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MEMORANDUM

Date: May 7, 2012

Project #: 170670/P09033.010

To: San Mateo 101 Hybrid HOV Lane Study Team

From: Kevin Chen, Rick Dowling

Project: San Mateo 101 Hybrid HOV Lane Analysis

Subject: Staged HOV Lane Analysis (from Whipple Road to I-380) – Deliverable 8

INTRODUCTION

Kittelson & Associates/Dowling had submitted a Final Mainline Report on March 8, 2012, for the San Mateo 101 Hybrid HOV Lane Study. The report presented an evaluation of a full hybrid HOV lane option in both directions, from existing HOV lane terminus at Whipple Avenue in Redwood City, to San Francisco/San Mateo County line (approximately 19 miles). In review of the report, stakeholders expressed interest to evaluate a staged hybrid HOV lane option, from Whipple Avenue to south of the I-380 interchange in San Bruno.

This memo provides a summary of the evaluation for staged hybrid HOV lane option, including procedures in developing traffic forecast, traffic operations analysis results, as well as comparisons to Year 2040 baseline, and the full hybrid HOV lane option conditions.

STAGED HYBRID HOV LANE LIMIT AND GEOMETRIC CONFIGURATION

In the northbound direction, this staged hybrid HOV lane would extend from existing terminus at Whipple Avenue to approximately half a mile south of the I-380 off-ramp (about halfway between the SFO on-ramp and San Bruno Avenue off-ramp), where it would then continue as a mixed-flow lane to the north. South of Millbrae Avenue on-ramp, this option would retain identical geometric configuration as proposed for the full hybrid HOV lane option. The section between Millbrae on-ramp and SFO on-ramp would contain three mixed-flow, one HOV lane, and no auxiliary lane. Auxiliary lane between SFO on-ramp and San Bruno off-ramp would be retained. North of the I-380 off-ramp, this option would retain identical geometric configuration as the future baseline (No Build) scenario.

In the southbound direction, geometric configuration for this staged option would be identical to future baseline conditions north of the Access Road on-ramp/San Bruno Avenue overcrossing. The staged hybrid HOV lane would begin south of the San Bruno Avenue overcrossing, and from this location south to Whipple Avenue, the staged hybrid HOV lane option would retain identical geometric configuration as proposed for the full hybrid HOV lane option.

COST ESTIMATES

Based on preliminary analysis, the cost for this staged hybrid HOV lane option is estimated to range between $156 million and $180 million, if implemented using the lane configurations and geometrics described above. Referencing to the segment numbers as shown in Chapter 8 of the Final Mainline Report, the $156 million total includes cost estimate for both northbound and southbound directions for segments 1 to 8, and 10; as for segment 9, this estimate reflects 50% of the total segment cost, as the total number of lanes would conform with the baseline scenario in northbound, and widening would only be required in the southbound direction. The upper range of the cost estimate reflects potential additional cost for improving deceleration lengths at off-ramps for the staged hybrid HOV lane option.

TRAFFIC FORECAST

A set of traffic forecast volumes for the freeway mainline and ramps are derived based on the two sets of forecast volumes previously developed and presented for Year 2040 baseline and full hybrid HOV lane option. As described previously in the Final Mainline Report, traffic forecast volumes developed for the full hybrid HOV lane option reflects conservative induced demands for an addition new HOV lane throughout the study corridor between Whipple Avenue and San Francisco County line. In order to more realistically assess traffic operations of the staged hybrid HOV lane option, total induced demands for the full add an HOV lane option were reduced, based on a comparison of freeway mainline capacity between all three scenarios: Year 2040 baseline, Add an HOV lane, and staged hybrid HOV lane, as capacity and demand correlates closely for this heavily traveled freeway corridor (i.e. higher capacity generally attracts higher induced demands).

Based on the evaluation of mainline capacity comparisons, approximately 36% of the full induced demands (applied previously to the full hybrid HOV lane evaluation) were added to the baseline forecast, to create a set of traffic forecast for the staged hybrid HOV lane option.

TRAFFIC OPERATIONS ANALYSIS AND RESULTS COMPARISONS

Traffic operations analysis was conducted using the same tool and methodologies to be consistent with the baseline and full hybrid HOV lane evaluations.

