

# **An Integrated Methodology for Corridor Management Planning**

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**Abstract:**

Corridor management planning aims to find solutions to corridor-level mobility and congestion problems via both planning and operational analyses. A successful corridor management plan can be a backbone for developing comprehensive transportation system management strategies for an entire region. This paper presents a new methodology to integrate the state-of-the-art operational analysis, such as advanced data archives, dynamic traffic network modeling, and traffic simulation techniques, into more traditional transportation planning processes for congested urban corridors. It focuses on new methods of evaluating current and future investment and/or operational improvement strategies as possible solutions to mobility problems.

The methodology developed in this paper includes phased processes which are integrated between the typical aims of both planning and operations. It begins with project scoping, to preliminary and detailed corridor performance assessment and causality analysis, analysis model development, and finally improvement scenario evaluation and recommendations. Examples and case studies are also provided in this paper based on the three corridor management planning studies that the authors recently conducted. These projects and particularly the methodology proposed in this paper have helped influence the Corridor Mobility Improvement Account (CMIA) requirement for corridor management plans in California; the CMIA was developed as part of a \$4.5 billion dollar transportation infrastructure bond recently approved by voters in the State of California.

## 1. Introduction and Motivation

Traffic congestion and safety issues continue to be increasing concerns to both the traveling public and transportation agencies. Many of the nation's urban corridors experience a considerable amount of congestion every day. Because of these challenges, corridor management planning (CMP) and related concepts have been proposed recently, including the CMP Demonstration by Caltrans (1) and the Integrated Corridor Management (ICM) program by Federal Highway Administration (FHWA) (2).

CMP aims to find solutions to corridor-level mobility and congestion problems via both planning and operational analyses by defining how a travel corridor is performing, understands why it is performing that way, evaluating potential (current and future) improvement strategies through various modeling tools, and recommending system management strategies to address problems within the context of the existing short-term, and long-range planning vision.

This paper proposes a new methodology for conducting CMP, which incorporates operational analyses (such as detailed data analysis, dynamic network modeling and traffic simulation) into traditional planning process. The methodology is a phased process, starting from project scoping, to preliminary and detailed corridor performance assessment and causality analysis, analysis model development, and finally improvement scenario evaluation and recommendations. The goal of this methodology is to resolve corridor management planning issues, such as short- or long-term improvement or investment alternatives, but involved with substantial operational analyses. For instance, the performance assessment requires detailed bottleneck analysis to identify corridor problems and their causes.

The proposed methodology is based on three CMP studies that the authors recently conducted, including the I-880 corridor in the San Francisco Bay Area, the I-5 corridor in Orange County (Southern California), and the SR-41 corridor in Fresno (Central California). These projects and particularly the methodology proposed in this paper have helped influence of the Corridor Mobility Improvement Account (CMIA) requirement for corridor management plans in California; the CMIA was developed as part of a \$4.5 billion dollar transportation infrastructure bond recently approved by voters in the State of California (3). The CMP study on the I-880

corridor in the San Francisco Bay Area also facilitated the selection of the corridor to be included as one of the eight FHWA-sponsored ICM study sites (4, 5). Examples and case studies are provided in this paper based on the three corridor management planning studies to illustrate the key components of the proposed methodology.

## **2. Overview of the Methodology**

The methodology proposed in this paper incorporates operational analysis into more traditional transportation planning processes at the corridor level. It is based on performance-based decision making, which is an important objective of a corridor management plan. ITS and ICM efforts strongly support this objective because systems-generated data provides feedback to measure transportation system performance in areas such as congestion and safety.

As shown in Figure 1, the CMP methodology consists of four major steps: projects scoping and stakeholder involvement, performance assessment, analysis model development, and improvement scenario evaluation and recommendations. The first step includes the initial scoping and preliminary examination of the corridor that could be done internally or with preliminary stakeholder coordination. It also includes the interactions with stakeholders to discuss the needs of the project. This may include, e.g., the determination of the coverage of the corridor and which analysis and modeling tools to use. In the case that the corridors are already defined, this step may be simplified. The second step focuses on performance evaluation. It starts with a preliminary data collection, based on which a preliminary performance assessment can be conducted. A more comprehensive performance assessment may be conducted depending on whether the detection system is sufficient and the particular purpose of the study. Detailed data analysis techniques, such as bottleneck identification (6) along the corridor, can be applied in this step to help identify the existing problems of the corridor. A causality analysis is then performed to reveal the exact causes of the problem. The following step is the development of the analysis models, which could be macro-, meso-, or micro-simulation models. The models include a base year model, focusing on existing corridor conditions, and future year models, focusing on projected future corridor performances. These models need to be calibrated to reflect real-world traffic conditions. For this purpose, dynamic network modeling and simulation calibration are crucial techniques to be employed. An example of calibration of the simulation models is the

calibration of bottlenecks along the corridor. Based on the developed base year and future models, the fourth step is to explore the potential current and future improvement strategies and investments along the corridor. All strategies will be evaluated via the developed modeling tools and benefit cost analysis will be conducted. The most promising strategy or list of strategies will be summarized and presented to decision makers.

This methodology provides procedures that practitioners can use to conduct similar corridor management studies easily and quickly. It includes guidelines to develop a work scope based on the target network, available resources and time frame, as well as highlight procedures and tools to set up a traffic analysis framework and collect corridor performance measurements. It also recommends processes to evaluate different corridor management strategies (including ITS strategies and/or operational improvements). Furthermore, the data requirement, collection, processing, and quality control issues for each of the major steps are summarized in the methodology. This CMP methodology focuses on high-level processes needed to develop management strategies on travel corridors of interest to a region. When employed as part of the regional transportation planning processes, corridor management plans can act as the backbone for developing more comprehensive system management strategies for the entire region.

