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The Los Angeles Freeway Service Patrol (FSP) Evaluation: Study Methodology and Preliminary Findings

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Abstract

In this paper we present and discuss a methodology to evaluate the effectiveness, in terms of benefit-to-cost ratio, of the Freeway Service Patrol (FSP) in a Los Angeles freeway section. The methodology addresses the process of estimating incident delay using probe vehicles, and the lack of “before” field data. We discuss the difficulties that these problems present. We also report some preliminary findings.

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Chapter 1

Introduction

This report presents the methodology behind the proposed LA FSP study. The goal of the LA FSP project is to estimate the benefit to cost ratio of the FSP tow truck service on a section of freeway in the Los Angeles area. This study will be much like the I-880 Study [1] with the key difference being that there is only going to be one data collection period. During this period, the FSP tow trucks will be in operation assisting motorists. The measurements that will be taken in LA are summarized below:

- Probe vehicles will be driven up and down the test site during the specified measurement time. These vehicles will sample the traffic stream speed, measure the incident durations and characteristics, and observe response and clearance time of the FSP tow trucks.
- The traffic flow on the test site will be measured with a rather dense set of loop detectors. These loop detectors will provide us with lane-by-lane flows and occupancies.
- Archived LA area CAD data will be used to calculate the response and duration of incidents before the FSP tow truck service was started.

Following the discussions that occurred during many meetings we have developed a methodology that allows us to calculate the benefit to cost ratio using only the above proposed measurements. This methodology is presented and discussed in Chapter 2. Chapters 3 and 4 will then discuss, in detail, the various steps in the methodology, the assumptions that they include and the validity of applying these assumptions to the LA area. Finally, in Chapter 5 we will summarize the various steps of the methodology and in Section 5.2 we present some preliminary results.

Chapter 2

Overview of the Methodology

The methodology that we have developed can be listed in these steps:

1. Measure the delay and duration for each incident (“after”).
2. Model the delay caused by each incident with the standard queuing diagram.
3. For each incident, estimate what the increase in incident duration would be if there was no FSP service present.
4. For each incident, calculate the new delay for the new duration based on the model determined in step 2 (“before”).
5. For all of the incidents, find the new delay. Compare the old delay, which is the “before” delay, with the new, or “after,” delay to get the savings and then get the benefit to cost ratio.

The problem that we are trying to solve with this (or any) methodology is how to get the delay per incident in the before study (when the incidents were assisted only by non-FSP tow trucks). Since we can't measure this value we have to estimate it using the measurements available and some model. What the above methodology represents is a combination of assumptions that when applied to the data that we can measure will allow us to predict the before study delay per incident.

Hence we claim that the above methodology will allow us to calculate the benefit to cost ratio in the LA Area without the aid of a before study. While there are some assumptions that we need to make we will show that they are rather reasonable. We believe that this methodology minimizes not only the number of assumptions needed but also minimizes the reliance on the results from the I-880 Study.

Note that there are a few ways to estimate the delay versus duration curve without a before study. A historical perspective might help to clarify why we chose the above method. What we were originally considering is to parameterize the delay versus duration curve from the I-880

before study by some model. We would then use this model to predict the delay in the LA Area before case. The problem with this approach is that the model couldn't take into account the geometrics of the freeway, like the conditions of the shoulders. Hence, we couldn't use our model on a location that didn't have shoulders similar to I-880 (and the LA site doesn't). Therefore we decided to start from a slightly different perspective. Instead of assuming that the delay versus duration curve would be similar in both locations we decided to essentially model the delay versus duration curve for every incident. This would allow us to take into account the different geometrics for each and every incident. In light of other studies done in LA this assumption seems pretty reasonable. Hence, this methodology will allow us to draw conclusions about the LA area which will incorporate the expected higher flows and smaller shoulders. Consequently, this calculation will be done without reference to the delay calculations done in the I-880 Study. A more detailed summary of the steps that incorporate the methodology are given below.

In step 1 we will use the loop detector flow data and the probe vehicle speed data to generate density plots of the entire study section. We will then use these plots to identify the delay induced by specific incidents. From this we can determine the delay and duration for every incident. The key thing here is that these plots will reflect the higher flows and smaller shoulders in the LA area. The specific steps involved in making these plots are discussed in Chapter 3.

Once we have these points (the delay and duration), we will fit a standard queuing model to them for each incident in step 2. What we are really trying to determine here is the incident capacity. Since we know the delay that the incident caused, the duration of the incident, and the demand, and we can assume a value for the discharge capacity we can determine from a standard queuing model the incident capacity. Note that this will automatically take into account the geometrics at the incident site. These models will allow us to make predictions about the incident delay under different tow truck response scenarios. The details of this step are discussed in Chapter 4.

Once we have these incident modeled, we will adjust for the fact that the FSP tow trucks oversample the short duration incidents in step 3. An examination of the I-880 data indicates that this effect needs to be taken into account. Section 4.2.1 will examine this effect and will discuss how we can compensate for it. This compensation will give us a set of points that reflect the true effect of the FSP tow trucks.

