Multimodal Corridor System Management – Incorporating Analysis of Transit, Demand Management Programs and Operational Strategies

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Abstract

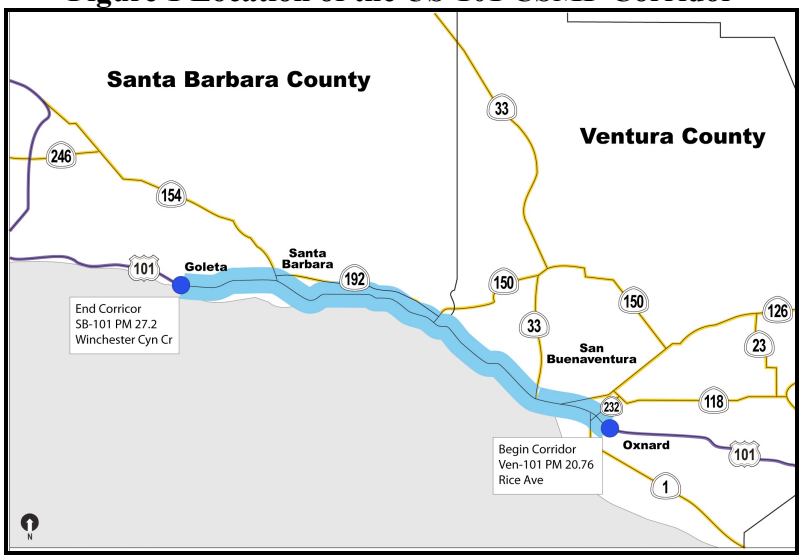
Identifying cost-effective solutions for the increasingly complex congested urban corridors in our U.S. metropolitan areas is requiring greater sophistication in analysis tools and consideration of all modes of travel. Modeling methods are required that can produce forecasts of future traffic volumes but that can also simulate the operational characteristics of traffic in a corridor with sensitivity to a broad range of improvement options. New model systems are now being used to assess the potential benefits of a variety of operational and management strategies designed to maintain the optimal flow of people and goods in the corridors and to sustain the capacity gained through investments in infrastructure. In Santa Barbara and Ventura Counties, a Corridor System Management Plan has been prepared for a fifty-mile stretch of US 101 to sustain multi-modal mobility. The plan was developed with significant attention being given to public transportation, non-motorized modes and transportation demand management options.

Overview

There has been significant movement towards planning for operations in major complex corridors (1), (2) and (3). This paper describes how a multi-modal corridor management plan was developed for a fifty-mile corridor in Santa Barbara and Ventura Counties shown in Figure 1. The US-101 Corridor System Management Plan has been a collaborative effort between the two Caltrans districts that govern the Santa Barbara and Ventura County regions, the Santa Barbara County Association of Governments, and the Ventura County Transportation Commission. The US-101 Corridor System Management Plan process also gained input from over twenty other organizations including representatives from the two counties, several cities, several unincorporated communities in the corridor, transit service providers, and a number of other interested parties. The objectives of the US-101 plan were to improve safety on the transportation system, reduce travel time or delay on all modes, reduce traffic congestion, improve connectivity between modes and facilities, improve travel-time reliability, and expand mobility options along the corridor in a cost-effective manner..

The corridor system management planning approach in the US-101 corridor included explicit consideration of management and operations in the planning and programming of transportation improvements. The corridor planning process was also multimodal and used detailed information to understand how a corridor functions both currently and in the future. The US-101 Corridor System Management Plan was built directly on the prior work by the stakeholder agencies including the Regional Transportation Plans for the two regions covered by the corridors (4) and (5), Congestion Management Programs of both counties (6) and (7), a long range corridor plan called ***101 In Motion*** prepared specifically for the US-101 Corridor in Santa Barbara County (8), and a Regional Ramp Metering Plan developed by Caltrans (9).