### **3. Project Scoping and Stakeholder Involvement**

Project scoping is an important aspect to obtain an accurate corridor assessment and will help determine the proper analysis tool. The study scope acts the foundation for the rest of the study process, so it is imperative that it be developed methodically and systematically. Changing the scope later in the process could prove to be a costly mistake, both in terms of funding as well as time. For this reason and others, accurately identifying the corridor plan's scope of study is critical. The problems may vary among studies, but the process should remain the same.

Stakeholders must engage at this early point in the CMP to help identify problems and set project goals. Stakeholders must come to agreement very early in the process on problem identification, data collection plans and levels, analysis method to be used, calibration levels, validation acceptability, and evaluation scenarios. Problem identification begins with examining current planning documents, perceived performance gaps, and differences between actual and desired

performance of the network. This is a good point to recognize and mitigate bias and conflicts of interests so that these issues do not arise later in the study. A few examples of such bias might be the conscious or unconscious to stereotype analysis methods, assume a solution prior to analysis, or assume the same results of previous studies. Acknowledging bias and working through these issues as early as possible in the process will prevent problems later.

### **3.1 Initial Scoping**

As shown in Figure 1, coming out of the “Determine Scope” step of the CMP process, the four major points in determining the scope are choosing a target network, determining the time period to work within, looking at what resources are available for the study, and identifying the appropriate plans, policies and architectures.

A large part of the initial scoping efforts should be concentrated on identifying the target network that helps determine what the geographic parameters of the study will be and which stakeholders need to be involved. It will later have bearing on which method is used for analysis. For example, the I-880 study identified the I-880 travel corridor between I-980 and SR-237 as its target network, along with the major parallel arterials. Highways, arterials, ITS infrastructure, HOV lanes, transit, and land use are among the many factors that could be identified for analysis within the target network.

It is important to consider the period within which the study is expected to be completed in the scoping process. This is helpful in choosing the appropriate analysis method as well as deciding on an analysis approach for the study. For instance, decision makers may need quick answers regarding a specific issue or alternately may be seeking comprehensive solutions to input into a long-range plan.

Having a clear picture of the available resources is likely to be the most important part of determining the scope of the study. Available resources can be broken down into two categories, as shown in Figure 2: stakeholder outreach, and data inventory and availability. Stakeholder outreach should begin in the scoping process and will remain an important on-going effort during the study. Commitments should be made by the stakeholders regarding the data that they will provide for performance evaluation and model development at the later stages in creating the

corridor management plan. The goal at this point is to determine who should be involved, discussing their needs as well as the resources that they could devote to a corridor study.

At the scoping stage, data inventory and availability should also be determined. This is likely to include identifying required data, an assessment of the quality of data available, current and previous data processing and collection capabilities, in addition to a review of previous and similar studies. Data collection capabilities can vary based on scope and funding of the study. Collecting new data can be costly, but may be necessary to analyze the network at the level of detail needed for the corridor. Previous studies are valuable resources worth investigating, as they may have data sets that are available for use. More importantly, looking into previous studies can offer insight into what successes or difficulties were encountered and assist in the alignment of the study scope in order to address the issues found in previous work. Similarly, validation and calibration levels should be discussed and agreed upon by the stakeholder group.

Policy and regulatory settings in which the corridor study is taking place should also be considered from the beginning of the scoping process. Applicable planning goals and objectives, relevant policies, and ITS architectures should all be explored in detail. There are a number of planning documents, which will be useful in identifying applicable goals and policies, as well as potential stakeholders. For instance:

- A Regional Transportation Plan (sometimes called a Metropolitan Transportation Plan) is required by state and federal regulations to set a region's long term transportation goals and objectives
- County level transportation plans are often produced to feed into the Regional Transportation Plan
- Short-range transit plans are prepared by transit agencies to identify desired transit projects and services within their service areas
- Regional ITS Architectures play an important role in decision making for regional-level ITS planning activities, and like Regional Transportation Plans are required by federal regulation (6).

These goals and policies may be prioritized by the stakeholder groups and used to help develop performance measures or weightings to help inform project recommendations. These priorities are likely to vary between corridors; examples of corridor priorities include improving mobility, reliability, safety, accessibility, and many more depending on the needs of the corridor as determined by the stakeholders.

The scope should be reviewed to ensure it fits the criteria of a corridor management study. From the scoping process, it may be determined that other study approaches, such as a safety analysis or a single-issue project study, may be more appropriate than a comprehensive corridor study. Generally, a corridor management plan is appropriate when the identified problems within the corridor require analysis of a broad range of strategies over time to find lasting solutions. At this point, the internal corridor scoping ends and the corridor management plan development begins.

### **3.2 Stakeholder Involvement**

Stakeholder involvement must build from the initial stakeholder outreach completed in prior sections of the process. Commitment from the stakeholders should now be actively coordinated in order to define the role of each stakeholder participating in the study. Institutions, agencies, and organizations that are active in regional collaboration and coordination are likely to be valuable stakeholders, depending on factors like the scope of need, the range of responsibility, desired outcomes, and availability of resources by collaborating agencies and organizations. Together, the stakeholders will address problems and opportunities of local, regional and interregional significance that demand improved information sharing, effective communications, integrated systems, and efficient use of resources.

Study committees should be organized at this point in the process in order to provide guidance on policy issues and technical issues. There should be at least two committees formed; one whose members are high-level decision makers among the stakeholder groups and focus on the study's policy issues and a second to address technical issues made up of technical experts from the stakeholder group's staff. The stakeholders should have already come to agreement on problem identification, data collection plans and levels, analysis method to be used, calibration levels, validation acceptability, and evaluation scenarios. One of the important purposes for

stakeholder involvement here is to get the commitment from stakeholders to provide corridor related data. These committees should be working with and building from the guidelines established earlier in the process.

