BRT services and TOC development, we turned to photo-simulation techniques to portray how the TOC might look from a pedestrian's perspective. The very notion of transit-oriented growth in a place like Stockton likely conjures up images of towering buildings and big-city streetscapes in the minds of some. There is no getting around the fact, however, that "mass transit" needs "mass" – densities are necessary to generate enough rides to sustain frequent, high-quality service (Guerra and Cervero, 2010).

The general approach adopted in this study was to project images of BRT-served transit-oriented corridors in two parts of Stockton. For a road cross-section and visual perspective of each corridor, three sets of images were presented, ranging from low to medium to high densities. As densities increased, so did an amenity package (e.g., landscaping, street furniture, building articulations, multi-modal options such as bike lanes). Consistent with theories of urban design, the aim was to soften the perception of higher densities by layering in more amenities that improved the image and "feel" of the corridor. Community representatives were then asked to comment on the images. Images portrayed how development might look to a pedestrian on the street. The intent was to stimulate dialogue about the kinds of density envelopes that might be acceptable in light of improved aesthetics, urban-design qualities, and transit services. Such interactions are needed before a major transformation such as TOC is investigated in greater depth. Because our aim was to engage local stakeholders to discuss the pros and cons of high-end BRT investments using photo-simulated images, this paper focuses on the technique itself and its role in participatory planning process versus honing in on a preferred TOC scenario.

The two street cross-sections chosen along Route 40 for photo-simulation represented two contrasting settings: Miner Avenue at El Dorado Street (Figure 2) is in downtown Stockton; Pacific Avenue near West Benjamin Holt Avenue is a more residentially oriented setting (Figure 7). Each of these corridors is discussed next.

6. Miner Avenue at El Dorado Street

Miner Avenue in Downtown Stockton runs east-west connecting the ACE Rail Station in the east and the downtown waterfront in the west. The street currently has a wide right-of-way with ample street parking (Figure 3). The building typologies are higher and denser than other areas along bus route #40. The combined number of jobs and residents per gross acre is 35 (this number is primarily composed of jobs per acre, not residents, given the large number of employment centers downtown). The three photo simulations below (Figures 4, 5, and 6) depict the possible density configurations that could occur with various BRT investments.