Finally in steps 4 and 5 we will use the models to calculate the delay generated by each type of incident for the calculated before study duration and the measured after study duration. These values will then give us the final benefit to cost ratio. The calculated before study duration will come from the LA area CAD database. The problems associated with generating the before duration from the CAD database are discussed in Chapter 5.

The following sections of this paper give the details of each step in the methodology. They also present some results when these steps are applied to the data from the I-880 FSP Study. Throughout the paper we will give arguments as to why this is the best method to estimate the benefits from the FSP tow trucks.

Chapter 3

Incident Delay Estimation

Estimating the incident delay from field data and developing delay versus duration relationships is the biggest part of the study in the sense that it will consume the most time. The estimation process is going to be done much like it was done in the I-880 study. The various steps that need to be done for this are as follows:

1. The density contour plots will be generated of the study section.
2. The incident locations and durations will be overlaid on these plot.
3. The plots will be examined by hand to associate build-ups in density with specific incidents wherever possible. This involves drawing bounding boxes on the density plots.
4. Based on the bounding boxes, delays will be calculated for each incident.
5. Plots of delay versus duration for different types of incidents will be generated.

These are exactly the same steps that were followed in the I-880 study with only one important difference. Since the loop detectors in the LA area are single trap loop detectors it is not possible to accurately measure speed. Therefore, the calculations of density and delay have to rely on the loop detector flow and the probe vehicle speeds. This is not necessarily a problem but it needs to be verified that the density plots calculated from the probe vehicle speeds and the loop detector flows are similar to the ones made solely from the loop detector data. This line of inquiry leads to another question as to whether the percentage of probe vehicles in the traffic stream will be high enough to accurately measure the speed. To answer these questions we provide a short summary of the meaning of delay in our setting.

3.1 Loop Speed Based Delay

One way to compute delay is to completely rely on the loop detector measurements of speed and flow. When doing this, we can use the standard formula to compute the delay at each loop

detector for each output period:

$$D_k(i) = L_k \frac{\Delta T}{60} F_k(i) \left(\frac{1}{V_k(i)} - \frac{1}{V_T} \right) \quad (3.1)$$

Where $D_k(i)$ is the delay on segment k at time period i , L_k is the length of segment k in miles, ΔT is the time slice in minutes, $F_k(i)$ is the flow on segment k at time period i , $V_k(i)$ is the speed on segment k at time period i , and V_T is the threshold or congestion speed. Then, we sum these values up over the length and duration of our incident to get one value:

$$D_{inc} = \sum_{k=1}^N \sum_{i=1}^M D_k(i) \quad (3.2)$$

Where we assume that there are N sections and M time periods for our incident. Note that there are different ways to compute this delay depending on what you choose for the threshold speed V_T . For example, one could choose V_T to be a constant or to be the average speed for a particular time of day. It is generally assumed that this delay calculation gives you the most accurate results.

3.2 Probe Speed Based Delay

Another method to calculate the delay is to use the probe vehicle speeds and the loop detector flows. This calculation is done when there is no speed data from the loop detectors (or when we don't trust the speed values). To calculate this delay we can use the same equation as in the loop based method but substitute in the probe vehicle speeds for the loop speeds:

$$D_k(i) = L_k \frac{\Delta T}{60} F_k(i) \left(\frac{1}{V_{k,probe}(i)} - \frac{1}{V_T} \right) \quad (3.3)$$

Where $V_{k,probe}(i)$ is the speed at the loop detector location k at time period i from the probe vehicles. Since the probe vehicles are not always on top of the loop detectors this method requires some interpolation to get the data. Note that you can still set the threshold speed, V_T , to be whatever speed you like.

This calculation for probe speed based delay has a number of problems. The biggest is that the accuracy of our measurement depends on the density of probe vehicles. Therefore anything that perturbs the uniform density of the probe vehicles will also perturb the uniform sampling of the speed surface. Hence, whenever there is an incident and our probe vehicle is stuck in the queue our picture of the density of the freeway is warped. This is in contrast to the loop speed based delay measurements which are oblivious to traffic queues. A plot of the effect of probe vehicle density on speed surface accuracy is given in Figure 3.1. This figure is simply a measurement of the distance between the double trap based speed surface (which is assumed to be the best), the single trap based speed surface, and the speed surfaces generated when we have 1, 2, 3 or 4 probe vehicles. Note that for 4 probe vehicles the density of probes in the traffic stream is approximately 0.13%. This says that if we think that the single trap loop