### **3.3 Corridor Selection**

While the study sponsor and stakeholder group have a general idea of the target network to be studied, the study team must now specifically define the study corridor in an official Scope of Work. Stakeholder groups may develop criteria to assist in selecting specific corridor to be studied. The corridor selected should be linked with identified issues and planning objectives of local, regional, state, and federal planning documents, as well as other priorities identified by the stakeholder team.

One crucial step of this process is to determine the arterial coverage, which reflects tradeoffs between stakeholder needs and resource constraints of the project. Some stakeholders, especially the local transportation management agencies, may prefer to have a wider arterial coverage so that more improvement strategies might be evaluated and tested. However, the ramifications in terms of costs, schedule, and ability to properly calibrate the full corridor model can be dramatic. For example, adding one major arterial into the I-880 corridor added more than 30 intersections. As a result, additional data collection was required at a significant cost. Calibrating a larger model is also extremely challenging; these issues should all be considered in the corridor selection process.

### **3.4 Determine Analysis Model**

Transportation planners, operations engineers, and design staff often have different analysis requirements. For instance:

- Planning: Includes short- or long-range studies that input into State, regional, or local transportation plans
- Design: Includes approved and funded projects that are going through analysis of the alternatives or preliminary design to determine the best option for implementation.

- Operations/Construction: Studies performed to determine the best approach for optimizing or evaluating existing systems.

In a CMP, however, the above requirements need to be integrated to best address the corridor level needs. Choosing an appropriate analysis method can therefore be a complex task. The fact that there are many different methods and techniques, from simple sketch planning to complex microsimulations, makes it difficult to choose the most appropriate one for the corridor in question.

The FHWA developed a Traffic Analysis Toolbox to assist in the selection of an analysis method (8). The factors that FHWA considers are study area and geographic scope, facility type, travel mode, management strategy and applications, traveler response, performance measures, and cost effectiveness of the tool. In simple terms, methods of corridor analysis can be broken into three categories: 1) hand calculations and sketch planning tools (such as Highway Capacity Manual methodologies, and travel demand models), 2) traffic simulation tools, and 3) integrated or hybrid solutions.

Hand calculations and other straightforward methods typically have low costs and generally do not require specialized software or expertise. One example of such calculations used for planning and operations are queuing diagrams, which given arrival and departure rates, can be useful in determining the delay and number of vehicles in the queue of a bottleneck. In addition, FHWA provides a series of simple analysis tools that uses information developed through the travel demand modeling process to estimate the value of mobility and safety benefits of transportation improvements (9)

Simulation tools can be macroscopic, meso-level, or microscopic, with each type providing trade-offs in terms of geographic coverage and level of detail needed for the network, as well as the level of detail needed in the output data for practitioners to analyze performance measures. There are many effective simulation tools on the market. But training to use these tools effectively can be expensive and requires a high level of technical expertise. For example, consultant support is often necessary when microsimulation is needed to achieve the level of detail needed to meet study requirements. Microsimulations commonly require large amounts of

data; it should be determined early in the study the feasibility of gathering the level and amount of data needed for this type of analysis.

Integrated solutions are another option as a method of analysis for a corridor study. For example, micro-simulation can be used in an integrated manner with meso-simulation and travel demand models to dynamically estimate origin-destination (OD) tables. This may be an efficient way to balance the detail of micro-simulation at bottleneck locations with the efficiency of meso-simulation at the corridor level. For instance, the I-880 study used DynaSmart (*10*) for the dynamic OD estimation for a regional model, which was input as a seed matrix to the OD estimation of the micro-simulation model (*11*).

#### **4. Corridor Data Collection and Performance Evaluation**

Performance evaluation of a corridor is a key component of CMP. Corridor system management strategies and the resulting CMP are unobtainable without a clear understanding how the corridor is performing and why it is performing that way. Depending on the method of analysis chosen to examine the corridor, arrangements or agreements to provide the needed detection should be set in place. If the stakeholders determine that additional detection should be deployed, then operations and maintenance agreements should be drafted and agreed upon, as well as other measures put in place to ensure that the agreed data needs are met. Comprehensive data collection can then be performed, followed by a comprehensive corridor performance evaluation to identify bottlenecks and causality relationships.

##### **4.1 Preliminary Data Collection and Performance Evaluation**

Preliminary performance evaluation uses general measures to assess a corridor's performance. Examples of typical performance measurements for highways and mass transportation for corridor performance evaluation, and its associated data needs, are summarized in the Table 1.

Preliminary performance evaluation includes base performance measurements related to current or recent conditions, and may include forecasts of future performance derived from model projections. The evaluation relies on data that is currently available or can be obtained from existing model projections. Performance data for urban freeway corridors is often easier to

collect than other elements of the transportation network, especially if a robust detection network is already in place. For example, for the I-880 study, traffic data are obtained mainly from PeMS (Freeway Performance Measurement System) (12), and other dedicated sources, including the California Highway Patrol (CHP) (13) and Caltrans' Traffic Accident Surveillance and Analysis System (TASAS) (14) for data on incidents. Another important data provider is stakeholders. For example, cities or counties within the studied corridor have detailed signal timing and corridor description data that are crucial to both performance evaluation and model development. Therefore, one of the important purposes for stakeholder involvement in Section 3.2 is to get the commitment from stakeholders to provide corridor related data. Regardless of the complexity of the study, a Data Collection Plan is useful in organizing and coordinating the necessary data collection activities. This plan must be realistic and comprehensive; it should include data for all modes and routes being considered, including arterials and potentially problematic data.

