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Data for Transportation Modeling in the Santa Monica Corridor

Joy Dahlgren

**California PATH Working Paper
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Report for MOU 269

February 1998

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**DATA FOR TRANSPORTATION MODELING IN
THE SANTA MONICA CORRIDOR**

Final Report

A Study Conducted Under MOU 269
In Support of MOU 270

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February 8, 1998

ABSTRACT

The City of Los Angeles and Caltrans would like a simulation testbed for testing alternate traffic management strategies in the Santa Monica corridor. This study assesses the data available for such a simulation and describes data needs, potential sources, and data preparation required. It presents a work plan and resource requirements for acquiring the necessary data. The Appendix analyzes the conditions under which a simulation testbed is worthwhile.

This study supported another PATH project, *Los Angeles Smart Corridor Simulation Feasibility Study* (MOU 270), which analyzed candidate models for the simulation and determined their data requirements.

Key words: Data, transportation modeling, traffic simulation, Santa Monica Corridor, Smart Corridor

Executive Summary

The City of Los Angeles, Caltrans, and others have seen the value of establishing a simulation testbed in the Santa Monica corridor to test alternative traffic management strategies before they are implemented in the corridor. However, such an effort is worthwhile only if a suitable model can be found and if data for the model can be generated at a reasonable cost.

Candidate models were identified and evaluated under MOU 270, *Los Angeles Smart Corridor Simulation Feasibility Study*. This project evaluated the availability and quality of the data required by the candidate models and identified additional data needs, sources, and resources required.

Two previous attempts to model the corridor were abandoned because they could not provide the desired level of accuracy. However, in the process, a large body of data was accumulated. Data describing the network and the freeway and street characteristics can be reused because the corridor has not changed physically. Ramp metering rates and arterial signal timing plans and turning may have changed, and in any case should be expanded to include the entire congested period. Turning and parking restrictions must also be checked, updated if necessary, and expanded to cover the entire congested period. A critical feature that must be incorporated into any model is the ramp meter queue override logic. The on-ramps have loop detectors that detect when the queue is getting too long and trigger an automatically increase in the metering rate.

Data related to the use of the facilities, such as volumes, turning movements, delay at intersections, travel times, incidents, and trip origins and destinations should be updated and should also cover the entire congested period. Volumes, incidents, and delay at intersections are routinely collected, though not archived. Turning movements, travel times, and origin-destination data require special data gathering. The costs of updating and gathering data are estimated to exceed \$100,000.

The value of establishing a testbed is explored in the Appendix. Simulation is valuable if it results in implementation of worthwhile projects that would not have been implemented without being demonstrated in the testbed or if it prevents implementation of poor projects that would have been implemented without the simulation. In either case, the value of the test bed depends on how accurately it predicts the actual outcome and how much it costs to develop and use.

DATA FOR TRANSPORTATION MODELING IN THE SANTA MONICA CORRIDOR

Final Report

Introduction

Both Caltrans and the city of Los Angeles have been interested in establishing a simulation testbed for evaluating and optimizing alternative traffic management strategies before they are tested or implemented in the Santa Monica corridor (Figure 1). The feasibility and cost-effectiveness of establishing such a testbed depends on the availability of a suitable simulation model and sufficient accurate data on which to base the simulation. This report describes the data currently available and notes unmet data needs and potential methods of meeting them. The first section contains an assessment of the data needed and currently available. The second section contains a work plan for acquiring the necessary data along with estimated costs for data collection. There is also an appendix containing a decision analysis regarding the value of the simulation testbed, which shows the circumstances under which simulation is worthwhile.