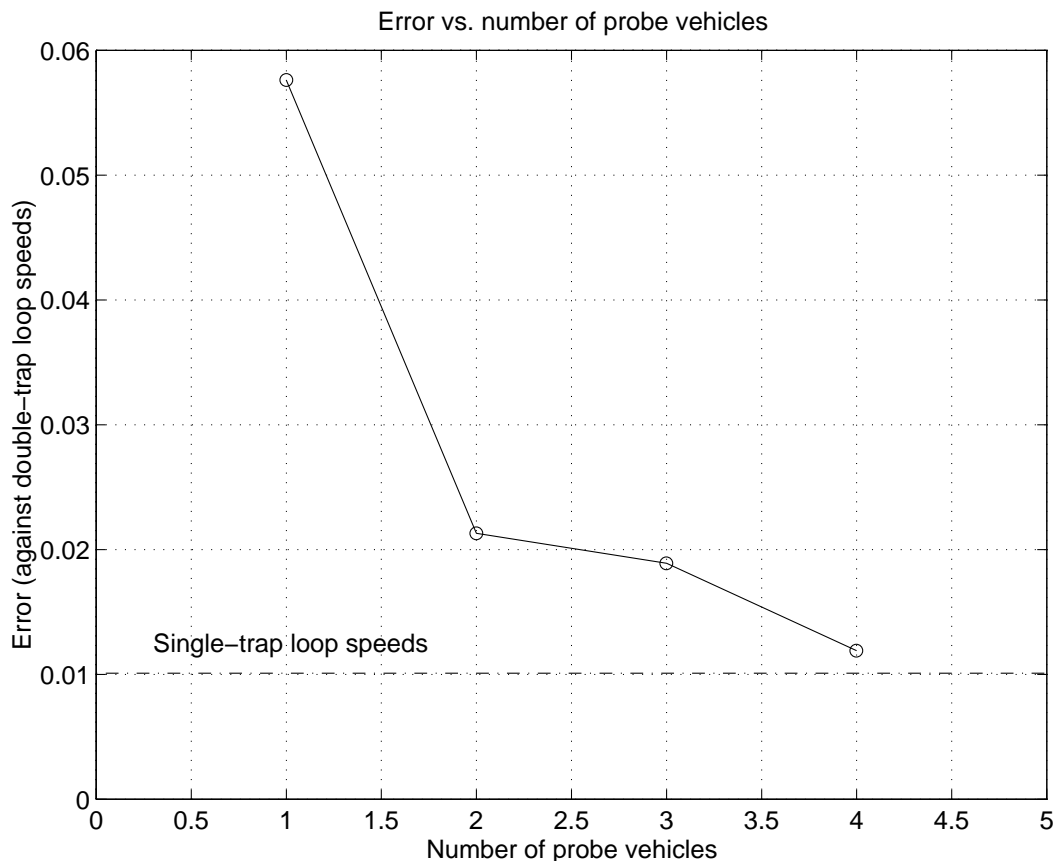


Figure 3.1: Errors introduced by probe vehicles.

speeds are not accurate, then we shouldn't think that the probe vehicle loop speeds (at this density) are any more accurate. Hence, the percentage of probe vehicles on the Los Angeles test section will be larger than 0.13%.

Related to the sampling problem is the question of interpolating the speeds when there is no probe vehicle data. The form of the delay calculation requires a speed value for every loop detector and for every output period (usually every 30 seconds). This means that we have to do two things: 1) figure out exactly where the probe vehicles are at every instant, 2) interpolate between the times when the probe vehicles pass over a loop detector. The first problem is basically a noise problem because we aren't exactly sure where the vehicle is at any given moment. We can dismiss this by arguing that the locations are close enough and hence the speed measurements aren't going to be that far off. But the second problem is more likely to give us trouble. A detailed look at what we do to get the probe vehicle speeds for the delay calculation will show us why. The process is given in Figure 3.2. The left side of Figure 3.2 is the distance vs. time plot of freeway with the probe vehicle trajectories overlaid. The dotted lines mark out the "regions of attraction" for each loop detector and time period. The program assigns to the dot in the middle of the region the average of all the speed points inside the region. Although the probe trajectory is physically a continuous line, the data is only reported

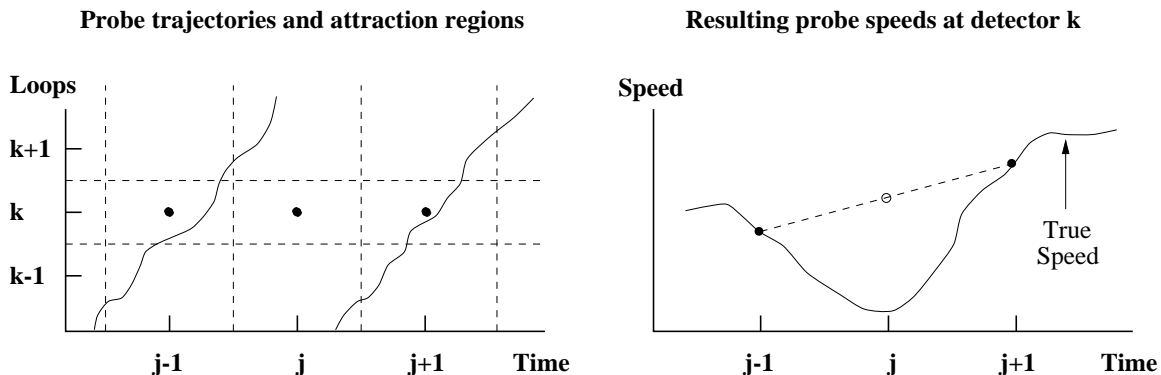


Figure 3.2: Interpolation of probe trajectories to get speeds.