The results of the preliminary performance evaluation are metrics describing how the system performs. The evaluation could be for current situation or future conditions by using data from simulation modeling. As an example, Table 2 shows the delays of the I-880 corridor from 2003 – 2005 for both directions. This data shows a general increase of delays for the entire corridor. This preliminary look at the corridor can guide stakeholders into the next steps of the study and help determine what additional data needs to be collected and which performance measures to focus on.

## **4.2 Comprehensive Data Collection and Performance Evaluation**

Comprehensive performance evaluation is the foundation for implementing the system management philosophy, which is a vital component of these corridor management plans. The comprehensive performance evaluation contains three major components: 1) compute and evaluate corridor-wide performance and trends, 2) identify key bottlenecks, and 3) understand the relative contributions of each bottleneck to overall corridor performance. These three steps enabled the team to get an accurate picture of the corridor's performance based on these measures.

For comprehensive performance evaluation, data collection is a more complex issue. One needs to investigate data from multiple days, or even months or years, to reveal the trend of the system performances. Again, for this purpose, existing data archiving systems like PeMS would be very helpful. The data resolution in Table 1 also applies to comprehensive performance evaluation. With any additional necessary data collected, a comprehensive performance evaluation can be conducted to meet the study requirements. Elements missing from the preliminary evaluation are now complete. Current performance along the corridor, including highways, major arterials, and transit, should be documented in this evaluation. As one example, this paper will illustrate in this section how the bottleneck analysis should be conducted.

Bottleneck analysis is done through the use of speed-contour or occupancy-contour mapping of the corridor as shown in (6). To further improve the reliability of the analysis, mainly to reduce day-to-day variations and extreme cases, data from multiple days can be analyzed and the median values may be used for the bottleneck analysis. In his report on I-880, Ban used 20 typical week-days, from Tuesday to Thursday, in analysis to represent a “normal” commute. This was done so that recurrent bottlenecks can be properly captured, while the non-recurrent bottlenecks get smoothed out and disappear in the median speed-contour maps. Figure 3 depicts the speed contour map for the NB of the I-880 corridor during AM peak hours. The vertical axis shows the absolute post-mile (PM) of the corridor. It clearly shows that there are two major bottlenecks for the NB of the corridor during AM peak hours. The cross street locations are labeled in the figure. It is easy to find not only the locations, but also the temporal and spatial extents (i.e., queue durations and lengths) from the speed-contour maps. For example, the bottleneck at Tennyson St activates from 6:45 AM – 9:15 AM and the queue may propagate back to Whipple St for almost 3 miles. It is shown in Figure 3 that there is a less severe bottleneck at 98<sup>th</sup> Ave that nearly fuses with the bottleneck at 23<sup>rd</sup> Ave.

### **4.3 Causality Analysis**

Causality analysis aims to discover the exact reasons why a bottleneck exists at certain location, based on which informed decisions can be made on development of improvement alternatives. There are many ways to identify causality from field observations and professional judgment to systematic analysis. Field observations and professional judgment require people to be in the

field, especially during peak hours, to observe and record the flow, delays and queues. Then, based on these observations, some judgment can be made and cause and effect relationships identified. However, the problem of pure expert judgment is that typically one can only obtain limited data and thus information regarding what is actually going on in the field may be skewed or biased. Therefore, a more systematic analysis based on comprehensive performance evaluation in Section 4.2, especially the bottleneck analysis, is proven to be more effective.

The Tennyson Street bottleneck shown in Figure 4 offers an example of how field investigations can be conducted along a corridor for a CMP (11). Through field observation and analysis of PeMS data, investigator suggested that this bottleneck is mainly due to merging vehicles from on-ramps. As identified in Figure 4, there are in fact two side-by-side on-ramps at this location, both of which have high volumes. Adding to the complexity of this location, there is a short on-ramp merge taper that allows for possible platoons to occur at the merge; all these factors contribute to the heavy congestion at this particular location. Causes for other bottleneck locations can be identified in similar ways. Hence, the recommended causality analysis method in this paper is a combination of the comprehensive performance evaluation and field observations.

## **5. Analysis Model Development**

Several types of models are needed for CMP. First, regional travel demand models provide a basis for other types of analysis models, especially for OD matrix estimation. The development of travel demand models is not the focus of the CMP methodology because these models have most likely been developed by regional transportation planning agencies. Other types of analysis models required by CMP may be grouped into a base year model and several future year models that depict short term and mid-term forecasts respectively. The base year model should be built to reflect current conditions and are used to evaluate current and near-term improvement scenarios. Future year models should be built under the assumptions of the dedicated funding indicated in approved planning documents such as the Regional Transportation Plan, and/or other planning and programming documents agreed upon by the stakeholders. The goal of the mid-term models is to assess future improvement strategies. Forecasts and models for a corridor beyond 10 years should be approached with caution because of the difficulty in validating and

calibrating the models, but also in terms of value or usefulness of the results of the model. Section 5.2 offers additional discussion on making assumptions in the development of future year models.

## **5.1 Development of the Base Year Model**

Any model used must be calibrated and validated to show that they are an accurate representation of the actual traffic situation. This is a relatively straightforward task for base year models primarily because observed data, such as flow, travel times, queue lengths, etc, are usually available from current detection along the corridor. The CMP demonstration studies showed that actually developing the base model may be very time and resource consuming depending on the corridor's features. Also, the performance evaluation provides important inputs, like bottleneck analysis results, to use to calibrate the base year model. For example, if micro-simulation is adopted as the analysis model for CMP, three issues are of especially important: data collection, dynamic OD estimation, and bottleneck calibration. Data collection contributes directly to model development and it is critical not to underestimate the level of details needed in planning the data collection efforts. A comprehensive data collection plan should be developed in the early stages of a CMP study. All parties, including simulation modelers, should be involved in developing the plan. Modelers should certify that the plan is adequate for proper calibration since it has been shown that any change to the plan may be both time and resource expensive.