Assessment of Data

Data from the Previous Simulation

Some of the data for simulating the Santa Monica corridor have already been assembled for a simulation attempted by the Los Angeles Department of Transportation (LADOT) in 1996 using the CORFLO model developed for the Federal Highway Administration (FHWA). That attempt was abandoned when repeated re-calibration failed to yield the required level of accuracy. The following data have been collected and formatted as input to CORFLO:

- ❑ urban link characteristics
- ❑ freeway link characteristics
- ❑ urban street turning movements
- ❑ freeway turn movements (apply to traffic exiting each section)
- ❑ signal control
- ❑ entry link volumes
- ❑ source/sink volumes
- ❑ node coordinates for graphics

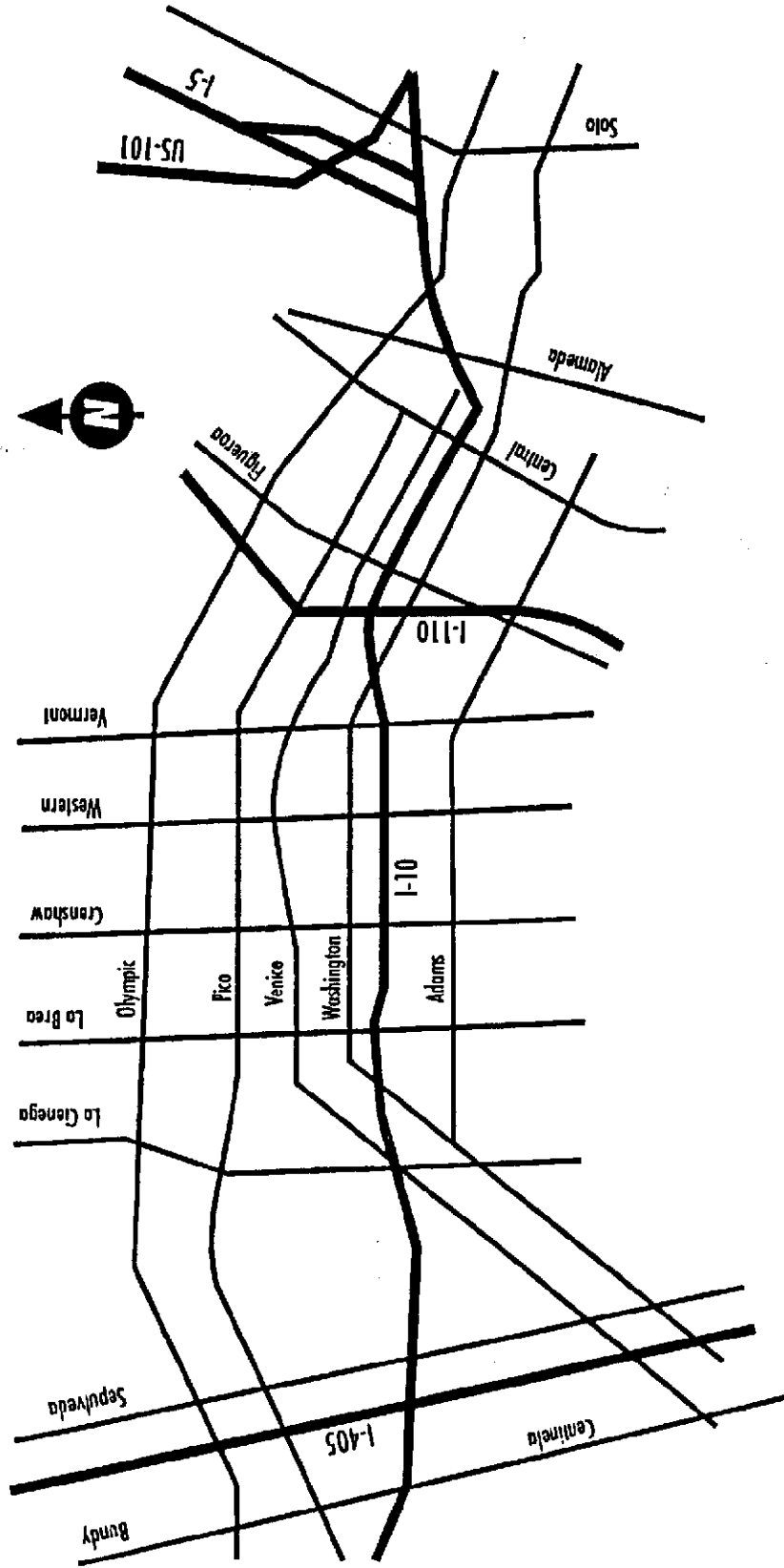


Figure 1: Smart Corridor Region

A new simulation effort could use the same supply data—road and street characteristics. However, the previous simulation covered only the PM peak period, so new signal timing, turning movement, and volume data would be needed. Furthermore, signal timing, turning movements and volumes in the PM period may have changed since the previous simulation and should be checked and updated if necessary.

