Modeling for a Multi-modal Transportation Corridor – the Grand Boulevard Initiative Project

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Abstract

The Grand Boulevard Multimodal Transportation Corridor Plan is a joint effort of the San Mateo County Transit District (SamTrans), the San Mateo City/County Association of Governments (C/CAG) and the Santa Clara Valley Transportation Authority (VTA) under the larger planning effort known as the Grand Boulevard Initiative (GBI). The goal of the Plan is to facilitate development with an emphasis on transit and land use in the El Camino Real Corridor (State Highway 82) from Daly City to the Alameda/San Jose Diridon Station to support smart growth policies. The objective of the travel demand forecasting was to evaluate the effects of 1) implementing BRT service in the corridor, 2) densification of land use in the corridor and 3) combined effects of intensifying both transit services and land use. The travel demand model used for the corridor plan was an enhanced version of the VTA Countywide model with added detail in San Mateo County along the project corridor. The results of the forecasts showed that the ridership market for BRT was significant under all land use scenarios and ridership increased with both land use densification and enhanced transit services. The model results also showed other benefits in terms of increases in non-motorized mode shares of walk and bike trips and decreases in vehicle-miles-traveled by household caused by the implementation of BRT and land use densification. The implementation of BRT also helped to mitigate the increase in traffic caused by intensified land use densities in the project corridor.

Introduction

In San Francisco Bay Area, congestion and housing affordability are recognized as two top issues for residents. These two issues are interrelated in that the lack of affordable housing forces people to live far away from job, service and social life, the process of which is often referred to as urban sprawl. The isolation of residences from non-residential areas in turn causes congestion and many other transportation, social and environmental problems such as long journey times to work, ozone pollution, shrinkage of forest and agricultural land, etc. To relieve congestion and mitigate other transportation related issues, efforts to reduce the amount of sprawl have been taking on an increased significance in both land use and transportation planning. The sprawl and job/housing imbalance is portrayed in Table 1.

Table 1 Intra-County Commuters and Commuters from Elsewhere to Bay Area as Percentages of Total Commuters in Bay Area

Year	1960	1970	1980	1990	2000
Intra-County Commuters	83%	79%	76%	72%	70%
Commuters from Elsewhere to Bay Area	N/A	N/A	1%	2%	3%

Data Source: 1960, 1970, 1980, 1990 and 2000 Census "journey-to-work" datasets.

Table 1 depicts the trend of urban sprawl in the past few decades. The intra-county commuter trips, as a percentage of total daily commuter trips in or out of Bay Area, trend downward consistently, reducing from 83% in 1960 to 70% in 2000. On the contrary, the percentage of

commuters from elsewhere to Bay Area shows a reversed trend with an increase of 1% in every ten year since 1980. Here, elsewhere refers to places other than the nine-counties in Bay Area. The commuter trips from elsewhere to Bay Area tends to have the longer travel time and contribute more to congestion than the intra-county commuter trips. Hence, these two opposite trends both indicate urban sprawl, or in another word, during the past few decades people in Bay Area on average have lived further and further away from work.

The segment of El Camino Real in Santa Clara County is a major Bus Rapid Transit (BRT) corridor as designated by VTA. El Camino Real is a historic 4-6 lane corridor, and stretches across several counties along the San Francisco Peninsula. In the history of the Bay Area, El Camino Real once acted as a main transportation artery to the thriving Peninsula by carrying workers, commerce and goods up and down the Peninsula. Even now, it maintains an important position in the local transportation network, as pointed out in the Grand Boulevard Initiative Existing Conditions Report (2006) and quoted here that *it carries more traffic, runs through more communities, and hosts more businesses and residents than any other single street on the Peninsula, and is the only major north-south arterial along Peninsula*. However, with its existing auto-oriented streetscape and low land use density, the potential of this corridor to have vibrant activities centers with balanced housing and job opportunities and high transit usage are not achieved. As a response, the Grand Boulevard Initiative, a collaboration of 19 cities, San Mateo and Santa Clara counties, and local and regional agencies, aims to apply vision, principles and guidelines similar to those established in VTA Community Design & Transportation (CDT) Program guidelines to improve the performance, safety and aesthetics of El Camino Real from San Jose Diridon Caltrain Station in Santa Clara County all the way to the north border of San Mateo County at Daly City. To guide its planning work, the GBI team set up the following vision.