One of the other key challenges in the calibration and validation of a micro-simulation is handling the OD matrix. Usually, static OD is available for traditional travel demand models. However, dynamic OD matrices are usually required by micro-simulations. Dynamic OD needs to be estimated from static planning OD data, such as traffic flow, counts, and turning volume data. This requires data with a finer level of detail, e.g., 5 or 15-minute link volume data is usually needed for entire peak periods in order to produce an acceptable dynamic OD matrix. Our CMP studies particularly utilized meso-simulation models (DynaSmart) to conduct initial OD estimation, which was fed as a seed matrix to more detailed dynamic OD estimation in micro-simulation. More details can be found in (11).

Calibration of micro-simulation can be done by following the FHWA micro-simulation guidelines (15). Current FHWA guidance is mainly based on two criteria: volume and travel times. However, our CMP experience showed that it is even more important to calibrate bottleneck locations and their spatial and temporal extents (i.e., queue length and duration incurred by the bottleneck). After all, the primary reason to develop a micro-simulation model for a corridor is to evaluate alternative investments and their ability to eliminate existing bottlenecks or at least reduce their severity. Some methods for corridor-level bottleneck identification and calibration were reported by the authors (6).

## **5.2 Development of Future Year Models**

Future year models are developed based on the base year model according to the following assumption: the calibrated parameters, like gap acceptance, lane changing and car following, of the base year model remain unchanged in future year models. For this reason, it a future year horizon within 10 years is recommend because otherwise the assumption may change significantly over longer periods. As a result, no calibration is needed for developing the future year models. It is impossible to conduct this calibration with no future year observed data available.

Future year models can be further constructed via three steps: coding the improvement strategies, dynamic OD projection, and traffic signal re-optimization. First, the improvement strategies can be coded by either modifying the geometrics of the network, such as adding one auxiliary lane, or changing the network control, like using more aggressive ramp metering, or both.

Second, the projection of future OD matrixes may be quite challenging. The starting point is the planning OD matrixes of the base year and future year from travel demand models. “Growth factor” can then be calculated from the two matrices, which can then be applied to the base year OD matrix to generate future year ODs. However, our CMP experience showed that this method may generate extremely high OD demands for some OD pairs of the network, which creates unrealistic traffic congestion in future year models. The reason is that with demand increases in the future year, it is expected that in reality the peak period should also be expanded. Therefore,

the simple “growth factor” method can not capture this “peak spreading” phenomena. Detailed procedures for conducting peak spreading to estimate future year ODs can be found in (16).

Third, under the projected future year OD, the traffic signal timing may need to be changed to accommodate the OD changes from the base year to future year. This can be done via re-optimizing the traffic signal timing plans. This re-optimization may also need to be done for other traffic control devices that are sensitive to OD demands, such as ramp metering control. Issues in this regard will be explored in the future.

## **6. Improvement Scenario Evaluation and Recommendations**

Alternative investment scenarios are built upon the outputs of the performance assessment, causality of current problems as well as expected future performance of planned/programmed improvements. These inputs are used to develop and evaluate multiple improvement scenarios whose resulting performance measures will be developed into recommendations for action.

### **6.1 Scenario Development and Evaluation**

Development of improvement scenarios is based on sufficient data collection and performance evaluation as discussed previously. Future performance, bottlenecks, and potential improvements should all be considered to develop corridor improvement scenarios. Then, the scenario performance should be evaluated and additional refinements made until the study team is confident in making recommendations made based on the scenarios considered.

Therefore, developing and examining different scenarios will be an iterative process, regardless of the analysis method chosen. Stakeholder input and acceptance of the scenarios being tested are important to ensure that all desired scenarios have been discussed and consensus achieved on a finite set.

A variety of strategies can be tested depending on the analysis method chosen. In the I-880 study, for example, system management strategies and operational improvements were the basis of each scenario. Examples include an aggressive ramp metering with queue control scenario, an operational improvement scenario with lane additions, and scenarios with combinations of

investment options. Micro simulation will allow for more detailed evaluation of ITS-related strategies as well as more with more traditional capital and operational improvements.

Table 3 displays examples of the detailed improvement scenarios initially defined for the I-880 CMP. These scenarios were created for both the base year and future year's scenarios. These scenarios considered both direct and indirect programming, as well as ramp metering strategies, queue control, operational improvements, and other stakeholder recommendations. In this table, "programmed" changes are those which already have a dedicated funding source. "Planned" changes are those which have been approved by either the stakeholder group as part of the vision for the corridor, or part of current planning documents. Our experience has shown that projecting future-state micro-simulation models beyond 10 years in the future is problematic. If scenario testing at 20 or 30 year is desired, then it is best to use a tool other than microsimulation such as travel demand models or macro-level simulations. The dangers of long-term scenario testing lie within the unpredictability of the dynamic OD tables and the difficulties of calibrating the microsimulation models with this data.

The selected base and future year scenarios will be evaluated using the base and future year models respectively. The results of the tested scenarios, using the selected evaluation method, should be consistent with performance metrics employed for initial corridor performance assessment in order to compare the impacts on the corridor. The evaluation results of these before and after studies will enable a detailed benefit-cost analysis to select the most promising improvement strategies.