Data Needs and Availability

Table 1 summarizes the data requirements for simulation models and the data available. The data expected to be required for whatever model is selected are shown on the left; the availability and other relevant characteristics are shown to the right. The Source column indicates the agency and contact person. The Source Document Number refers to the number written on the sample data collected by PATH. The availability of each data item is discussed in greater detail below.

Freeway Mainline Segment Lengths and Number of Lanes

These have already been coded for the previous simulation.

Effort required: Check for changes and modify if necessary. Few changes expected.

Ramp Lengths and Number of Lanes

These have already been coded for the previous simulation.

Effort required: Check for changes and modify if necessary. Few changes expected.

Ramp Metering Rates

PM peak period rates have already been coded for the previous simulation. AM and midday metering rates are still needed.

Effort required: Check for changes in PM rates and modify if necessary. Some changes expected. Gather AM and midday rates for approximately 25 on-ramps.

Ramp Meter Queue Overrides

An override occurs when the queue waiting to enter the freeway backs up into the city streets. Therefore, although it is a control strategy, its use is dependent on demand.

There are automatically controlled queue overrides on all freeway on-ramps, more than 25 on freeway and connector roads in the portion of the corridor to be modeled. When a queue backs up to the first queue-sensing loop, the metering rate is increased. When the queue backs up the

Table 1

DATA FOR MODELING THE SANTA MONICA CORRIDOR

Data Item	Complete Over Space	Complete Over Time	Quality	Ease of Access	Ease of Use	Knowledge of Provider	Cooperation Interest	Current?	Source	Source Document Number
Supply										
Freeway mainline segment length and lanes	yes	na	good	in hand	easy	good	good	yes	Caltrans/Kalbasi	1
Ramp lengths and number of lanes	on ramps only	na	good	in hand	fair	good	fair	1994	LADOT/KAKU	2
Ramp metering rates	yes	yes	good	good	easy	good	good	yes	Caltrans/ Abaza	3
Records of meter rate overrides	not available									
Arterial lengths	yes	na	good	in hand	easy	good	good	1994	LADOT/KAKU	
Arterial number of lanes midblock	yes	na	good	in hand	easy	good	fair	1994	LADOT/KAKU	2
Arterial lanes at intersection	yes	na	good	good	easy	good	good	yes	LADOT/Gallagher	
Arterial lane turning restrictions	yes	na	good	good	easy	good	good	yes	LADOT/Gallagher	
Parking restrictions	yes	yes	good	in hand	easy	good	good	1994	LADOT/KAKU	2
Signal timing plans	yes	yes	good	good	difficult	good	good	yes	LADOT/Tvedten	4
Demand										
Freeway mainline volumes	yes	yes	75% of loops OK	fair	fair	good	good	yes	Caltrans/Kalbasi	5
Freeway ramp volumes	yes	yes	unknown	fair	fair	good	good	yes	Caltrans/Kalbasi	
Freeway travel times	not available									
Freeway incidents	yes	yes	good	fair	difficult	good	good	yes	CHP/Diebold	
Arterial volumes	major arterial	15 min, all day	good	fair	difficult	good	good	yes	LADOT/Tvedten	
Arterial turning movements	major intersections	peak hour only	fair	in hand	difficult	good	good	1988-96	LADOT/Tvedten	6
Arterial travel times	yes	4:30-6:30	good	good	easy	good	good	1995	LADOT/Tvedten	7
Delay at intersection approaches	yes	yes	good	difficult	difficult	good	good	yes	LADOT/Gallagher	
Arterial incidents	yes	yes	good	difficult	difficult	good	good	yes	LADOT/Tvedten	
Origin-destination data	census tracts	yes	fair	fair	fair	fair	good	1991	SCAG/Minjares	

Sources:

1. Caltrans schematic of freeway and ramps labeled 07-LA-10-R6.00/14.0 from Kalbesi at Caltrans
2. *Smart Corridor Operations Planning Element, Issue Paper on Existing Traffic Conditions, Draft*, March 1994, Prepared by KAKU Associates for JHK & Associates from Tvedten at LADOT
3. Time of Day Table from Caltrans TMC from Abaza at Caltrans
4. Untitles handwritten worksheets from Tvedten at LADOT
5. Smart Corridor Main Line Loop Status from Kalbesi at Caltrans
6. Record Type 21 - Turning Movements and attached data printouts from Tvedten at LADOT
7. Actual Travel times used in calibration runs

second queue-sensing loop, the meter turns green until the queue is cleared. This is done automatically and no record is kept of how often it occurs. If this aspect of the ramp metering strategy is not taken into account, the simulation will underestimate the amount of traffic on the freeway and overestimate the traffic on the adjacent arterials. This was, in fact, one of the problems with the CORFLO simulation.

The best way to model the queue override would be to build the queue override logic into the model. This would involve significant programming effort to modify the model and would require gathering data on the vehicle storage capacities downstream from the queue-sensing loop detectors. However, it would realistically model the effects of changes in demand at the ramps. An alternate approach would be to alter the nominal metering rate to account for the queue overrides; the metering rate would be demand dependent. This would require observation of each on-ramp during the congested period to determine the frequency with which overrides occur. The frequency would depend both on the average volume and the variation in volume. Either way, significant effort would be required. However, not making the effort would seriously compromise the results of the simulation.

Effort required: Programming the queue override logic would require determining the vehicle storage capacity downstream from both queue-detecting loops at over 25 on-ramps. Caltrans has the locations of all detectors in an on-line system. (Mohammed Kalbasi can describe how to access these.)

Arterial Lengths

These have already been coded for the previous simulation.

Effort required: Check for changes and modify if necessary. No changes expected.

Arterial Number of Lanes at Mid-block

These have already been coded for the previous simulation.

Effort required: Check for changes and modify if necessary. No changes expected.

Arterial Number of Lanes at Intersections

Diagrams of major intersections are available from Brian Gallagher of the LADOT.

Effort required: Record number of lanes at approximately 4 approaches to approximately 400 intersections.

Arterial Lane Turning Restrictions

PM peak restrictions were collected for the previous simulation.

Effort required: Check for changes in PM peak restrictions, and modify if necessary. Few changes expected. Record AM and midday restrictions at approximately 4 approaches to approximately 400 intersections.

Arterial Parking Restrictions

Restrictions for all times of day were collected for the previous simulation.

Effort required: Check for changes in restrictions and modify if necessary. Few changes expected.

Arterial Signal Timing Plans

Plans for the PM peak restrictions were collected for the previous simulation.

Effort required: Check for changes in PM peak plans, and modify if necessary. Some changes expected. Record AM and midday restrictions on over 100 arterial links.

Freeway Mainline Volumes

Although volume data was collected for the earlier simulation, it is likely that travel patterns have changes because of the Northridge earthquake and cutbacks in the defense industry, rendering this data obsolete. Loop detectors measure every link and lane of the mainline and the connector roads. However, the detectors are not always functioning properly. Caltrans has been monitoring these detectors for the Smart Corridor Project. In January about 75% of the detectors were functioning properly. Getting complete and accurate counts will require additional detector repair and maintenance on Caltrans' part. Because the computer used to store and transmit the data is slow, some of this data that has been sent to PATH for the Freeway Service Patrol project has been corrupted. Caltrans' staff has been investigating better methods for transmitting the data, including purchasing a faster computer, putting the data on a web site, or sending data tapes. The first option is the least expensive (an estimated \$3,000).

Effort required: Monitor mainline loop detectors and repair as required. Improve data transfer method. Aggregate and average volume data for each time period.

Freeway Ramp Volumes

The accuracy of the ramp detectors is not being monitored, so it would be difficult to determine if the counts are accurate. Checking the accuracy of the approximately 80 detectors necessary to determine volumes entering and exiting the freeway and connector roads would require calling up each loop to determine if it is working. The problems with transmitting the data are the same as for the mainline counts.

Effort required: Monitor mainline loop detectors and repair as required. Improve data transfer method. Aggregate and average volume data for each time period.

Freeway Travel Times

There is no freeway travel time information.