"El Camino Real will achieve its full potential as a place for residents to work, live, shop and play, creating links between communities that promote walking, biking, and transit and an improved quality of life."

The Grand Boulevard Multimodal Transportation Corridor Plan is a joint effort of the San Mateo County Transit District (SamTrans), the San Mateo City/County Association of Governments (C/CAG) and the Santa Clara Valley Transportation Authority (VTA) under the larger planning effort GBI. The modeling effort presented in the paper is part of Grand Boulevard Multimodal Transportation Corridor Plan. The goal of the Plan is to facilitate development with an emphasis on transit and mixed high density land use in and around the commuter rail and BRT stations along the corridor to support smart growth policies. With land use densification plus transit improvement as two key components and with its focus along station area, the development envisioned in GBI study is essential a large corridor-level TOD.

Three primary questions are raised related to TOD in the GBI corridor, which are of special interest to the public, planner and policy makers alike:

1. Is there a market for enhanced transit (BRT) along the corridor?
2. Are there benefits of implementing BRT and intensified land use together?
3. Are there other benefits besides increased transit ridership?

The modeling study presented in this study aims to provide guided answered to these questions. The VTA's model, a conventional four step transportation model, is employed to simulate various year 2035 land use and transit scenarios and then the model results are used to evaluate both the separate and joint impact on travel behavior from land use densification and transit improvements. In the remaining part, this paper will present the current condition in the study area, the year 2035 modeling scenarios, including modeling assumptions and results, and conclusions.

Existing Conditions

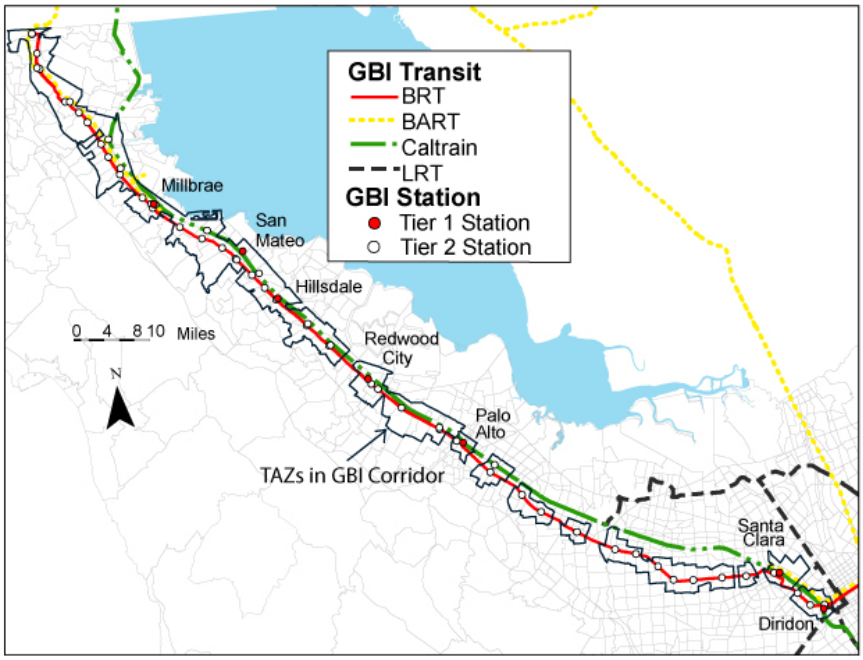
I. Study Area

Since TOD development can be characterized to take the form of "pearls in a necklace", the land use densification evaluated by the model will be limited to discrete station areas instead of along the whole 43-mile segment of El Camino Real under study. Accordingly, the study area of the model refers to the Traffic Analysis Zones (TAZ) intersecting the buffer area that represents reasonable walking distance to the GBI stations.