## **6.2 Recommended Improvement Scenarios**

This portion of the process should be dedicated to pulling together what has been learned from the study. Specific improvements should be prioritized based on ranked choice or weightings based on corridor objectives linked to performance measures. Recommended strategies and investments should at least be organized into short-term vs. long-term deliverables. The strategies and investments should be prioritized based on the performance measures determined by the stakeholder group earlier in the process. Considerations should go beyond the quantitative cost-benefit analysis in the strategy and investment recommendations, such as mobility,

reliability, and safety, to consider qualitative factors like closing system gaps, improving freight mobility, or addressing community and/or environmental issues.

The recommended strategies should be presented to decision makers for approval. This approval process can be conducted in a number of ways, such as the endorsement of the study's Policy Advisory Committee, or an action of the sponsoring agency's governing board. High-level review of the strategies as well as stakeholder acceptance of the strategies will occur at this step.

The implementation of this methodology for corridor management studies allows for more detailed scenario testing than previously used by Caltrans. These processes have been implemented with positive results; the scenario testing of the simulations has been validated through field testing. This proves the value of corridor management and promotes its use to evaluate other scenarios or strategies along the same corridor or other corridors. This methodology was used to validate the recommended scenarios of the I-880 study. It can be used in general, to prove a project's creditability and to make certain decision makers are making informed decisions on project for the greatest overall benefit.

With the appropriate approvals, an action plan can be created to carry out the recommendations of the corridor management study. An additional component following the CMP is the development of a before/after study, to be conducted after the initial improvements are delivered. The "before" study should be the performance assessment already conducted, the "after" study checks to see if near- or long-term improvements deliver the expected benefits. Results in this regard will be reported in future papers/reports.

## **7. Conclusions**

In this paper, a methodology for conducting corridor management planning that aims to evaluate short- and long-term improvement strategies to mitigate corridor-wide mobility problems has been presented. Four key components of such a methodology have been shown: project scoping and stakeholder involvement, performance evaluation, analysis model development, and improvement scenario evaluation and recommendation. It has also been illustrated, using examples from three CMP studies recently conducted, how detailed operational analysis, like bottleneck analysis and micro-simulation, can be integrated into the planning process.

The concept of a CMP, by its nature of integrating both planning and operational analyses, is still evolving. Many explorations are currently being conducted by both researchers and practitioners. This proposed methodology, together with the recent experience of conducting the three CMP studies in California, could shed some lights on how the goal of CMP may be achieved.

## **Acknowledgement**

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**Table 1 Typical Performance Measures for Corridor Evaluation**

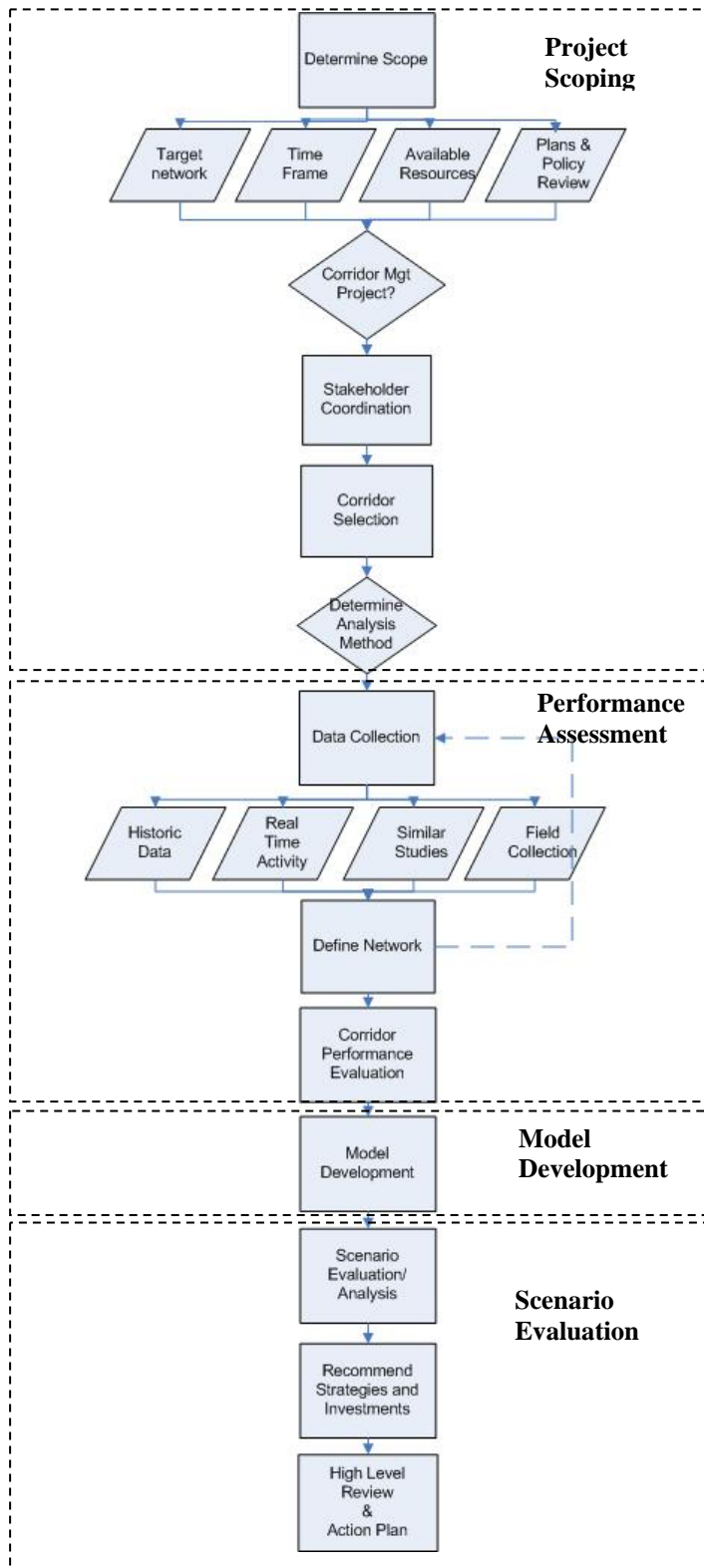
<b>Measurements</b>	<b>Data Needs</b>	<b>Level of Detail</b>
Bottleneck Analysis, Vehicle Miles Traveled, Delay, Speed, Productivity,	Volume, Occupancy, Speeds	5- or 15-minute
Safety	Incident/Accident reports	Per Incident/Accident
Travel time Reliability	Travel time	15 or 30-minute interval
Truck VMT	Truck Volume	15 or 30-minute interval
Level of Service	Speeds	15 or 30-minute interval or by Cycle
Mean time Between Failures (Transit)	Maintenance Data	Hour Intervals
Passenger Average Travel Time (Transit)	Volume, Boardings, Speeds	Per Trip