Figure 1 Location of the US-101 CSMP Corridor

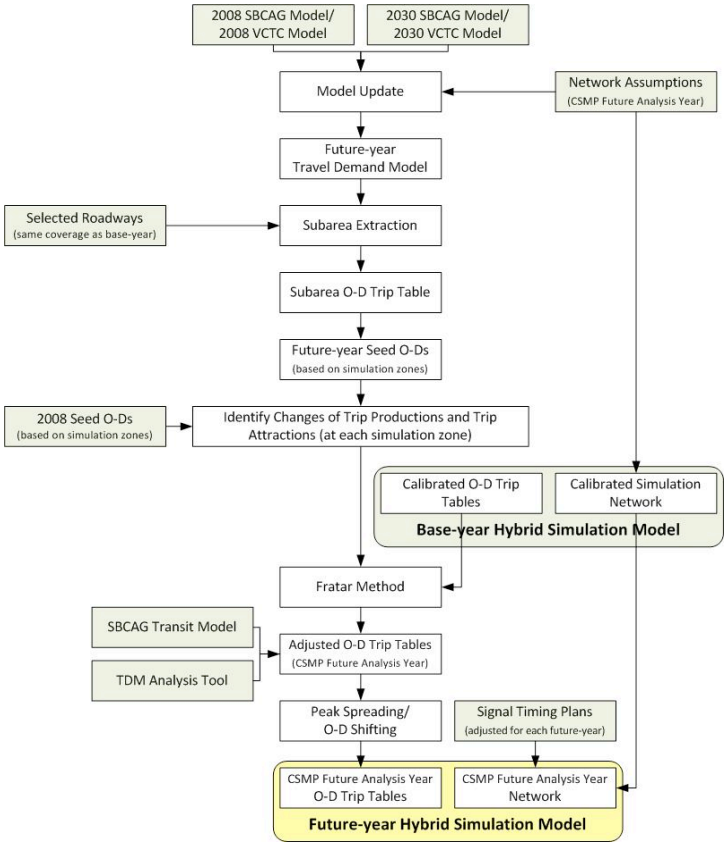


To support the multi-modal analysis, the project team assembled a suite of tools. As indicated in Figure 2, basic forecasting of travel patterns for 2013 and 2023 were performed using the models developed for the two counties as well as the model maintained by the Southern California Association of Governments: the MPO for an area that includes Ventura County. A supplemental tool developed by the Santa Barbara County Association of Governments (the MPO for the county) for a corridor master plan was used to test the benefits of alternative transit options which include adding local service, transit signal priority, bus rapid transit, express bus, and enhanced regional rail to provide better service for long-distance commutes. The supplemental analysis tool for transit in the SBCAG model uses a regional trip table of commute trips by mode and performs a pivot-point analysis using the mode choice model parameters. A similar supplemental tool was used to assess the benefits of transportation demand management (TDM) strategies and non-motorized mode improvements. The TDM tool was designed to link to a travel demand model and apply effectiveness factors from observed responses to demand management strategies.

The supplemental transit tool and the TDM tool allowed the project team to reflect the vehicle trip reduction effects of the transit, non-motorized and TDM strategies on the corridor vehicle trip table. These benefits could then be reflected in the volumes loaded into the simulation model where freeway and arterial management strategies were tested. The simulation was performed using the TransModeler simulation package.

The process of selecting strategies to be tested for the corridor has included a broad range of stakeholders from the corridor including both counties, all of the cities, several unincorporated communities in the corridor, all transit service providers, the air pollution control agency, and other interested parties. The stakeholder group as a whole provided input at key decision points throughout the project including the selection of strategies to be considered.

Figure 2 Model Framework for the US-101 CSMP



Three subcommittees also provided more direct input on how multimodal management options were included in the Corridor System Management Plan:

- Transit and TDM Subcommittee,
- Traffic Operations Subcommittee and
- Modeling Subcommittee.

The commitment to a multimodal approach in the Corridor System Management Plan was also reflected in the goals and objectives selected for the effort. As indicated in Table 1, goals and objectives reflect travel by all modes and the movement of people and goods as well as the movement of vehicles.

Characteristics of the US-101 Corridor

The US-101 corridor has a mixed urban, suburban and semi-rural character with dramatic scenic beauty. US-101 serves as the main connection between the communities serving commute, school, personal, business and leisure travel. Employment is concentrated in the northern end of the corridor in and near the cities of Santa Barbara and Goleta. This part of the corridor includes the University of California Santa Barbara campus, which also attracts a large number of trips during the peak commute periods. As a result, there is more commute period traffic congestion northbound along the US-101 corridor in the morning and southbound in the evening.