Freeway Performance Measures

The corridor-wide mobility performance results for Year 2040 are summarized in Exhibit 1. Comparing to baseline conditions, the staged hybrid HOV lane option on the San Mateo 101 freeway corridor:

- Vehicle miles of travel would be increased by 4%, which would improve productivity of the freeway;
- Both vehicle hours of travel and vehicle hours of delay would be reduced by 5%, and 10%, respectively, which translate to lower gasoline consumption and greenhouse gas emissions;
- Person hours of delay would be reduced by 9%, which translates into direct cost savings to freeway users;
- Average peak period speeds would be increased for both vehicle-trips and person-trips.

Exhibit 1 – 2040 Freeway System Performance Comparison

Performance Measures	2040 Baseline	2040 Full Hybrid HOV	2040 Staged Hybrid HOV	Full Hybrid HOV vs Baseline	Staged Hybrid HOV vs Baseline
VMT – vehicle miles of travel	4,925,100	5,264,400	5,145,620	7%	4%
VHT – vehicle hours of travel	196,000	190,500	187,043	-3%	-5%
VHD – vehicle hours of delay	120,400	109,400	107,841	-9%	-10%
PHD – person hours of delay	120,600	110,900	109,240	-8%	-9%
Average vehicle speed (MPH)	25.1	27.6	27.5	10%	9%
Average person speed (MPH)	25.9	29.9	29.3	15%	13%

Source: FREQ Analysis, both HOV and mixed-flow lanes combined.

Carpool vehicles and express transit buses would experience much improved travel time savings and reliability with the HOV lane. The analysis found that average peak period travel times for HOV's would be improved on the order of 7 to 26 minutes. For mixed-flow lane users, average travel times would be significantly improved, on the order of 33 minutes of travel time savings compared to baseline conditions for PM peak period travel in the northbound direction, and 7 minutes for AM peak period in the southbound direction. SOV's using US 101 during the AM peak period in the northbound direction and PM peak period in the southbound direction, however, would experience minor increases of between 2 and 5 minutes when compared to baseline conditions (see Exhibit 2). All of these travel time savings or increases are for travel the full length of the corridor.

Maximum peak hour travel times (as opposed to the averages for the full peak period described above) would be affected to a much greater extent. HOV lane users would experience savings of 9 to 59 minutes. Mixed-flow lane users would experience significant maximum peak hour travel time savings for northbound travel in the PM peak period of 60 minutes, and 23 minutes for southbound travel in the AM peak hour. SOV's using US 101 during the AM peak hour in the northbound direction and PM peak hour in the southbound direction, however, would experience minor increases of between 8 and 10 minutes when compared to baseline conditions.

Exhibit 2 – Travel Time Comparisons

Average Peak Period Travel Time

Dir/Peak	Baseline			Full Hybrid HOV Lane			Staged Hybrid HOV Lane			Staged HOV Versus Baseline					
	Mixed-Flow (mins.)	HOV (mins.)	HOV TT Savings (mins.)	Mixed-Flow (mins.)	HOV (mins.)	HOV TT Savings (mins.)	Mixed-Flow (mins.)	HOV (mins.)	HOV TT Savings (mins.)	Mixed-Flow Diff (mins.)	(%)	HOV Diff (mins.)	(%)	HOV TT Savings (mins.)	(%)
Northbound AM	108.6	54.5	54.1	117.1	43.7	73.4	110.2	47.3	62.9	1.6	1%	-7.2	-13%	8.8	16%
Northbound PM	169	61.4	107.6	139.4	45.6	93.8	135.6	50.8	84.8	-33.4	-20%	-10.6	-17%	-22.8	-21%
Southbound AM	70.5	69.6	0.9	72.8	37.5	35.3	63.7	43.2	20.5	-6.8	-10%	-26.4	-38%	19.6	2178%
Southbound PM	95.6	61.6	34	99.8	43.4	56.4	100.2	61.9	38.3	4.6	5%	0.3	0%	4.3	13%