Table 2 Tier 1 and Tier 2 Station Classification for Future Land Use Scenarios

San Mateo County		Santa Clara County	
Tier 1	**Tier 2**	**Tier 1**	**Tier 2**
Millbrae Caltrain/Bart	All Other Caltrain (except Bayshore, South SF)	Palo Alto Caltrain	California Ave. Caltrain
San Mateo Caltrain	All BART (except Millbrae and SF Airport)	Santa Clara Caltrain/BART	All BRT Stations
Hillsdale Caltrain	All BRT Stations	SJ Diridon Caltrain/BART	
Redwood City Caltrain			

Figure 1
TAZs and Transit Stations in GBI Corridor



Specifically, GBI stations include all existing Caltrain and BART stations, future planned BART stations, and future potential BRT stations within one-half mile of El Camino Real, which were listed and classified into Tier 1 and Tier 2 stations, shown in Table 2. Either a third mile or a quarter mile buffer area was created for each station in the study scope according to whether it was classified as Tier 1 or Tier 2. These

buffer areas are considered the primary market for two levels of land use densification. Then, the TAZs intersecting the buffer areas are queried out and used as an approximation for the study area or the GBI Corridor since TAZ is the analysis unit in the model. Figure 1 displays the TAZs and transit stations in the GBI study area.

II. Existing Land Use

Table 3 shows that the GBI Corridor already has relatively higher density than county wide averages, though even that is still lower than the ideal density envisioned by the VTA's CDT manual or by typical TOD standards.

Table 3 Land Use Density in GBI Station Area versus County Wide

	San Mateo County		Santa Clara County	
	Station Area	**County**	**Station Area**	**County**
Jobs	122,318	337,342	72,657	874,011
Households	84,273	260,072	45,153	590,590
Jobs Per Employment Acre	21	8	19	10
Households Per Residential Acre	10	5	12	6
Jobs/Households	1.45	1.30	1.61	1.48

Data Source: ABAG Projections 2007 and Year 2005 Land Use Geographical File for Bay Area

III. Existing Transit Service

As quoted by Dueker & Bianco (1999), TOD development is likely to be more successful in older established areas already well served by transit. This aspect of the GBI corridor is examined in terms of existing transit service and transit ridership. El Camino Real boasts significant rail infrastructures: Caltrain and Bart, as well as multiple top performing bus services, including express bus 522 and local bus 22 in Santa Clara County and intercity local bus lines 390, 391 and express bus line KX in San Mateo County. In year 2005, about 17,000 daily boardings are observed at the 14 Caltrain stations in the study area, which is about 50% of total boarding at all 29 stations in Bay Area Caltrain system; about 21,000 daily boardings are observed at the 5 Bart stations in the study area, about 6% of total boardings at all 43 stations in Bart system. For bus lines serving the study area, the observed daily weekday boardings in year 2005 are shown in Table 4. Lines 522 and 22 together account for about 20% total bus boardings in Santa Clara County and Lines 390, 391, KX about 30% total bus boardings in San Mateo County.

Table 4 Year 2005 Average Daily Weekday Boarding for Lines Serving GBI Corridor

	Lines	**Observed Boardings**	**Percent of total bus boarding**
Santa Clara	32_22	16,171	16%
	33_522	5,384	5%
San Mateo	26_KX	2,125	5%
	30_390	5,932	13%
	30_391	5,690	13%

Data Source: SamTrans and VTA Operation Division

Year 2035 Modeling Scenarios

The VTA model, specially tailored to suit the GBI study with addition TAZs and network details added along GBI corridor, is used to develop ridership forecasts for the year 2035 planning horizon after being recalibrated and validated to match the observed travel conditions for 2005. The following sections provide a summary of the year 2035 land use assumptions, transportation network assumptions, and scenarios that were modeled in this task.

Year 2035 Land Use Assumptions

ABAG Projections 2007 socioeconomic datasets for the year 2035 serve as the base land use alternative, based on which the Moderate and Enhanced land use alternatives are developed. In the Moderate and Enhanced land use datasets, Housing and jobs for the portion of TAZ inside the buffer area were increased according to density levels targeted based on industry standards and VTA Community Design & Transportation (CDT) Program guidelines, as shown in Table 5.