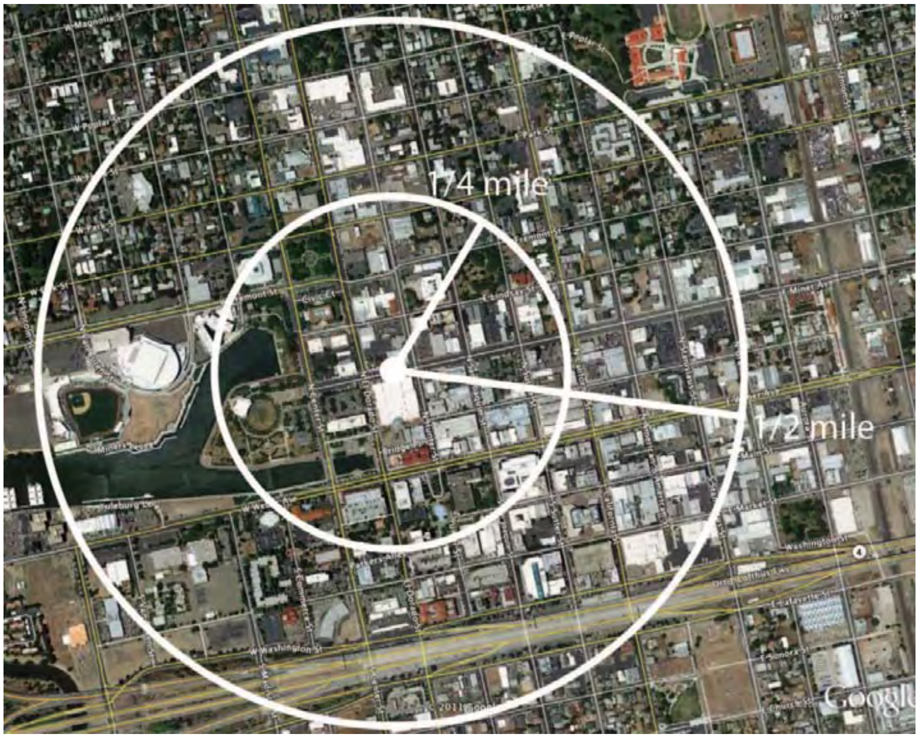

Figure 2. Miner Avenue at El Dorado Street - Walk Sheds


Figure 3. Miner Ave - Existing Conditions

Figure 4. Miner Ave - Scenario 1

Figure 5. Miner Ave - Scenario 2

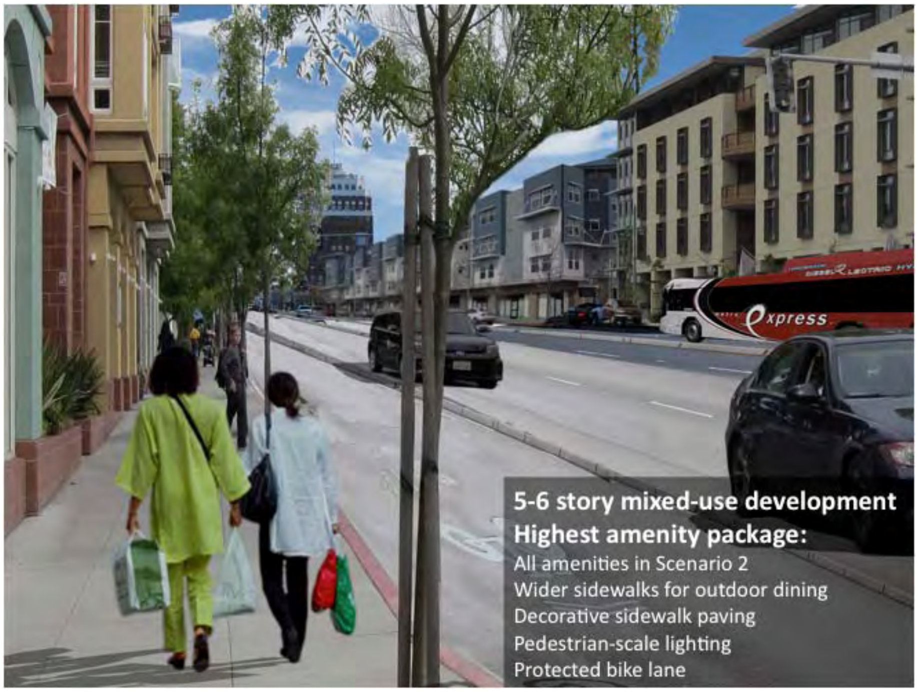

Figure 6. Miner Ave - Scenario 3

7. Pacific Avenue

The Pacific Avenue photo simulations were captured at a station near Benjamin Holt Drive (Figure 7). This area of Stockton is composed of single-family homes abutting parking lots, strip malls, and big-box retail outlets. We felt it was important that the photo-simulations maintained the single-family character of the surrounding neighborhoods, while also demonstrating the potential for developing immediately adjacent to Pacific Ave on existing surface parking lots and sites currently occupied by easily replaceable low-density retail. The existing conditions (Figure 8) show the presence of a generous right-of-way and the absence of on-street parking. This provided an open canvas for visually conveying ways in which the current Pacific Avenue streetscape might be radically transformed. The three photo simulations (Figures 9, 10, and 11) demonstrate a slightly lower density building than along Miner Ave so as to better integrate the surrounding neighborhood's single-family residential character.

Figure 7. Pacific Ave - Walk Sheds

Figure 8. Pacific Ave - Existing Conditions

Figure 9. Pacfic Ave - Scenario 1

Figure 10. Pacfic Ave - Scenario 2

Figure 11. Pacific Ave - Scenario 3

8. Soliciting Feedback

Presenting the photo simulations of TOCs and accompanying information on the projects to community stakeholders in Stockton and getting their feedback was an important aspect of the research project. While an objective survey was prepared to solicit views from stakeholder interests, because insufficient numbers of respondents were available to produce statistically reliable results, we relied on general commentary of participants instead. Participants were asked to comment on what they found desirable and undesirable about particular scenarios and images. We hoped this would shed light on the kinds of densities, urban amenities, and transit service attributes that might be broadly embraced by the community and what would not. Participants were also asked to share their thoughts on major barriers to implementing a transit-oriented corridor in Stockton and if they thought the barriers differed for the two different scenarios (downtown versus Pacific Avenue).