Maximum Peak Period Travel Time

Dir/Peak	Baseline			Full Hybrid HOV Lane			Staged Hybrid HOV Lane			Staged HOV Versus Baseline					
	Mixed-Flow (mins.)	HOV (mins.)	HOV TT Savings (mins.)	Mixed-Flow (mins.)	HOV (mins.)	HOV TT Savings (mins.)	Mixed-Flow (mins.)	HOV (mins.)	HOV TT Savings (mins.)	Mixed-Flow Diff (mins.)	(%)	HOV Diff (mins.)	(%)	HOV TT Savings (mins.)	(%)
Northbound AM	161.8	63.3	98.5	177.8	43.4	134.4	169.3	52.1	117.2	7.5	5%	-11.2	-18%	18.7	19%
Northbound PM	249.7	75.5	174.2	184.5	47.1	137.4	189.9	65	124.9	-59.8	-24%	-10.5	-14%	-49.3	-28%
Southbound AM	105.9	105.9	0	113.8	37.5	76.3	82.5	47.3	35.2	-23.4	-22%	-58.6	-55%	35.2	>100%
Southbound PM	139.8	88.4	51.4	153.8	50.7	103.1	149.9	79.9	70	10.1	7%	-8.5	-10%	18.6	36%

Source: Peak period average travel times from FREQ analysis, including congestion beyond study limits south of SR 85 interchange (13 miles), and north of San Francisco county line (9 miles). Total distance is approximately 43 miles for the northbound direction, and 39 miles for the southbound direction.

Freeway Bottlenecks and Queues

In terms of freeway operations in the mixed-flow lanes for the staged hybrid HOV lane, mainline bottleneck locations would generally be consistent with the full hybrid HOV lane south of I-380, and consistent with the baseline conditions north of I-380, with freeway queue lengths varying depending on the time period and direction of travel. However, these effects would not significantly affect mainline operations. Overall, freeway operations and performances would generally be improved with the staged hybrid HOV lane compared to the baseline conditions, as described above with travel time and productivity comparisons.

Northbound AM Peak – During the AM peak period, seven (7) bottlenecks would develop in the following freeway segments:

- Rengstorff Avenue loop off-ramp to on-ramp
- Willow Road loop off-ramp to loop on-ramp
- Woodside Road off-ramp to on-ramp
- Kehoe Avenue on-ramp to 3rd Avenue off-ramp
- 3rd Avenue on-ramp to Dore Avenue off-ramp
- Broadway on-ramp to Millbrae off-ramp
- Bayshore Boulevard off ramp to Sierra Point Parkway off-ramp

By the height of the peak (when delay or travel time through the corridor is the longest), it would take approximately 169 minutes for mixed-flow lane vehicles to travel through the entire corridor, of which about 128 minutes are associated with delay due to bottleneck and queuing effects. Three of the bottlenecks, Rengstorff Avenue and Kehoe, and Broadway, will have become hidden by queues from the downstream bottlenecks. The Rengstorff Avenue bottleneck will be hidden by queues extending south approximately 10 miles beyond the SR-85 study limit from the Willow Road bottleneck, resulting in a total queue length of 16.3 miles. The Kehoe bottleneck will be embedded in a 2-mile queue extending to the Hillsdale Boulevard interchange from the 3rd Avenue bottleneck. Similarly, the Broadway bottleneck will be embedded in a 6-mile queue extending to south of the Broadway on-ramp from the Bayshore Boulevard bottleneck. The Woodside bottleneck would result in queues extending to the Marsh interchange, or approximately 1.7 miles.

Northbound PM Peak – During the PM peak period, nine (9) bottlenecks would develop in the following freeway segments:

- Rengstorff Avenue loop off-ramp to on-ramp
- Marsh Road loop on–ramp to diagonal on-ramp
- Kehoe Avenue on-ramp to 3rd Avenue off-ramp
- 3rd Avenue on-ramp to Dore Avenue off-ramp
- Anza Boulevard on-ramp to Broadway off-ramp
- Millbrae Avenue on-ramp to SFO Airport on-ramp
- Broadway on-ramp to Millbrae Avenue off-ramp
- Sierra Point Parkway on-ramp to Harney Way off-ramp
- Harney Way on-ramp to 3rd Street off-ramp