once every second and hence we can get an average. Note that this average is over the entire distance of the loop detector segment, and over the time period. The thing to note is that in this example no probe vehicle trajectory fell in the time period-loop detector pair of (j, k) . Therefore this speed will have to be interpolated. That action is represented on the right side of Figure 3.2. Here we have two data points and we simply interpolate with a straight line to get the data point in the middle. This is indicated by the empty circle at the grid coordinates (j, k) . The problem here is that we have no idea what the speed is in the middle of these two points (as indicated on the plot by the true speed line). If the two vehicles are far apart in time then the speeds at that location could be fluctuating wildly and we would never know it.

3.3 Probe Travel Time Based Delay

Another method to calculate delay based on probe data is to record the increase in travel times for each probe vehicle and then multiply this by the flow to get vehicle-hours. This setup could be used when there are probe vehicles driving around on the segment, but there is only one or two accurate loop detector stations on the entire segment. In this situation you would only accurately know the flow for one or two places and hence it makes sense to use this form of delay calculation.

This calculation is done with the following equation:

$$D(i) = F(i) (TT_{prob}(i) - TT_{avg}(i)) \quad (3.4)$$

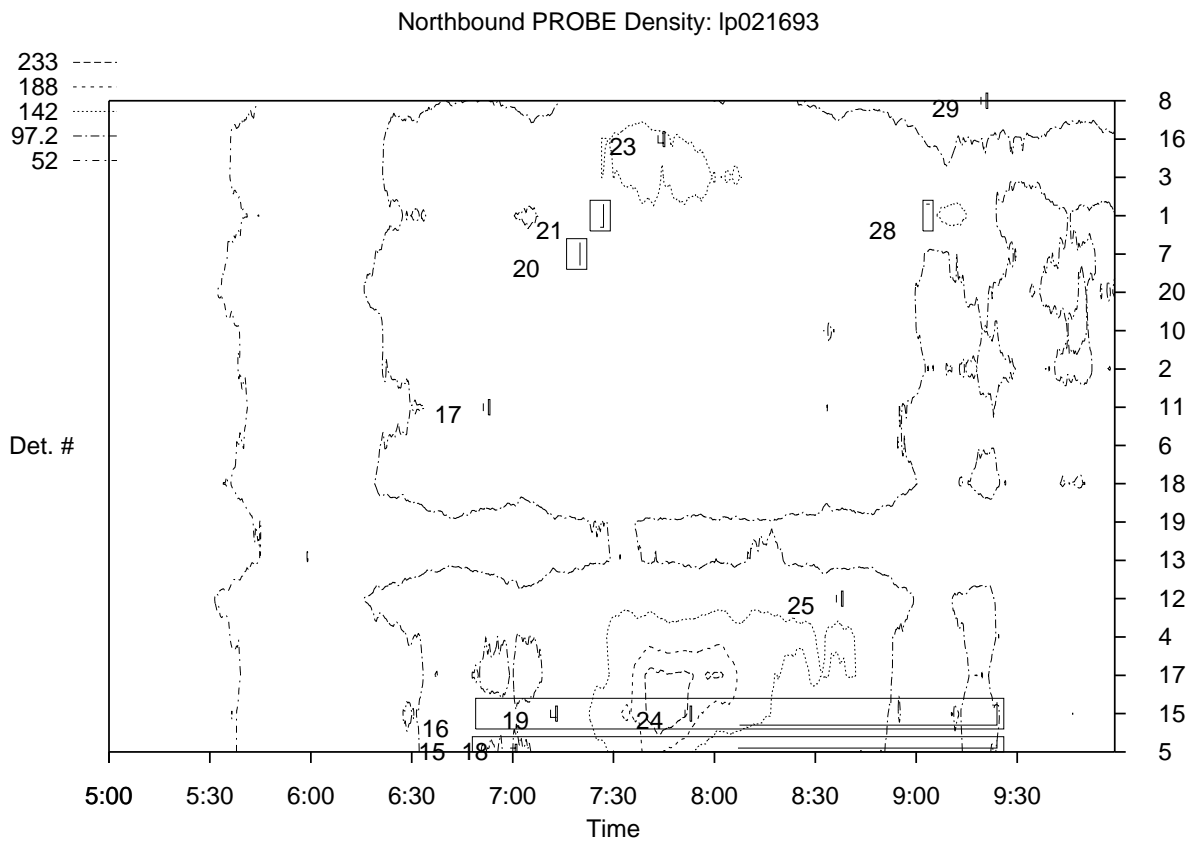
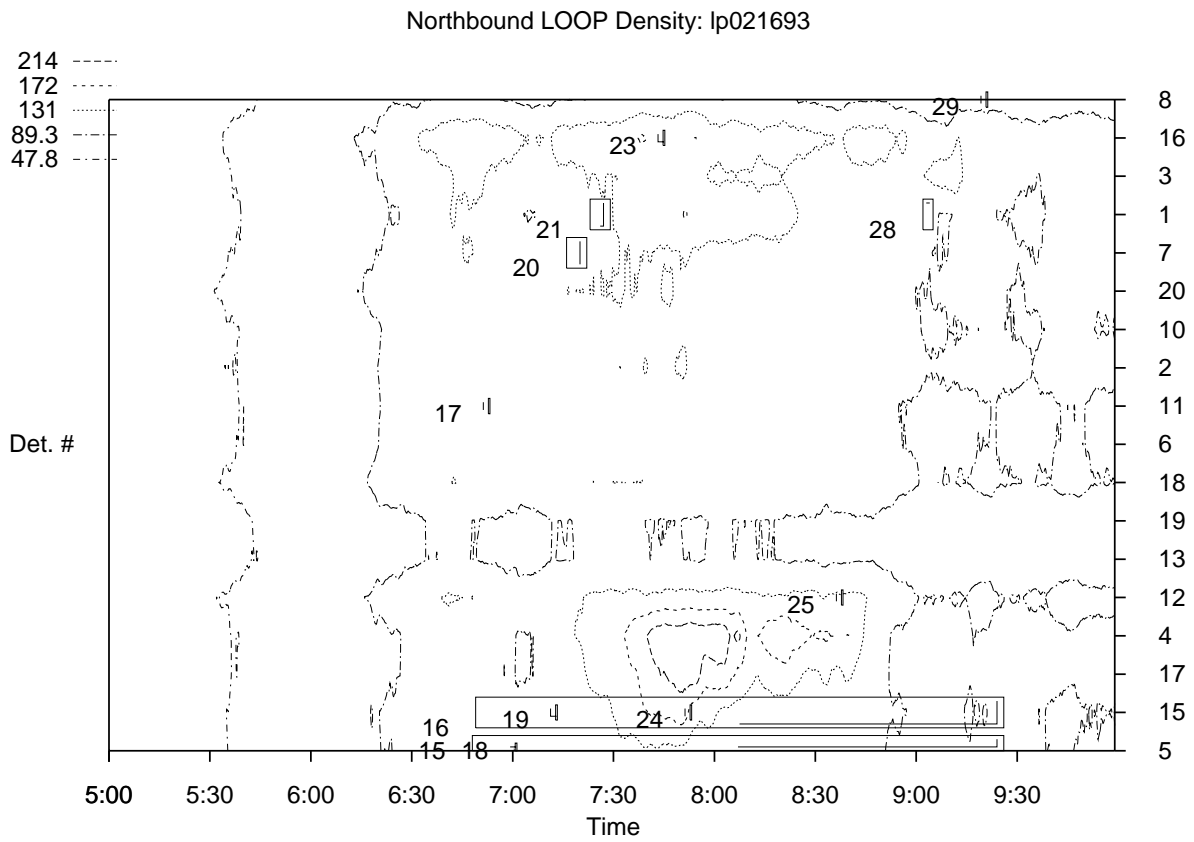
Where $D(i)$ is the delay in vehicle-hours for time period i , $F(i)$ is the average flow down the freeway during time period i , $TT_{prob}(i)$ is the travel time down the freeway for the probe vehicle for time period i , and $TT_{avg}(i)$ is the average travel time down the freeway at time period i (possibly based on historical data or some constant speed). This will give you an aggregate value of delay. Although this form of delay calculation is interesting, it is not applicable to the LA FSP study because we will need to obtain the delay for a specific incident. This method only provides you with delay for an entire section of the freeway. Hence we will not be able to use this method in LA.

3.4 Choice of the Incident-Free Speed

One of the more questionable points is what threshold, V_T (the incident-free speed), should one choose to carry out the delay calculations? Should you use the average speed down the freeway as a function of location and time? Or should one use a constant speed? A logical answer would be that we want to be able to measure whenever an incident causes the traffic stream to fluctuate and hence causes delay. If we were trying to see this with a constant threshold of 35 mph then we won't see any delay for an incident that causes the traffic to slow down to 40 mph for an hour. On the other hand, if we know that there is recurrent congestion at one location during one time of the day, then it would be incorrect to classify that as incident induced delay. So the logical choice would be to use the average traffic speed which is a function of location and time for the threshold excluding incidents.