Table 1 Goals and Objectives for the US 101 Corridor System Management Plan

Goals	Detailed Objectives
Improve Safety	Reduce the number and severity of transportation-related accidents in the corridor
Improve Mobility	Reduce delay associated with travel in the corridor particularly for carpools, vanpools and transit users
	Reduce reliance on single-occupancy vehicles for travel in the corridor
	Increase the travel options for people traveling in the corridor
	Reduce the duration of congestion in the corridor
Improve Reliability	Improve the travel-time reliability for travel in the corridor
Increase System Productivity	Increase person throughput of corridor facilities
	Reduce loss of throughput due to delay
Improve Environmental Quality	Reduce the rate of pollutant and green house gas emissions per person-mile traveled in the corridor
	Reduce traffic on local streets and arterials that parallel the freeway
	Reduce vehicle miles of travel per person mile of travel
Improve Economic Prosperity	Increase person-carrying capacity of the corridor
	Reduce commute times within the corridor
	Reduce travel cost per person-mile of travel within the corridor

US-101 is on the Interregional Road System (IRRS) as a designated Focus Route. (10) The U.S. Department of Defense has identified US-101 as a Strategic Highway Network (STRAHNET) route. (11) It is part of a network of linked highways deemed essential to national defense for facilitating the movement of troops and equipment to airports, ports, rail lines, and military bases. The highway is a State Highway Extra Legal Load (SHELL) roadway and is designated for use by larger trucks (12). It is also listed on the National Highway System, which means that it connects rural areas to growing urban centers and is critical for moving people, goods, services, and technology. US-101 also plays a larger role in the state economy by serving as a secondary route to Interstate 5, by connecting the Los Angeles Basin to Northern California. Approximately 6.7 percent of the traffic along this corridor is attributed to trucks.

While most of US-101 in the corridor study limits is a six-lane freeway, about 16 miles between Mussel Shoals and Milpas Street is a four-lane freeway. In a portion of this four-lane section, there are three median openings that provide access to the communities of Mussel Shoals, La Conchita and to the industrial site known as Tank Farm. The elimination of the at-grade crossings and the addition of a lane in each direction in the four-lane section is the focus of funded project.

US-101 and many of the major parallel streets in each county are at or near capacity during some part of the peak commute periods. Although the existing level of congestion on the freeway on an average weekday during non-peak periods when there are no major incidents is moderate, small variations in traffic volume or incidents can greatly increase congestion and delay. Because of the scenic beauty in the corridor and the attraction of the corridor beaches, the traffic on the weekends, during the summer, or for special events can be much more congested.

There have been significant efforts to provide alternative modes of travel for commute and non-commute travel in the two counties. These include local and express bus service, demand-responsive paratransit services, bicycle routes, multi-use trails, ridesharing services, employer-based flexible work schedules and other trip reduction programs. Limited passenger rail service is also provided by Amtrak, but the existing service schedule does not offer a meaningful option for commute travel. Because of the relatively limited transit services and the low density of population and employment centers along the corridor, the vast majority of passenger travel is by automobile.

Future Conditions

The expected growth in the corridor is described in the forecasts presented in Table 2. There will be significant growth in population and employment in both parts of the corridor, but the growth in vehicle trips is expected to be even greater. Congestion in the future will not be uniform throughout the corridor, but will likely focus on a few major bottleneck points. The projects under construction and those programmed will significantly help to decrease the amount and frequency of corridor delay. The improvements underway in Santa Barbara County south of downtown Santa Barbara and the programmed addition of the high-occupancy vehicle (HOV) lanes will reduce the congestion at most of the bottlenecks between downtown Santa Barbara and the Ventura County line. The main locations of congestion in Ventura County will be in the southern half of the corridor in the cities of Ventura and Oxnard. Traffic analysis has identified three main bottlenecks that will develop and will cause a significant increase in delay for the corridor.