9. Photo-simulation Feedback Results

The participatory phases of the work occurred in two steps. First, we met with technical staff from the city planning and transportation departments of the city of Stockton on two different occasions to review draft photo-simulation images with regard to what might be most acceptable in Stockton. Suggestions and recommendations were then incorporated to make the images more relevant to the perceived preferences of Stockton residents.

Another important aspect of the research project was the estimation of costs of various urban amenities and BRT infrastructure. This was undertaken through a literature review of investment cost estimates from various government documents and academic studies for the various amenities and BRT service attributes imbedded in the photo-simulated images. Estimated costs used in the analysis are shown in Table 1.

SERVICE/AMENITY	COST
BRT Characteristics	
Signal prioritization	$100,000 + $900-$1,100 per vehicle + $10,800-$14,000 per light
Enhanced shelters	$25,000-$35,000 per station
"Train-like" stations	$150,000 - $300,000 per station
Dedicated bus lane	$2.5 - $2.9 million per lane mile
Articulated buses	$700,000 - $750,000 per bus
Urban Amenities:	
Street Trees:	
20 foot intervals	$5,000 per year
15 foot intervals	$6,700 per year
10 foot intervals	$10,000 per year
Bike lane (restriping only)	$5,000 per mile
Protected bike lane	$25,000 per mile
Decorative sidewalk paving	$15 per square foot + cost of removal of existing paving
Pedestrian street lighting	$9,000 each
Street furniture	Varies

Table 1. Estimates of BRT Service and Urban Amenity Costs used for Photo-Simulations

With data inputs from Table 1, we were able to quantify the estimated cost of developing transit-oriented corridors in Stockton. Given the uncertainty of the project's scale and design components, we focused less on presenting "bottom line" cost estimates of each scenario and more on making participants aware of the cost figures.

In addition to these cost estimates, estimates of ridership of expanded and upgraded BRT services in Stockton were made assuming increases of 50% and 100% in population and job densities along the corridors. Data on population density within one-half mile of the corridor were obtained from the 2010 Census and job density information came from the 2009 Longitudinal Employer-Household Dynamics database. The average monthly ridership was adjusted upwards based on assumed increases in density and service quality. Table 2 presents the results.

Population Density	Job Density	Ridership	Frequency per Hour	
			Peak	Off-Peak
9	8	62,000	5	2
14	12	110,000	8	4
18	16	130,000	12	5

Table 2. Ridership and Density Increases

We presented the photo-simulations and background information to a group of stakeholder interests at Stockton's Climate Action Plan Advisory Committee on May 19, 2011. This meeting consisted of city staff, interested public individuals, business owners, and non-governmental organizations interested in climate action strategies. The Advisory Committee represented a reasonable cross-section of stakeholder interest because, in keeping with California's SB 375 Climate Change legislation, the group was highly attuned to and conversant about possibilities for advancing more sustainable patterns of urbanism through integrated transportation and land-use planning. In the meeting, the research group presented an outline of the transit-oriented corridor concept and discussed challenges of advancing more sustainable patterns of development in medium-sized cities of California's Central Valley like Stockton. Following this brief introduction, the 20-member advisory committee was shown the photo simulations, along with background information, and asked for their comments on each alternative of the two TOC scenarios.

Forging consensus among a cross-section of interests is never easy, particularly given the fairly major urban transformations inherent in the TOC concept, particularly in a traditional car-oriented setting like Stockton. Based on the responses of attendees, it became apparent that the proposed densities along the TOCs were too high in the minds of Stockton residents, even if a host of urban amenities were introduced and BRT services markedly improved. Sentiments expressed by the stakeholder participants that were generally agreed upon by all present were the following:

- There was general disapproval of a dedicated lane for BRT service. The feeling was that traffic congestion was not serious enough and the prospects of expropriating a lane for buses only would be controversial enough that it was premature to present this option. Support was expressed for increased transit service levels however in ways that would not significantly reduce existing roadway capacity to motorists. Implicitly this viewpoint is in support of "BRT lite" – e.g., introduction of signal prioritization schemes, far-side bus stops, passenger information systems, and other design treatments that mildly enhance the transit riding experience but fails to significantly increase average bus speeds.