Table 5 Density Specification for Future Year Land Use Scenarios

		San Mateo County		Santa Clara County	
		Residential	Employment	Residential	Employment
Moderate land Use	Tier 1	40 DU/Acre	174 Emp/Acre (1.0 FAR)	55 DU/Acre	260 Emp/Acre (1.5 FAR)
	Tier 2	20 DU/Acre	87 Emp/Acre (0.5 FAR)	20 DU/Acre	130 Emp/Acre (0.75 FAR)
Enhanced Land Use	Tier 1	75 DU/Acre	384 Emp/Acre (2.0 FAR)	75 DU/Acre	348 Emp/Acre (2.0 FAR)
	Tier 2	40 DU/Acre	174 Emp/Acre (1.0 FAR)	40 DU/Acre	174 Emp/Acre (1.0 FAR)

Notes: DU = Dwelling Unit; FAR = Floor Area Ratio

In the reallocation to achieve the density targets for the Moderate and Enhanced land use alternatives, the following constraints were assumed:

- Preserve county control totals from ABAG Projections 2007 figures – re-allocate growth from outside to inside GBI corridor
- Do not borrow growth from rail stations outside GBI corridor
- In both counties, assume that 50% of land in station areas is potentially re-developable for both residential and commercial
- In San Mateo County, assume that 25% of the commercial acreage in station areas is available for redevelopment as residential, for both scenarios.

The population and other socioeconomic data including households by income group, population by age group, and employment residents, were increased to keep the ratio to the housing units the same. In the case that the density threshold is already met in the ABAG projections for year 2035, the ABAG data were preserved. For the portion of TAZ outside the buffer area, the ABAG data proportioned based on the area ratio are applied under the assumption that the original land use pattern is evenly distributed in a TAZ. The sum of the inside and outside portion thus derived constitutes the land use of each TAZ in the project corridor for the two additional land use alternatives, which are likely to be higher than the ABAG projections. The additional growth

required in the project corridor by these alternatives is achieved by reallocating growth from TAZs outside GBI corridor to TAZs in the project corridor.

Year 2035 Transportation Network Assumptions

For this study, roadway and transit networks consistent with the county long range plans were used as the basis for all future year scenarios. In addition, an enhanced transit network was created to evaluate the impact of transit enhancements on travel patterns in the GBI corridor. The Enhanced Transit network adds BRT along the length of the GBI corridor (Routes 522 and 391). BRT in the Enhanced transit alternatives is assumed to be an overlay service, with local routes 390, 391 and 22 continuing to serve the corridor. The headways for BRT were assumed to be 10 minutes all day**.** BRT station locations would be 0.75-1 mile apart on average. BRT travel times were assumed to be 33% below local bus times in Santa Clara County and 25% below in San Mateo County. It was also assumed that the BRT service would include other improvements, which would give BRT a premium over local bus in traveler's preferences and which were simulated in the model by using a "mode-specific coefficient" in the mode choice model. These other improvements could include:

- Enhanced low-floor vehicles with distinctive branding
- Ticket Vending Machines at most or all locations
- Transit Signal Priority (TSP) along the entire length of the corridor
- Real-time information along the entire length of the corridor

Each transit alternative was coded based on segment speed information, station locations, transit schedules and background feeder bus operating plans provided by SamTrans and VTA staff.

Scenarios Modeled

A total of six future year scenarios were modeled, including: 2035 Baseline/No Project, and five 2035 'Project' scenarios. All scenarios are listed in Table 6.

Table 6 Scenarios Modeled

Scenarios	Forecast Year	Land Use Alternative	Transit Alternative
S2	2035	ABAG 2035 Baseline	2035 Baseline Transit
S3	2035	ABAG 2035 Baseline	2035 Enhanced Transit
S4	2035	Moderate Land Use	2035 Baseline Transit
S5	2035	Moderate Land Use	2035 Enhanced Transit
S6	2035	Enhanced Land Use	2035 Baseline Transit
S7	2035	Enhanced Land Use	2035 Enhanced Transit