Table 2 Population, Employment and Travel Forecasts

Category	US-101 Corridor in Santa Barbara County			US-101 Corridor in Ventura County		
	2008	2013	2023	2008	2013	2023
Population	188,000	(+3.5%)	(+8.1%)	842,000	(+6.9%)	(+14.1%)
Households	68,000	(+2.0%)	(+4.9%)	269,000	(+8.1%)	(+15.1%)
Total Employment	125,000	(+6.0%)	(+13.7%)	362,000	(+9.3%)	(+18.4%)
Vehicle Trips	303,000	(+6.3%)	(+17.0%)	346,000	(+6.8%)	(+22.1%)

Data Source: Santa Barbara County -SBCAG Travel Demand Model, Ventura County - SCAG Travel Demand Model

Evaluation of Management and Operation Strategies

A wide variety of operations and management strategies were evaluated to determine which would improve corridor operation in the future (2023). Each of the packages of strategies demonstrated significant potential for reducing congestion. The strategies were grouped into four packages for analysis. Three packages were evaluated using models that simulate traffic flow on the freeway and the parallel roadways. Because the models do not include collisions or other incidents, the fourth

package was evaluated using a special model that analyzes the benefits of using freeway service patrol.

The four packages were:

- **Transit and Transportation Demand Management** – strategies designed to reduce the number of trips made by automobiles during the peak commute periods by increasing transit services in the peak and by encouraging a reduction in automobile use for commute trips during peak hours.
- **Ramp Metering** – strategies designed to manage the flow of traffic on US-101 by metering the flow from ramps onto the freeway.
- **Minor Physical Capacity Enhancements** – strategies, such as auxiliary lanes or spot widening, designed to improve the efficiency of US-101 by relieving bottleneck points or improving alternative routes.
- **Incident Management** – strategies to improve the safety of the corridor and reduce the amount of congestion by reducing the impact of collisions and other incidents.

The results of the analysis of the first three packages using the modeling system are illustrated by the changes in "delay a percentage of total travel time on the freeway" in Table 3. More detail about the specific results of the analysis of the individual scenarios is presented below.

Table 3 Effect of Scenarios on Delay as a Percentage of Freeway Travel Time

	AM Peak		PM Peak	
	Northbound	**Southbound**	**Northbound**	**Southbound**
Santa Barbara County				
2008 Baseline	15.6%	10.9%	15.4%	22.2%
2013 Baseline	18.7%	10.7%	16.4%	18.5%
2023 Baseline	22.3%	12.6%	35.1%	29.7%
2023 Transit and TDM	17.2%	12.6%	33.8%	17.2%
2023 Ramp Metering	20.8%	13.6%	31.9%	27.2%
2023 Minor Capacity	18.0%	11.7%	35.4%	21.1%
Ventura County				
2008 Baseline	16.3%	16.7%	19.2%	16.4%
2013 Baseline	13.7%	17.8%	18.0%	19.0%
2023 Baseline	17.3%	26.0%	32.1%	48.0%
2023 Transit and TDM	15.7%	25.0%	32.0%	40.6%
2023 Ramp Metering	16.2%	24.8%	32.4%	48.6%
2023 Minor Capacity	13.6%	12.6%	23.6%	39.9%

Transit and TDM

101 In Motion outlined a set of Transit and TDM strategies as part of a multimodal approach to maintaining mobility in the Santa Barbara County portion of the US-101 corridor. Most of the recommendations of that planning effort were included in the expenditure plan for a sales tax renewal in November 2008 (Measure A). ***101 In Motion*** identified enhancements in commuter-

friendly passenger rail service between Santa Barbara County and Ventura County, increases in express bus services, and a variety of employer-based TDM activities designed to reduce vehicle trips for commuters to jobs in Santa Barbara County. These enhancements became the core of the Transit and TDM scenario tested for the Corridor System Management Plan because they all benefit commuters between the two counties, though some were modified slightly to satisfy the Corridor System Management Plan and stakeholder agencies. The enhancement strategies directed at inter-county commute trips were evaluated for their impact on vehicle trips and the use of US-101.

The combined effect of the Transit and TDM scenario was very positive in the peak commute direction—northbound in the AM and southbound in the PM. Overall, the transit and TDM strategies together reduced AM and PM peak period drive-alone vehicle trips by over 7,200 for Ventura and Santa Barbara Counties combined, as indicated in Table 4. The estimates of trip reductions were based primarily on work performed for ***101 In Motion***, but with modifications to reflect the differences in the strategies that were tested.