**Table 2 Delays of the I-880 Corridor**

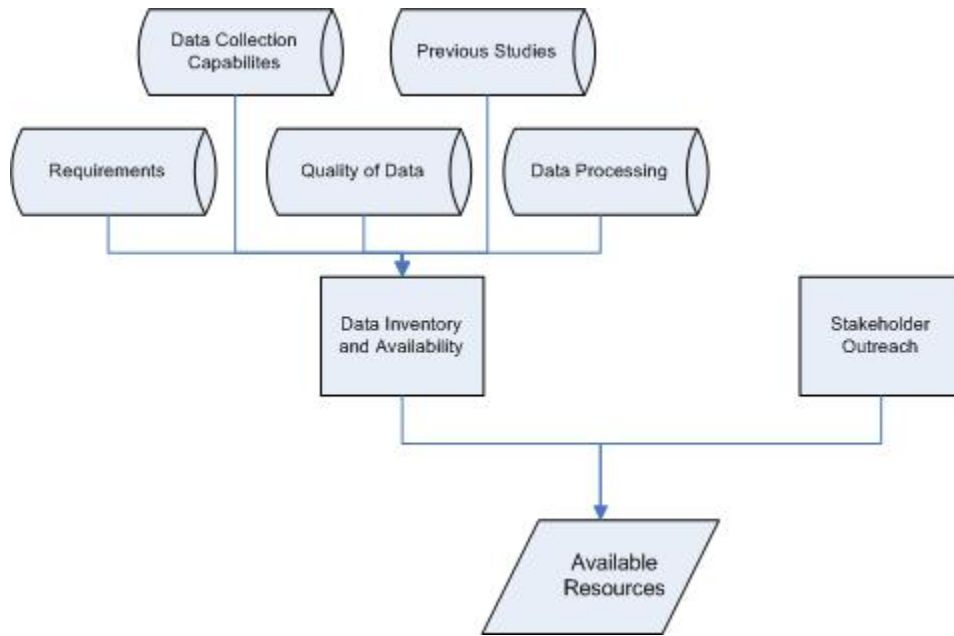
<b>Northbound Direction</b>						
Year	AM Peak	Mid Day	Evening and Early AM	PM Peak	Total Daily	
2003	1,499	1,237	552	2,547	5,835	
2004	1,124	1,067	360	2,317	4,867	
2005	1,331	1,434	285	2,351	5,402	
<b>Southbound Direction</b>						
Year	AM Peak	Mid Day	Evening and Early AM	PM Peak	Total Daily	
2003	1,924	1,397	276	2,249	5,846	
2004	1,728	1,796	291	2,677	6,491	
2005	1,678	2,196	232	2,885	6,991	

**Table 3 Overview of Simulation Scenarios**

<b>Scenario</b>	<b>Traffic Vol Year</b>	<b>Scenario Number</b>	<b>Network Enhancements</b>
Baseline Current State	Current	A0	Original calibrated network
TMS	Current	A1	TMS components including traveler information, detection, and incident mgmt.
Operational Improvements	Current	A2	Operational improvements that can be implemented within 3 years.
Aggressive RM with QC	Current	A3	Current metering algorithm with aggressive rates and queue control.
Best Short Term	Current	A4	Aggressive metering with queue control + operational improvements.
Baseline Future State	Future	B0	Aggressive metering with queue control + operational improvements with Future traffic.
Programmed Direct	Future	B1	Baseline Future + programmed projects in problem areas (direct).
+ Planned Direct	Future	B3	Baseline Future + all programmed projects + planned projects in problem areas (direct).
Caltrans Recommended	Future	B3-1	Baseline Future + all programmed projects + planned projects in problem areas (direct) + Caltrans recommended projects.
Corridor Adaptive RM with QC	Future	B3-2	Baseline Future + all programmed projects + planned projects in problem areas (direct) + corridor adaptive metering with queue control.