Effort required: Measure travel times over the course of the day using at least 3 cars with tachographic instruments. Aggregate and average the volume data for each time period.

Freeway Incidents

The highway patrol has logs from its computer aided dispatch (CAD) system which give date, time of day the call was received, location, the nature of the problem, and the time the CHP left the incident site. Because the logs cover a much wider area than is being studied and include many more things than incident information, extracting the relevant information will be time-consuming.

Effort required: Obtain and decode CAD logs. Record information relevant to incidents on the study section of the Santa Monica freeway.

Arterial Volumes

Because volume data are used for on-going operations of the LADOT, the loop detectors are likely to be providing relatively accurate volumes.

Effort required: Aggregate and average loop data for each time period for over 100 links.

Arterial Turning Movements

Turning movements used in the previous simulation were based on manual counts between 1988 and 1996 and include only the PM peak period. An accurate simulation would require data for the AM and midday as well and more current PM counts.

Effort required: Perform manual counts for at least one day at over 110 intersections. Average counts for each time period.

Arterial Travel Times

Travel times between 4:30 and 6:30 PM were collected in 1995 for use in calibrating the CORFLO model. However, this information may be out of date, and there is no information on travel times at other times of day.

Effort required: Measure travel times over the course of the day on the five east-west arterials and on four north-south arterials for at least one day using cars with tachographic equipment.

Delay at Intersection Approaches

At major intersections there are detectors which give seconds of delay per vehicle in real time, every 30 seconds. The data are not archived.

Effort required: Measurement of intersection delay would require capturing and aggregating the 30 delay information from the detectors at over 100 intersections with approximately 4 approaches each. Estimating travel times from tachographic car runs would probably be more accurate and less costly.

Arterial Incidents

The LADOT is developing an incident detection model and is keeping good records of incidents in order to tune the model. The records are kept for 4 months and include date, time the incident starts, time cleared, location, description of the incident, and action taken.

Effort required: Characterizing the incident data for use in the model.

Origin-destination Data

In 1991, the Southern California Association of Governments conducted an origin-destination survey to gain information for promoting ridesharing. It included 15,000 households in Los Angeles, San Bernardino, and Riverside Counties. People kept one-day diaries of all trips made by members of the households. Origins and destinations are at the census tract level. There are three problems with the use of the results of the study for the Santa Monica corridor. First, travel patterns may have changed since 1991. Second, because of the wide variety of routes available in Los Angeles, it would be difficult to determine which trips were made through the Santa Monica corridor. Finally, the sampling rate may not have been sufficient to provide reliable estimates for a relatively small area, such as the Santa Monica corridor. A similar study

is currently underway, but SCAG staff do not think it would be as useful as the 1991 survey because it is less detailed. The 1991 survey is available from SCAG; Peter Wong of Caltrans also has the survey data.

A license plate surveys typically cost up to \$15 per survey response.

Effort required: Design survey instrument. Arrange for license plan survey. Process results.

Work Plan for Acquiring Data

Most of the supply data has been coded as input for the CORFLO model, but some items will require updating. Additional ramp metering rates and signal timing plans will be required to simulate the AM peak and midday traffic because the previous simulation included only the PM peak hour.

Obtaining demand data will be more difficult and expensive. Caltrans District 7 staff believe that travel patterns and volumes have changed because of the reduction in defense work. Therefore, data from the previous simulation may no longer be accurate. Even if it should prove to be accurate, it covers only the evening peak period, so additional data will be needed for AM peak period and midday. Most data are available. The missing pieces are turning movements for the AM peak period and midday, origin-destination data, and freeway and arterial travel times.

Because traffic may vary from season to season, volume and travel time data should be collected during the same season. This will ensure that it is characteristic for at least that season. If data are gathered from different times of the year, they may not reflect conditions that prevail at any time.

Specific tasks are outlined below.