3.5 Comparison of Methods for Calculating Incident Delay

Despite the problems mentioned above, the use of the probe vehicle speeds and the loop detector flows to calculate the density of traffic, and hence delay, is quite accurate. This is illustrated in Figure 3.3. The plot on the top of Figure 3.3 is a contour plot of the density of vehicles on the freeway that was calculated from the loop detector speeds and flows. The plot on the bottom was calculated with the probe vehicle speeds and the loop detector flows. Hence we feel that with a high enough density of probe vehicles, the two measures of delay will be equivalent.



Chapter 4

Modeling the Effects of FSP

4.1 Incident Delay Modeling

In this section we will discuss the way that we decided to model the incidents. What we would like to do is to come up with a model, based on physical reality, that we can use to predict the delay based on the characteristics of the incident (duration, severity) and the local freeway (traffic volume, shoulder width). The normal way of doing this is to measure some data, come up with a physical model with some dependent parameters, and then fit the parameters in the model to the data.

The problem with this approach is that it tends to “mush” the data together and it doesn’t represent physical reality. The approach that we have taken is a bit more robust. After the previous step we will have a plot of the delay versus duration for all of the incidents, much like the representation given in Figure 4.1.

Each point in Figure 4.1 represents an incident. The question that we are faced with is,

“If the tow truck service changes, that is, FSP service is introduced, and the incident durations change in some manner, how does the delay for each incident change?”

The way that we attempt to answer this is we first model each incident with a standard queuing model as in Figure 4.2. That diagram on the right side of Figure 4.2 is a picture of the cumulative flow during an incident versus time. The line represented by V is the cumulative number of vehicles that want to pass down the freeway. The slope of this line, V , is the demand on the freeway in vehicles per hour. When the incident occurs, the capacity of the freeway is reduced to a slope of C_I vehicles per hour. In this model the freeway stays restricted to this lower capacity for the duration of the incident, t . Once the incident has cleared, after t minutes, the built-up queue will discharge at the capacity of the freeway C (maybe). This volume will be maintained until the queue is dissipated at some later time. The delay caused by this incident is the shaded area. The units of this shaded area are in vehicle-hours. It represents the cumulative amount of time that these vehicles had to wait in this queue due to this incident.

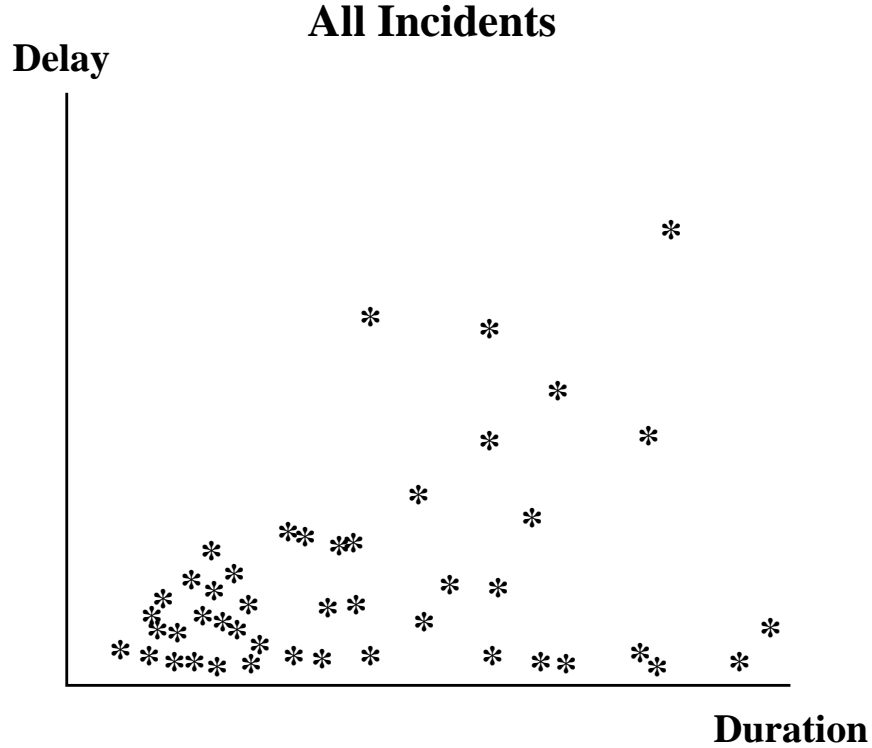


Figure 4.1: Raw data after first step of methodology.

There are, of course, some problems with this model that stem from two different sources. The first source is that this is not what happens in reality, and the second source is in our measurement technique. In reality, the line given by C_I is not a constant. One can think up many different stages of an incident: the vehicle initially blocks one lane, the vehicle is moved to the side of the road, the tow truck and a CHP officer show up, the vehicle is towed away, the CHP officer leaves. Every one of these possible stages is going to have a different effect, in terms of capacity reduction, on the traffic stream. So hoping that we can model it as a single straight line is probably a bit optimistic. The second problem arises in the way that we measured the durations of the incidents. Since we measured the durations with the probe vehicles we are only sampling the start and end times by the probe headway (5 to 7 minutes). Hence we are always under estimating the duration of the incident. Since the delay generated by the incident depends on the square of the duration any error here will be difficult for our models.