**Figure 1 Methodology Overview**



**Figure 2 Available Resources for Corridor Study**

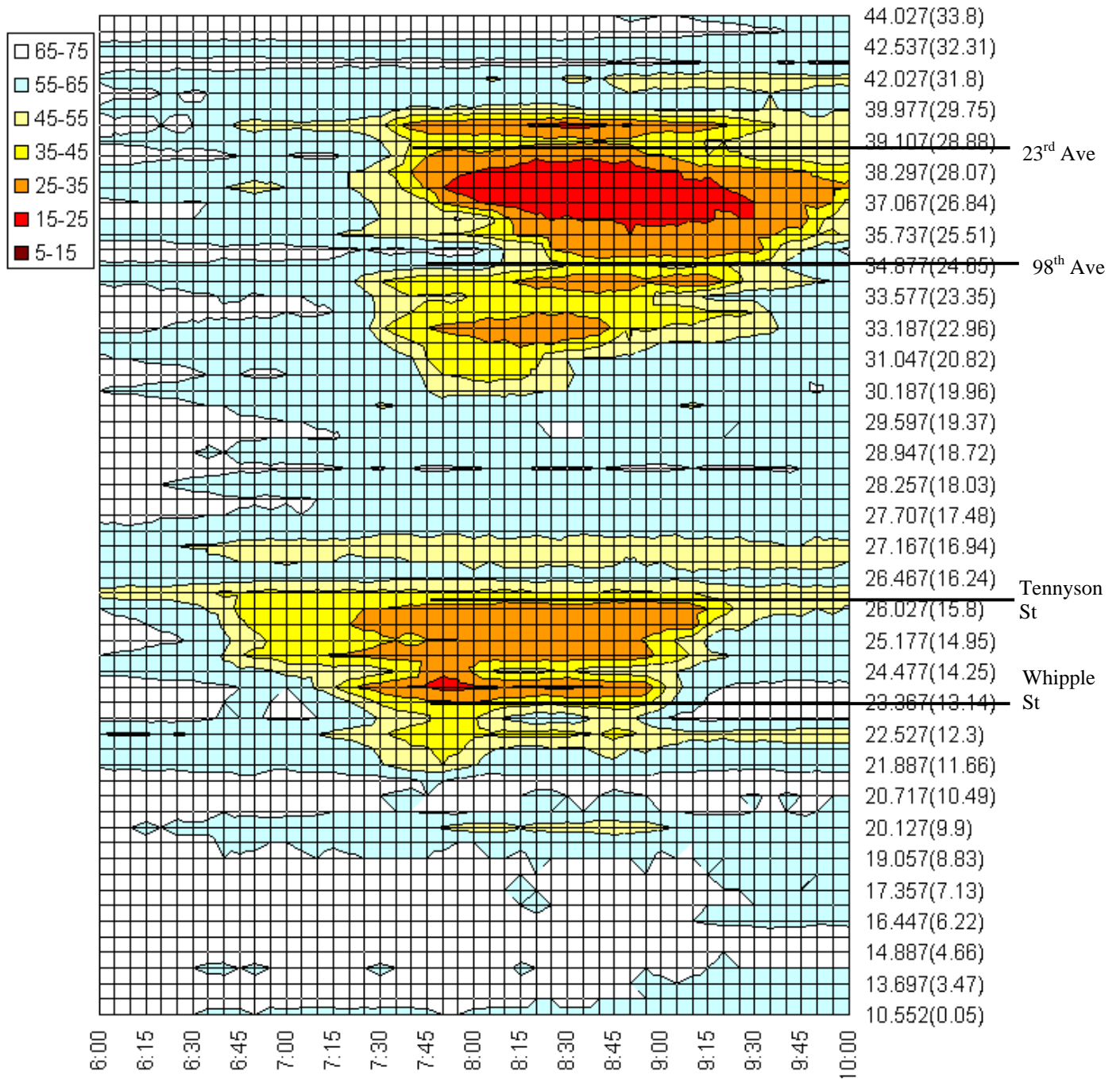
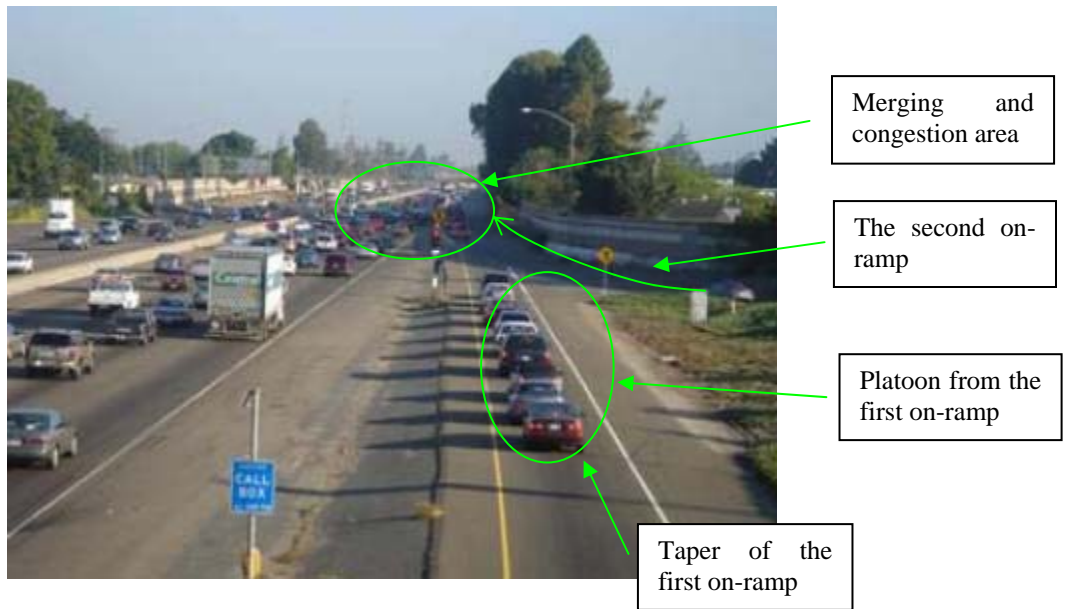


Figure 3 Speed Contour Map of the I-880 NB (AM)



**Figure 4 Tennyson Merging Bottleneck**