Modeling Results

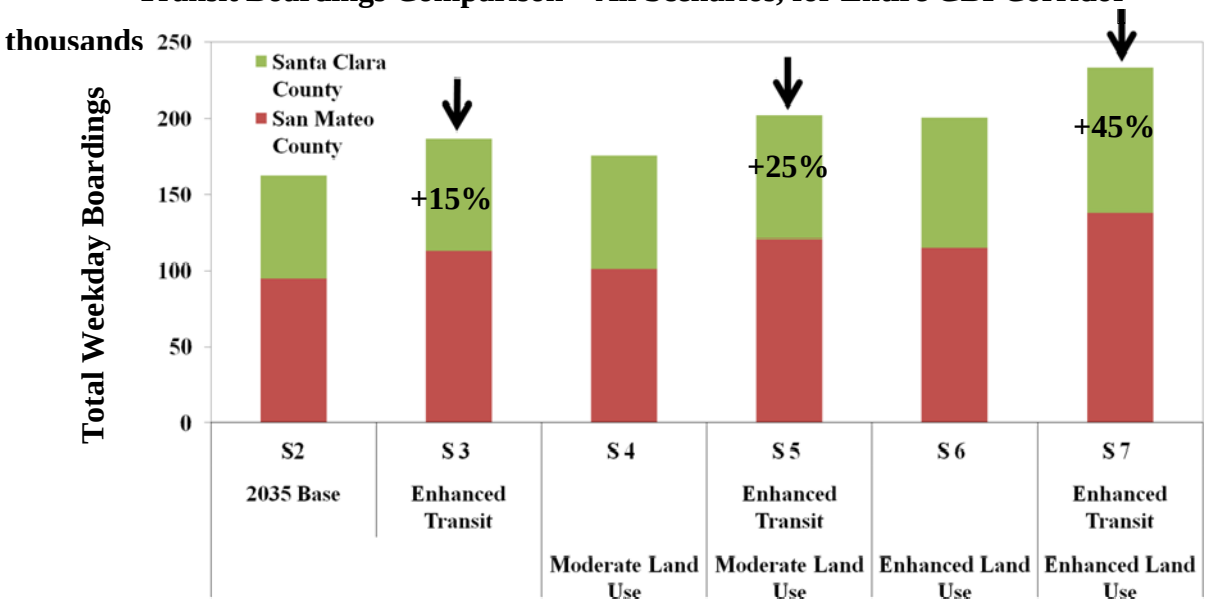
There are a variety of evaluation measures that are produced by the models that indicate the performance of each alternative. The evaluation measures used to summarize the results of the

GBI modeling analysis include: transit boardings, transit trip lengths, travel model share, vehicle miles traveled (VMT) and peak period traffic volumes, each of which will be presented in this section.

I. Transit Boardings

Transit boardings are one of the most basic performance measures of a transit route or system. For the GBI Corridor Plan modeling analysis, weekday boardings at transit stations including potential new BRT, Caltrain, and BART in the GBI study areas, as well as at the local bus stations along El Camino Real between San Jose and Daly City, were chosen as one key indicator of the benefits of each modeling scenario. **Error! Reference source not found.** depicts the boarding results for the full range of alternatives. As the figure indicates, implementing BRT could lead to a 15 to 45% increase in weekday transit boardings, depending on the land use scenario. The figure also shows that projected ridership increases with both Enhanced Transit and intensified land use, but the two scenarios with the highest ridership include both land use densification and BRT service.

Figure 2
Transit Boardings Comparison – All Scenarios, for Entire GBI Corridor



Another inference regarding boarding, that the benefits of implementing BRT and intensified land use together are greater than their effects separately, can be derived by comparing the actually boardings number resulted from the model, as shown in the equation below. It suggests that there are synergies to implementing enhanced transit (BRT) and intensified land use together – in other words, the whole (of these actions) is greater than the sum of the parts.

70,830	>	**62,105**	=	**37,889 + 24,216**
Increase in weekday boardings in S7 (vs. S2)		Increase in weekday boardings in S6 + S3 (vs. S2)		

II. Transit Trip Length

Average transit trip length is an indicator of how long people are riding a given transit route or system, on average. Trip length can be used to gain insight into the type of market a transit route serves – for instance, whether it serves a local/short-distance market or a regional/long-distance market.

Table 7 Average Transit Trip Length in the Corridor

Scenario ID	S2	S3	S4	S5	S6	S7
Transit Trip Length	9.07	8.73	9.03	8.68	8.98	8.6

The overall effect of the land use densification on average transit trip length is no different from that of the transit improvements, in that both reduce the average trip length in the corridor as portrayed in
Table **7**. However, the overall reduction is likely realized through different means, from the transit improvement via increasing the mobility to areas close by and from the land use densification via increasing the accessibility of activity centers close by.

Table 8 shows the relative transit trip lengths of local bus, BRT and Caltrain, for one representative scenario, S7 (Enhanced Transit + Enhanced Land Use). The patterns of the trip lengths for these three transit modes are similar in the other 2035 scenarios. In general, the average trip length for local El Camino bus is about 2 to 4 miles, for new BRT service about 6 to 8 miles, and for Caltrain about 14 to 16 miles. Segmented by trip lengths, the potential market for BRT appears to be clearly distinct from those served by local bus and Caltrain.