Table 4 Vehicle Trip Reductions from Transit and TDM Strategies

Peak Period	Santa Barbara County	Ventura County	Santa Barbara and Ventura Counties
AM Peak Period	2,500	1,100	3,600
PM Peak Period	2,500	1,100	3,600
AM & PM Peaks	5,000	2,200	7,200

The effects of the trip reductions on traffic volume and delay on US-101 were determined using the corridor simulation model. In Santa Barbara County, the strategies result in a 5 percent reduction in freeway traffic (as measured by the number of vehicle miles traveled) and a 53 percent reduction in freeway delay. In Ventura County, the strategies produce a 4 percent reduction in freeway VMT and a 30 percent reduction in delay. Although the Transit and TDM scenario produced significant benefits in almost all segments, the segments where delay was reduced the most were the cities of Santa Barbara and San Buenaventura. In both cases, the strategy significantly reduced congestion at most of the major bottlenecks in the 2023 baseline.

Ramp Metering

The analysis of ramp metering for the US-101 corridor revealed that the strategy can improve the traffic flow on the freeway, reduce bottlenecks, and reduce overall delay when the right conditions exist. The analysis also suggests that this can be accomplished without negative impacts on local arterials and that the improved productivity of the freeway will result in a better alternative for longer trips, thereby minimizing diversion of trips to parallel alternatives. Major bottlenecks that are expected to emerge in each county by 2023 will impact the potential effectiveness of ramp metering southbound in the PM peak period and possibly northbound in both periods in Ventura County. Because these bottlenecks are at locations that cannot be effectively mitigated by ramp metering and the bottlenecks themselves will meter flow downstream, the effectiveness of ramp metering may be limited for these segments.

The analysis of ramp metering indicated that an effective program would not necessarily include metering at all ramps. Under the forecast conditions for 2023, metering would not be required at some ramps because they are downstream of the corridor bottlenecks or too far from bottlenecks to have an effect. In some segments, the effectiveness of ramp metering will be limited because some ramps do not have adequate capacity for metering. They are either too short or they do not have enough lanes. During high ramp demand times, metering of these ramps would result in spillback into the adjacent intersections and so the metering would have to be discontinued. For some ramps, this would only affect the highest point in the peak period, but for other high-demand ramps, this might be the case during the entire peak period. Insufficient ramp capacity may limit the effectiveness of metering on most of the older ramps that have not been reconstructed. Other ramps also have limited capacity, and the test of the scenario indicated that at some point during the peak periods, metering would have to be suspended because the ramp queue would exceed the full length of the ramp and would potentially interfere with intersection operations. Those ramps are identified in the description of how ramp metering would affect bottlenecks presented below.

A very large bottleneck, like the one projected southbound at SR-126 in the PM peak in 2023, will in effect function as the meter for traffic downstream in Oxnard. As a result, metering might not be of use in that segment unless the bottleneck at SR-126 is relieved with a capacity improvement. Based on the preliminary assessment, it is unclear whether the delay reduction in the segment near Oxnard is the result of ramp metering or the bottleneck at SR-126. Additional analysis would be required to determine whether ramp metering would benefit this segment. The most significant reductions in delay from ramp metering will be in the segments adjacent to the main employment centers in the cities of Santa Barbara, San Buenaventura, and Oxnard; although the reductions in these segments are often the result of metering in upstream segments.

Minor Physical Improvements

The minor physical enhancements tested in this improvement scenario were for projects that are not already programmed and that could directly affect the operation of US-101. These included freeway auxiliary lanes, spot widening, ramp improvements, arterial connections and arterial intersection improvements. These plans are the combination of suggestions from the US-101 Corridor System Management Plan Traffic Operations Subcommittee (which includes Caltrans District 5, Caltrans District 7, SBCAG, and VCTC) and from DKS and are based on results of the baseline simulation models. The simulation analysis indicates that minor physical improvements can significantly impact delay. In the peak directions, the improvements could reduce freeway delay by 24 to 36 percent. The most significant benefits will again be in the vicinity of the major employment centers in the cities of Santa Barbara, San Buenaventura and the Oxnard.