Check Previously Coded Street and Road Data for Changes

These data were coded for the CORFLO simulation undertaken by the Los Angeles Department of Transportation (LADOT). PATH has a copy of this data on disk and has the CORFLO data format so this data can be interpreted. Physical features of the network have probably changed little, if at all, since the CORFLO simulation. Therefore, the only work required is to:

- Check with the LADOT and Caltrans to see if there have been changes in freeway mainline segment length and lanes, ramp lengths and number of lanes, arterial lengths, arterial number of lanes mid-block

Estimated time required to check and modify data: 2 person-days

Check Previously Coded Operational Data and Add AM Peak and Midday Data

Operations may have changed since the previous data were coded, so operations data must be checked. Furthermore, the previous simulation dealt only with the PM peak period, so data for the AM peak and midday have not been collected or coded. The following work will be required:

- Using LADOT, Culver City, and Beverly Hills data, record parking restrictions on 100+ arterial links.
- Using LADOT diagrams of major intersections and Culver City, and Beverly Hills data, record turning restrictions and number of lanes at intersections for approximately 4 approaches to approximately 400 intersections by time of day.
- Record signal timing plans for these intersections for by time of day.
- Using Caltrans map of the Santa Monica corridor, record metering rates for 30 on-ramps
- Determine queue override logic for each on-ramp

Estimated time required to check and gather AM and midday data: 30 person-days

Obtain New Freeway Mainline and Ramp Volume Data

Volumes are believed to have changed since the last simulations new data should be collected.

- Obtain counts at 30 on-ramps and 30+ mainline freeway segments (check that loop detectors are being monitored and are accurate)
- Aggregate data into required time periods

Estimated time required to gather and aggregate data: 10 person-days

Measure Freeway Travel Times

- Using three cars equipped with tachographic instruments, measure travel times over the course of the day for three days.
- Aggregate data into required time periods.

Estimated time to gather and aggregate data: 9 person-days

Equipment required: 3 cars equipped with tachographic equipment

Gather Freeway Incident Data

- Obtain and decode computer aided dispatch (CAD) logs from the California Highway Patrol
- Record location, time, effect (number of lanes closed), and duration of incidents affecting the Santa Monica Freeway.

Estimated time required to review logs and record information: 20 person-days

Calculate Arterial Volumes

- Using loop detector data from LADOT and other cities, calculate volumes for the required time periods for each arterial section.

Estimated time required to calculate volumes: 20 person-days

Record Arterial Turning Movements

- Manually record turning movements for one day each at 110 intersections.

Estimated time required for counts: 110 person-days

Measure Arterial Travel Times

- Using one car equipped with tachographic instruments, measure travel times over the course of the day for one days on five east-west arterials and four north south arterials in the Santa Monica Corridor.
- Aggregate data into required time periods.

Estimated time to gather and aggregate data: 9 person-days

Equipment required: 3 cars equipped with tachographic equipment

Record Arterial Incident Data

- Using LADOT incident records, note location, time, effect (number of lanes closed), and duration of incidents affecting the five east-west arterials and four north south arterials in the Santa Monica Corridor.

Estimated time to record incidents: 10 person-days

Origin-Destination Data

- Using license plate survey data to identify vehicles traveling in the corridor, mail a survey to owners of these vehicles asking about trips they make in the corridor. Conduct a two-stage sample, the first stage being used to estimate the sample size needed for a valid sample.

Estimated time to design survey instrument: 5 person-days

Estimated time to process results: 60 person-days

Estimated cost for 5000 responses: \$75000

Total Resources Required for Data Collection

Estimated person-days for data collection	285	
Estimated cost of data collection @ \$15/hr with 25% benefits		\$42750
Estimated cost for conducting license plate survey		\$75000
Three cars equipped with tachographic data for 6 days		
Programming services to modify the model to include the queue override logic		

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People Contacted for Information

Jack Smith	Caltrans
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Osama Assaad	Caltrans
Khaled Abasa	Caltrans
Sam Espinoza	Caltrans
Brian Gallagher	Los Angeles Department of Transportation
Sun-sun Tvedten	Los Angeles Department of Transportation
Tom Gaul	KAKU Associates
Lynn Diebold	California Highway Patrol
Sharezad Ameri	Metropolitan Transportation Authority
Hassan Ikhata	Southern California Council of Governments
Javier Minjares	Southern California Council of Governments

Appendix

Decision Analysis Regarding the Value of a Simulation Testbed

Because the calibration and testing of the model, as well as the data collection and preparation, will be quite costly, it is wise to consider the value of such a model. The model can be useful in preventing the implementation of projects that do not have net benefits or, on the other hand, enabling implementation of worthwhile projects that would not be implemented without modeling to demonstrate their benefits. Below is a simple decision analysis that should be useful in deciding whether developing a testbed would be worthwhile.