- Greening of the corridor was liked by most attendees. The idea of planting street trees along the corridor, providing a shaded canopy to pedestrians and bus patrons, was welcomed by everyone in attendance.

- Several participants expressed concerns and skepticism about the estimated cost recovery rates and BRT service levels of scenarios. Even with considerably higher densities, the prevalence of free parking and the absence of serious traffic congestion levels prompted some to question the estimated increases in transit ridership productivity. This likely reflects of limitation of single-image photo-simulations in the sense that participants did not associate higher urban densities with higher potential traffic densities and thus the possibility of increased traffic congestion and transit ridership.

- There was general agreement that the highest density scenario were simply too high for Stockton, both for the present and in the foreseeable future. This view held for downtown as well as the Pacific Avenue corridor. More acceptable for downtown were densities with 3-4 story buildings, and some vertical mixing of land uses, along the BRT corridor. By rejecting higher densities, implicitly the participants were also rejecting a high-end, dedicated-lane BRT investment.

Overall, participants supported the principle of transit-oriented corridors. However they wanted more information if they were to go beyond much more than that. Further elaboration of upfront and operating costs for both the transit investments and streetscape enhancements as well as ridership projections are needed to shed more light on the likely cost-effectiveness of these photo-simulated transformations. Ultimately, a full-blown cost-benefit analysis – possibly based on ex ante projections though more ideally informed by ex post evaluation – will be needed to move TOC from the conceptual to the implementation stage in settings like Stockton.

While we entered into this research assuming that stakeholder conversations would help articulate which elements of TOC designs were most liked and which were not, what our research perhaps most clearly showed is the disconnect between transit and urbanism in the minds of many. Notably, there was a clear disconnect between the kind of high-quality transit services that would be needed to make a serious dent in current modal splits (i.e., high-end BRT) and the kinds of urban land-use and streetscape transformations that would be needed to support these radically improved transit services. Participants widely embraced integrated transportation and land-use planning and the goal of Stockton following a more sustainable pattern of urban development. They also generally liked the idea of improved transit services, including BRT, as long as it did not encroach on road space occupied by Stockton motorists (which no doubt included many of the participants themselves). However when it came to growing "upwards instead of outwards" in the form of taller buildings, participants were generally uncomfortable with this prospect, even when higher densities were matched by a richer package of urban amenities. More pedestrian-scale densities of 3 to 4 story buildings appeared to be the tallest building heights acceptable to participants. Yet unless such densities exist throughout a corridor, it is unlikely that the cost of a high-end BRT could be economically justified. Regardless of whether in Stockton or any other city, as the adage goes, mass transit needs "mass". Unless considerably higher densities are embraced and politically accepted, high-end transit services will remain a pipedream in settings like Stockton. Perhaps a limitation of single-image photo-simulations is that they fail to reflect this dynamic. While they might provide feedback on specific elements that are liked or disliked by observers, they are hardly a platform for helping stakeholders sort through the kind of trade-offs needed to place a city like Stockton on a more sustainable pathway. In this sense, they are a single tool or snapshot, not a complete accounting of impacts or a panorama of urban futures. Their limitations must be weighed accordingly when engaging local residents and stakeholders in discussions about urban transformations.

10. Further Research

While this study shed light on the reactions of informed citizens to the idea of transit-oriented corridors and the use of photo-simulations as a participatory planning tool, more work is needed to advance the TOC concept. Of particular importance will be matching simulated images with better estimates of the monetary costs and externalities associated with implementing TOCs on a significant scale. In addition, the link between density and ridership in less transit-oriented contexts like Stockton is needed. Further, understanding which services and amenities are most highly valued or disliked in specific contexts could shed light on the barriers to transit-oriented corridors and how planners and officials might overcome such community opposition. A critical part of establishing community support will be linking research on transit service and urban amenity costs to densities and combinations of service and amenities that are acceptable to the community. While this study has shed light about public perceptions of transit-oriented corridor scenarios, more community engagement and thorough surveying could provide a wealth of information on this subject. Given the heightened concerns over creating sustainable urban futures in California in the wake of far-reaching climate-change legislation like AB 32 and SB 375, work that better connects the transit-oriented concept to future estimates of greenhouse gas emissions and air-quality outcomes would be of particular value.

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