Incident Management

Incident management on the Santa Barbara County US-101 segment is provided primarily by the Freeway Service Patrol (FSP). The FSP program is jointly managed by SBCAG and the California Highway Patrol (CHP) with assistance from Caltrans. For the US-101 Corridor System Management Plan efforts, current (2008) levels of Santa Barbara FSP service were assumed to remain constant for forecasting FSP delay savings benefits for two future year scenarios, “CMIA Opening Year” and “10 Years after CMIA Opening.” The forecasted annualized FSP performance measures for the Santa Barbara FSP program are listed in Table 5. The expected costs of and

benefits from FSP in Santa Barbara County were estimated using the observed costs and benefits of the FSP program in the county in the past. The delay savings per assist and per tow truck hour increase significantly from 2008 to "Ten Years after Opening" because congestion is expected to increase significantly on US-101 in Santa Barbara County over that time period.

The costs and benefits of implementing modest FSP service in Ventura County was estimated using the delay-savings estimates produced by the Caltrans Freeway Service Patrol Evaluation Model (FSPE) on the US-101 Santa Barbara FSP beats near the Santa Barbara/Ventura County border and the US-101 Los Angeles FSP beats near the Los Angeles/Ventura County border. The forecasted annualized FSP performance measures for the two modeled Ventura County FSP beats are shown in Table 6. The delay savings per assist and per tow truck hour increase even more in Ventura County than in Santa Barbara County from 2008 to "Ten Years after Opening" because the percentage increase in congestion on US-101 is expected to be greater in Ventura County.

Table 5 US-101 Santa Barbara County FSP Measures of Effectiveness

Measure of Effectiveness	Year 2008	Opening Year	Ten Years after Opening
Annual FSP Tow Truck Hours (FSP-tow-truck-hours)	2,952	2,952	2,952
Annual FSP Assists (assists/year)	1,215	1,271	1,442
Delay Savings Per Assist (VHT/Assist)	108	115	143
Delay Savings Per Tow Truck Hour (VHT/FSP-hour)	44	49	70
Annual Delay Savings (VHT/year)	130,800	145,700	206,400
Annual User Benefit ($/Year)	1,702,200	1,897,000	2,686,500
Annual FSP Costs ($/Year)	225,500	225,500	225,500
Annual Benefit-to-Cost Ratio	7.5	8.4	11.9

Table 6 US-101 Ventura County FSP Measures of Effectiveness

Measure of Effectiveness	Year: 2008	Opening Year	Ten Years After Opening
Annual FSP Tow Truck Hours (FSP-tow-truck-hours)	4,000	4,000	4,000
Annual FSP Assists (assists/year)	2,113	2,250	2,471
Delay Savings Per Assist (VHT/Assist)	30	41	78
Delay Savings Per Tow Truck Hour (VHT/FSP-hour)	15	25	52
Annual Delay Savings (VHT/year)	59,700	98,600	207,300
Annual User Benefit ($/Year)	777,600	1,283,200	2,698,600
Annual FSP Costs ($/Year)	250,300	250,300	250,300
Annual Benefit-to-Cost Ratio	3.1	5.1	10.8

Under current conditions in the US-101 Corridor System Management Plan corridor (combined Santa Barbara and Ventura Counties), the FSP program could reduce vehicular delays on US-101 by about 160,000 vehicle hours annually. This could grow to over 400,000 vehicle hours each year in the ten years after CMIA opening. Likewise, more aggressive expansions to the FSP program on US-101 would increase the delay savings from incident-related delays.

Conclusions

Consideration of all modes of travel was essential to gaining a consensus in the US-101 Corridor System Management Plan. Local stakeholders were committed to improving the movement of people and freight in an efficient and safe manner. A multi-modal approach to the Corridor System Management Plan required that special care be taken in defining the goals and objectives of the Corridor System Management Plan, in defining a modeling process and in the selection of strategies to be evaluated. A multi-modal team was also necessary to ensure that all modes were effectively integrated. The extensive involvement of stakeholders throughout the process also helped the team achieve consensus on the recommendations.

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