For simplicity, assume that the Smart Corridor will implement n projects that can be simulated with the same model with the following costs:

- developing the testbed will cost D
- each simulation will cost S

Suppose each project has the following characteristics:

- the present value of the total cost of the project is C
- two outcomes, O_1 and O_2 , have benefits with net present values of $V_1 > C$ and $V_2 < C$
- the simulation will not always correctly predict the outcome—the table below shows the probabilities of correct and incorrect predictions.

Probabilities

Outcome is O_1	Outcome is O_2
p	$1-p$

Simulation shows outcome O_1	Simulation shows outcome O_2
q	$1-q$

Joint Probabilities

	Outcome is O_1	Outcome Is O_2	Outcome is O_1 or O_2
Simulation shows outcome O_1	r	$q-r$	q
Simulation shows outcome O_2	$p-r$	$1-q-p+r$	$1-q$
Simulation shows outcome O_1 or O_2	p	$1-p$	1

Conditional Probabilities

$P\{\text{Outcome is } O_1 \text{ given simulation shows outcome } O_1\} = r/q$ true
 $P\{\text{Outcome is } O_2 \text{ given simulation shows outcome } O_1\} = 1-r/q$ false positive

$P\{\text{Outcome is } O_1 \text{ given simulation shows outcome } O_2\} = (p-r)/(1-q)$ false negative
 $P\{\text{Outcome is } O_2 \text{ and simulation shows outcome } O_2\} = (1-q-p+r)/(1-p) = 1 - (p-r)/(1-q)$ true

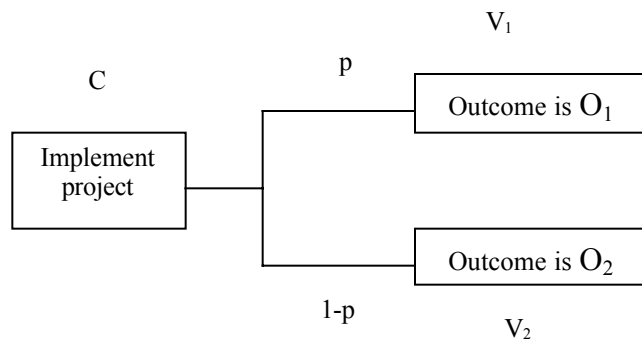
Comparison of Strategies

For each project there are three strategies:

1. Implement without simulation.
2. Simulate, and implement if simulation shows benefits greater than costs (simulation shows outcome O_1) and do not implement if simulation shows benefits less than costs (O_2).
3. Do not implement.

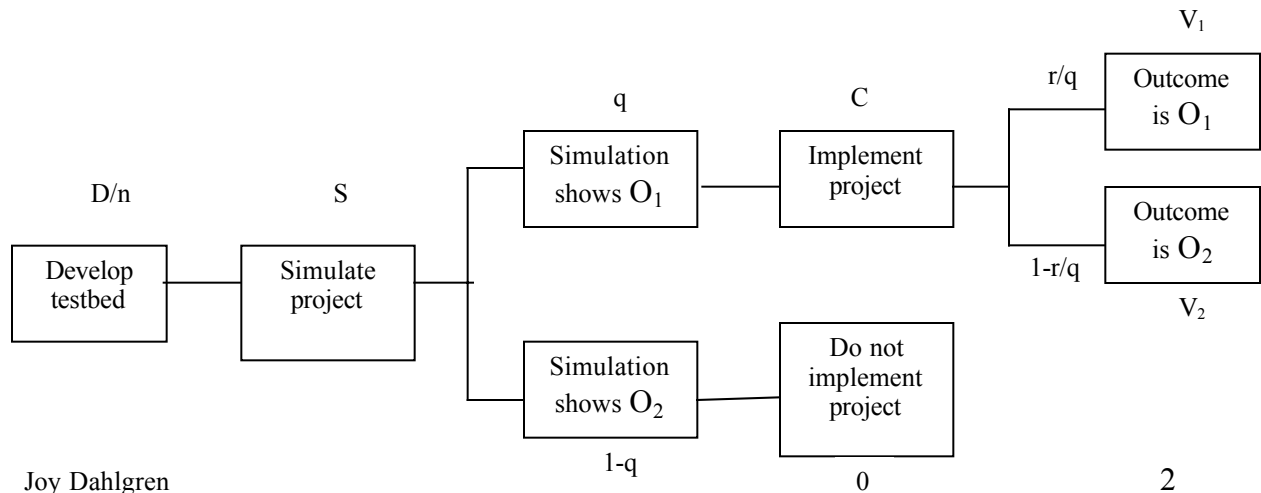
The expected value of each is diagramed below.