By the height of the peak, it would take approximately 190 minutes for mixed-flow lane vehicles to travel through the entire corridor, of which about 150 minutes are associated with delay due to bottleneck and queuing effects. The Rengstorff bottleneck will be hidden by queues extending south approximately 11 miles beyond the SR-85 study limit from the Marsh bottleneck, resulting in a total queue length of 19 miles. The Kehoe bottleneck would result in queues extending to south of the Whipple Avenue interchange, or approximately 6.6 miles in length. Queues associated with the 3rd Avenue, Millbrae Avenue and Broadway

on-ramp bottlenecks would be relatively short and would be contained within the interchanges. The Anza bottleneck would result in queues extending to south of the Peninsula interchange, or approximately 2 miles in length. The Sierra Point bottleneck would result in queues extending to south of the San Bruno on-ramp, or approximately 3 miles in length. The short queues resulting from the Harney Way on-ramp would develop earlier in the peak period and dissipate by the height of the peak.

Southbound AM Peak – During the AM peak period, seven (7) bottlenecks would develop in the following freeway segments:

- Beatty Road on-ramp to Sierra Point Parkway off-ramp
- SFO Airport on-ramp from international terminal to on-ramp from domestic terminal
- Poplar Avenue on-ramp to 3rd Avenue off-ramp
- Hillsdale Boulevard loop on-ramp to diagonal on-ramp
- Willow Road loop off-ramp to diagonal on-ramp
- University Avenue off-ramp to on-ramp
- Oregon Expressway on-ramp to San Antonio Road off-ramp

By the height of the peak, it would take approximately 83 minutes for mixed-flow lane vehicles to travel through the entire corridor, of which about 45 minutes are associated with delay due to bottleneck and queuing effects. The Beatty Road bottleneck would result in queues extending approximately 0.3 miles beyond the study limit into the San Francisco County. Both the SFO and Poplar bottlenecks will become hidden by the 10-mile queue from the downstream bottleneck at Hillsdale and the Millbrae bottleneck will have become hidden by queues of over 12 miles from the downstream bottleneck at Hillsdale. Queues associated with the Willow, University, and Oregon bottlenecks would develop earlier in the peak period and disappear during the height of the peak.

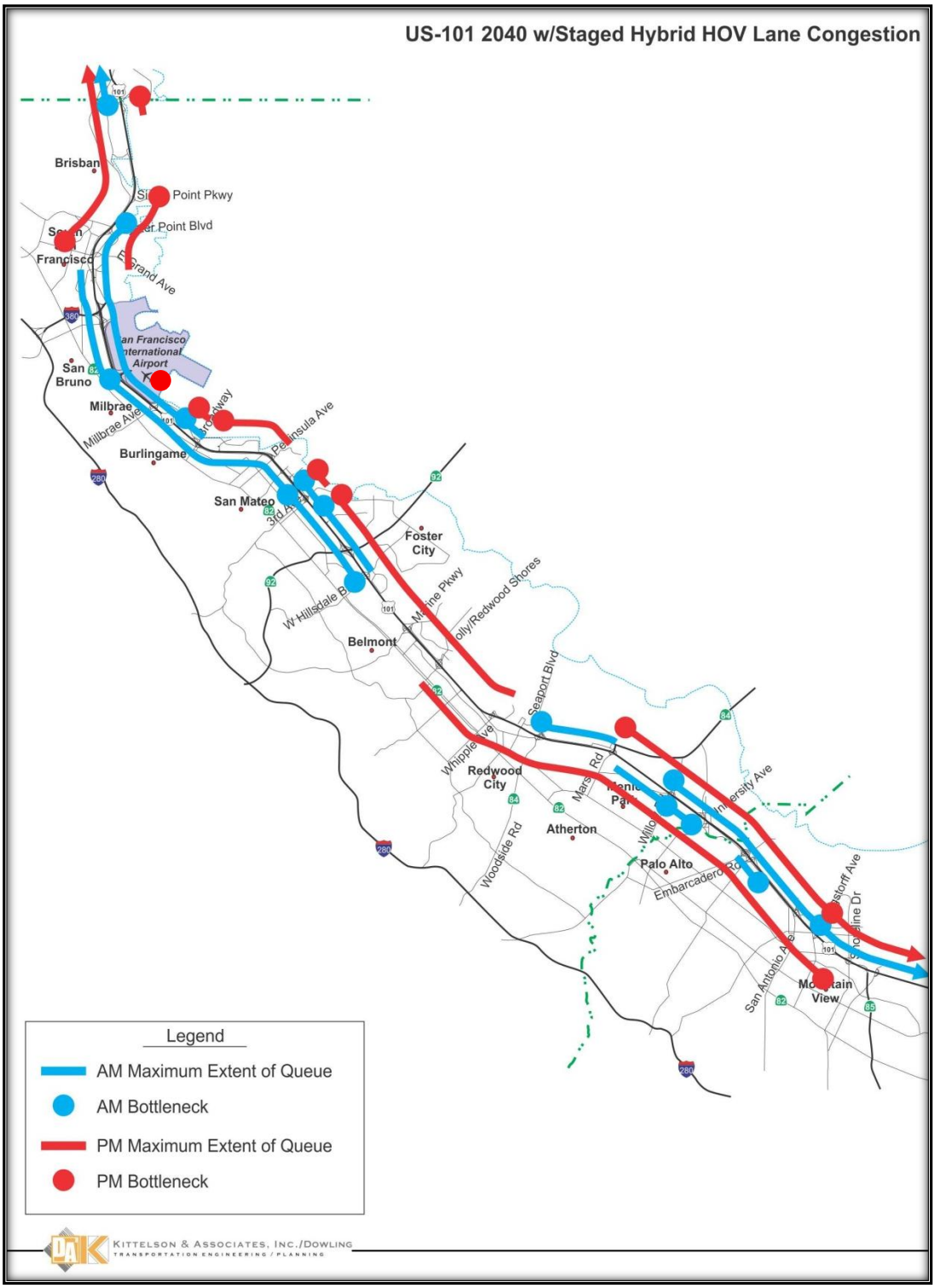
Southbound PM Peak – During the PM peak period, two (2) bottlenecks would develop in the following freeway segments:

- Oyster Point Boulevard on-ramp to Miller Avenue off-ramp
- Rengstorff Avenue on-ramp to Old Middlefield Way on-ramp

By the height of the peak, it would take approximately 150 minutes for mixed-flow lane vehicles to travel through the entire corridor, of which about 112 minutes are associated with delay due to bottleneck and queuing effects. Queues resulting from the Rengstorff Avenue bottleneck would extend to the Holly Street interchange, or approximately 11 miles. As for the bottleneck at Oyster Point Boulevard, queues would extend approximately 10 miles beyond the study limit into the San Francisco County, resulting in a total queue length of 14 miles.

Mixed-flow lane bottlenecks and maximum queue lengths are shown in Exhibit 3.

Exhibit 3 –Freeway Bottlenecks and Queues in 2040 with Staged Hybrid HOV Lane



GREENHOUSE GAS EMISSIONS EFFECTS

Exhibit 4 provides a comparison of the greenhouse gas emissions for the baseline conditions, full hybrid HOV lane option, as well as the staged hybrid HOV lane. The staged hybrid HOV lane option would result in higher VMT in the county, although average travel speeds are generally higher, the major emissions, CO2 and CO, is approximately 0.5%, and 0.3% higher than baseline conditions, respectively. Note also that these major emissions for staged versus full hybrid HOV lane options are approximately the same, although VMT for the staged hybrid HOV lane is lower, but average travel speeds are also generally lower as well.

Exhibit 4: Summary of Countywide Greenhouse Gas Emission for Peak Period (AM and PM)

GHG	Baseline	Full Hybrid HOV	Staged Hybrid HOV	Staged HOV vs Baseline	Staged vs Full Hybrid HOV
CO2 (1000)	2.02	2.03	2.03	0.5%	0%
TOG	2.59	2.59	2.59	0.0%	0%
CO	8.73	8.76	8.76	0.3%	0%
NOx	1.05	1.05	1.05	0.0%	0%
PM10	0.19	0.19	0.19	0.0%	0%

Source: C/CAG Model and California EMFAC Model, Emissions measured in tons, except CO2, which is measured in 1000 tons.

Key:
CO2 (1000) = Carbon Dioxide in thousands of tons
TOG = Total organic gases
CO = Carbon Monoxide
NOx = Nitrous oxides
PM10 = particulate matter under 10 microns in size
Diff = difference between hybrid HOV lane option and baseline