Never-the-less, we can put these objections aside and attempt to fit our data to the model given in the equations below:

$$\text{Delay} = \frac{1}{2}t^2(V - C_I) + \frac{1}{2}t^2 \frac{(V - C_I)^2}{(C - V)} \quad (4.1)$$

$$= \frac{1}{2}t^2(V - C_I) \frac{(C - C_I)^2}{(C - V)} \quad (4.2)$$

We can get a few of these parameters, like demand, V , and capacity, C , and duration, t , from

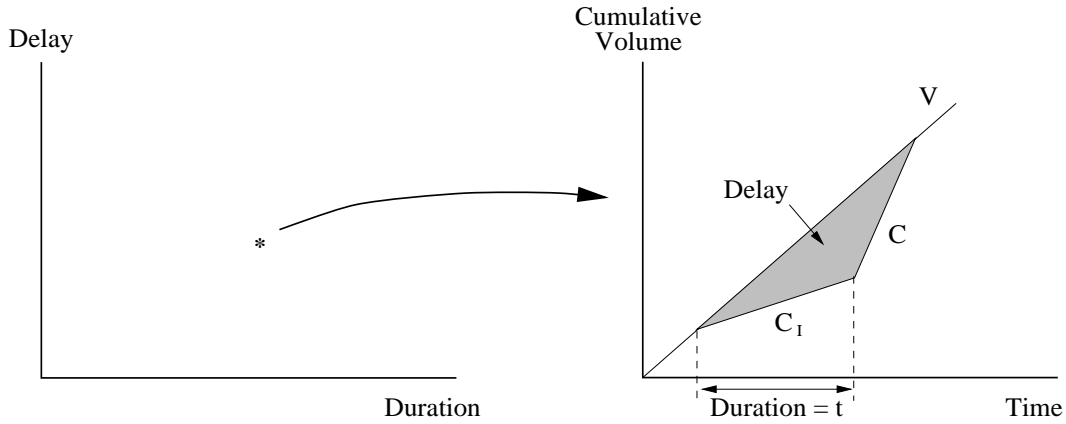


Figure 4.2: Modeling of a single incident.

the field measurements. What we don't know, and what we would be trying to fit in our model, is the amount of capacity reduction, C_I , due to a specific incident. So this value, C_I , is going to be a function of the characteristics of the incident and the local freeway (like whether or not there are shoulders). Since we know all of the other terms in equation 4.2 we can simply solve for C_I for each incident.

4.2 Incident Durations Before FSP

The next step in our methodology is to determine the duration of the incidents when there is no FSP tow truck service in place. This is a difficult problem because we don't have any field data "before" and also due to the presence of the oversampling of the short duration incidents by the FSP tow trucks. In the section below we examine the oversampling problem and discuss ways to compensate for it.

4.2.1 Correcting for the over-sampling of incidents

A common way to estimate the reduction in incident duration due to the FSP tow trucks is to simply take the difference between the before incident duration and the after. The results on incident duration for the I-880 FSP Study are given in Table 4.1. If, for the assisted

Incident Type	Duration (min)		Fraction (%)	
	Before	After	Before	After
Assisted Breakdowns	37.6	21.1	18	41.2
Non-assisted Breakdowns	22.6	22.8	82	58.8

Table 4.1: Incident durations

breakdowns, we simply subtract the after duration from the before duration we get a reduction of: $37.6 - 21.1 = 16.5$ minutes. Almost all studies take this reduction and use it in the queuing

diagram to calculate the delay savings. However, you can see in Table 4.1 that the fraction of assisted incidents went up from 18% in the before study to 41.2% in the after study. Let's assume for a moment that the only breakdowns assisted by the FSP tow trucks in the after study were breakdowns that really needed assistance - they couldn't have moved otherwise. This would imply that in the before study only 50% of the breakdowns that really needed help were assisted. This is hard to believe. How did these people ever get off the freeway if they truly needed assistance?

So the assumption that the FSP tow trucks were helping only those breakdowns that needed help is probably incorrect. A more likely assumption is that the FSP tow trucks helped a lot of breakdowns that otherwise wouldn't have needed help. Things like people stopping to read a map, switch drivers, or to change their own tire¹. In these cases it is reasonable to assume that the FSP tow trucks did nothing to help out the situation. Never-the-less, the observed incident was recorded as an assisted breakdown. Due to the nature of these incidents their durations are very short. Therefore, these short breakdowns, that normally wouldn't have been helped, are pulling down the average duration of the assisted breakdowns in the after study. As we will show later, this phenomena can be viewed as an oversampling of the short duration breakdowns by the FSP tow trucks.