Table 8 Transit Trip Length Comparison for Scenario S7

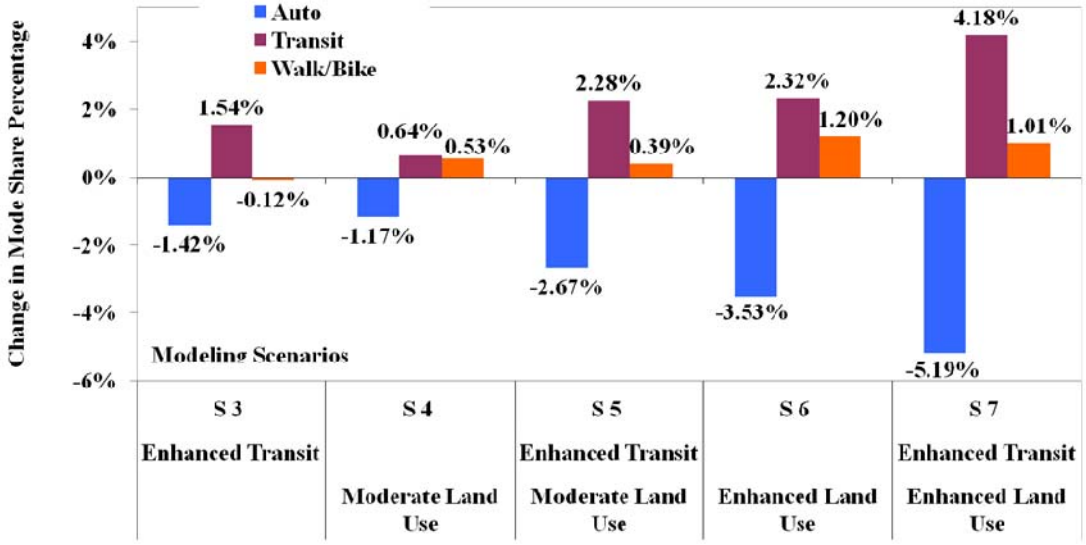
Route	San Mateo County	Santa Clara County
Local El Camino Bus	4.2	3.0
BRT	6.0	7.0
Caltrain	14.7	14.3

III. Travel Mode Share

Figure 3 shows the change in the share of the home based work trips in the GBI corridor among various modes: auto, transit, bike/walk. With the implementation of BRT alone in Scenario S3, the transit share can increase by 1.54%, accompanied by a corresponding reduction of the auto share (-1.42%), though also with a slight reduction in the bike/walk share (0.12%). Both land use densification alternatives (Scenarios S4 and S6) unanimously increase both the transit and bike/walk share compared to the baseline scenario. The mode shift effect is the most pronounced in Scenarios S7, the Enhanced Land Use and Enhanced Transit scenario, with the transit mode share increased by 4.18%, the bike/walk share by 1.01%, and the auto mode share correspondingly reduced by 5.19%. Similar to one conclusion drawn before the benefits of

combining transit improvements with land use densification on mode shifts are greater than the effects separately.

Figure 3
Change In Mode Shares – Home-Based Work Trips Inside GBI Corridor



IV. Vehicle Miles Traveled (VMT)

Parallel to the transit trip length, the aggregate number of miles traveled by automobile (VMT) divided by total households is a useful measure of average auto trip length. It is also another good indicator of the effectiveness of transit enhancements or land use changes in meeting planning objectives, because other factors, such as greenhouse gas emissions or energy consumption due to automobile use, are directly related to automobile VMT.

Table 9 compares the VMT per household for Baseline S2, Enhanced Transit & Moderate land use Scenario S5, and Enhanced Transit & Enhanced land use Scenario S7. Apparently households residing inside the GBI corridor on average travel far fewer miles per day by automobile than those living outside the corridor, or compared to the regional average. While the differences in the Countywide VMT per household for the three scenarios are relatively small, it is still observable that the greatest reduction in auto trip length is in Scenario 7, with both Enhanced Transit and the most dense land use.