Strategy 1 – Implement without simulation



Expected value = $pV_1 + (1-p)V_2 - C$

Strategy 2 – Simulate and implement if simulation shows benefits greater than costs



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2

Expected value = $[rV_1 + (q - r)V_2 - qC] - D/n - S$

Strategy 3 – Do not implement

Expected value = 0

Simulation will be cost effective if the expected benefits of strategy 2 are greater than those of strategy 1 or strategy 3.

Comparison of Strategies 1 and 2

Given n projects, the expected benefits of strategy 2 are greater than those of strategy 1 when:

$$\sum_i^n [r_i V_{1i} + (q_i - r_i) V_{2i} - q_i C_i - D/n - S_i] > \sum_i^n [p_i V_{1i} + (1-p_i) V_{2i} - C_i] \quad \text{or equivalently}$$

$$\sum_i^n [(1 - q_i - p_i + r_i)(C_i - V_{2i}) - (p_i - r_i)(V_{1i} - C_i)] > D + \sum_i^n S_i$$

The first term is the probability that the outcome will be O_2 and the simulation will correctly show O_2 , and the second term is the net loss due to O_2 ; together, these terms represent the savings from identifying and not implementing a cost-ineffective project. The third term is the probability that the simulation falsely shows a negative result, and the fourth term is the net benefit due to O_1 ; together these two terms represent the loss due to not implementing a cost-effective project. The two terms on the right side of the inequality are the cost of the simulation. Strategy 2 is more cost-effective than Strategy 1 when the first and second terms are large, the third and fourth are small and the last two are small. That is, when:

- the probability is high that the outcome will not be cost-effective and that the simulation will correctly show this
- the net loss due to implementing a project that is not cost-effective is high
- the probability is low that the simulation shows a cost-effective project to not be cost-effective
- the net benefit from implementing a cost-effective project is small
- the cost of setting up the model and running the simulations is low

Simulation is most worthwhile when many expensive and possibly ineffective projects are being considered *and* when cost-ineffective projects will not be implemented if the simulation shows them to be such.

Comparison of Strategies 2 and 3

Simulation is also cost-effective when the expected benefits of strategy 2 are greater than those of strategy 3, which occurs when:

n

$$\sum_i [r_i V_{1i} + (q_i - r_i) V_{2i} - q_i C_i - D/n - S_i] > 0 \quad \text{or equivalently}$$

$$\sum_i^n [r_i V_{1i} + (q_i - r_i) V_{2i} - q_i C_i] > D + \sum_i^n S_i$$

Here the first term represents the benefit from correctly identifying and implementing a cost-effective project. The second term represents the cost of mis-identifying and implementing a cost-ineffective project. The third term represents the cost of implementing projects. In this case simulation is worthwhile when:

- the probability is high that the outcome will be cost-effective and that the simulation will correctly show this
- the net gain due to implementing a cost-effective project is high
- the probability is low that the simulation shows a cost-ineffective project to be cost-effective
- the net cost from implementing a cost-ineffective project is small
- the cost of the setting up the model and running the simulations is low

Summary

A simulation is valuable if it results in implementation of worthwhile projects that would not be implemented without the simulation or if it prevents implementation of poor projects that would be implemented without the simulation. In either case, model accuracy is critically important. But, of course, the more accurate the simulation, the greater its cost. If the primary concern is that worthwhile projects are not being implemented, then simulation will be helpful to the extent that it correctly identifies these projects at a reasonable cost.