Table 9 Daily VMT per Household Comparison

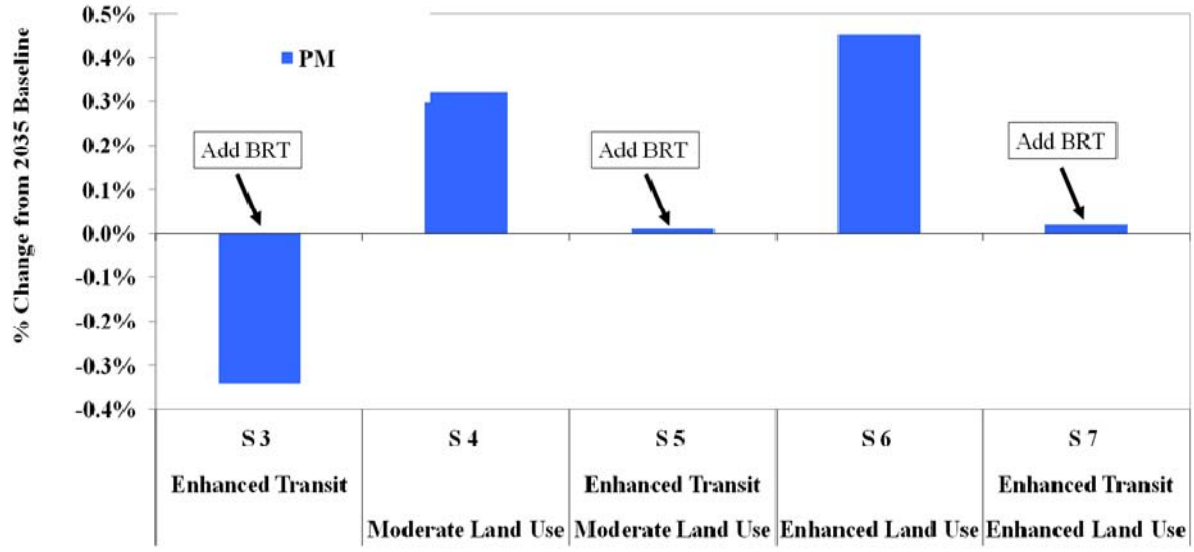
	Base Land Use Base Transit S2	**Moderate Land Use Enhanced Transit S5**	**Enhanced Land Use Enhanced Transit S7**
Within GBI Corridor	22.35	20.90	18.55
Outside of GBI Corridor	72.80	74.01	76.07
Countywide	65.17	65.12	64.79

V. Peak Period Traffic Volumes

To assess how well transit improvement in GBI corridor will counteract the traffic impact of land use densification, the peak period traffic volumes crossing a set of 4 screenlines, roughly evenly spaced along the GBI corridor, were calculated, combined and compared with baseline for each project scenario.

Figure 4 illustrates the change of PM peak period screen volume and the mitigation effects of the BRT service. In comparison with the baseline, both land use densification scenarios S4 and S6 increase the traffic volume crossing screenlines during PM peak periods. However, the implementation of BRT can significantly reduce the volumes, essentially mitigating the traffic impacts of the land use densification almost completely.

Figure 4
PM Peak Period (3PM to 7PM) Screenline Volume Comparison



Conclusion

The forecast results give positive answers to all three primary questions, which are set out at the beginning of the paper and relisted below with responding answers.

1. Is there a market for enhanced transit (BRT) along the GBI corridor? ***YES***
   The forecasted boarding results demonstrate that the ridership market for BRT was significant under all land use scenarios and enhanced transit service. In addition, BRT serves a distinct market from local buses and Caltrain in terms of trip length.
2. Are there benefits of implementing BRT and intensified land use together? ***YES***
   Both the forecasted boarding and transit mode share results indicate that the benefits of combining transit improvements with land use densification are greater than the effects separately.

3. Are there other benefits besides increased transit ridership? ***YES***
   The forecast results also showed other benefits in terms of increases in non-motorized mode shares and decreases in vehicle-miles-traveled per household caused by the implementation of BRT and land use densification. The implementation of BRT also helped to mitigate the increase in traffic caused by intensified land use densities in the project corridor and hence help reducing green gas pollution.

In conclusion, the modeling results paint a promising picture for employing TOD in the GBI corridor to relieve traffic congestion, improve housing/job balance and solve various problems spawned by congestion and imbalance.

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