Armed with this assumption we will attempt to separate the reduction in assisted breakdown duration into two parts: 1) the reduction due to the FSP tow trucks arriving at the scene earlier, and 2) the reduction due to the oversampling of short duration breakdowns. The benefits attributed to the FSP tow trucks should only come from the first type of reduction. This is illustrated using the I-880 study. We begin by looking at the cumulative distributions of the incident durations for the assisted and non-assisted breakdowns. These plots are given in Figure 4.3.

¹Note that in the FSP database, an assisted breakdown is any time that one of the probe vehicles witnessed an FSP tow truck stopped by a motorist.

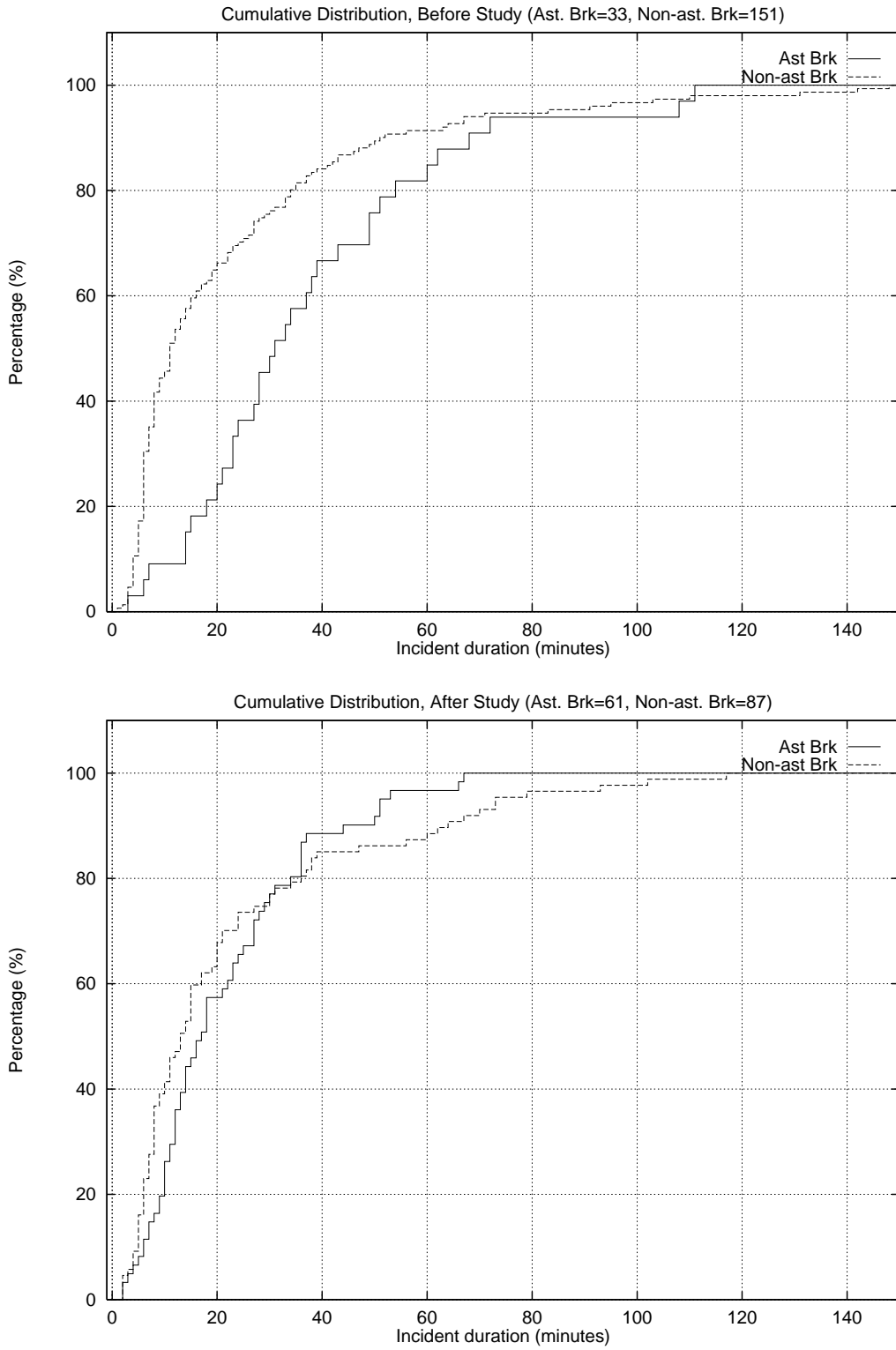


Figure 4.3: Cumulative distributions for assisted breakdowns

The cumulative distributions show pretty much what you would expect. The average duration of the assisted breakdowns in the after study has been reduced². But it is hard to tell from these plots how exactly to proceed. We need to break the shift in duration into two parts and the cumulative distributions just don't provide enough information. To get a better picture of what we are looking at we should consider the density distributions. Since the number of points that we have for each density plot is rather small, the actual density plots don't provide much information. Hence we present an idealized picture of what is going on in Figure 4.4. The top half of Figure 4.4 shows Venn diagrams of the breakdowns in the before and after

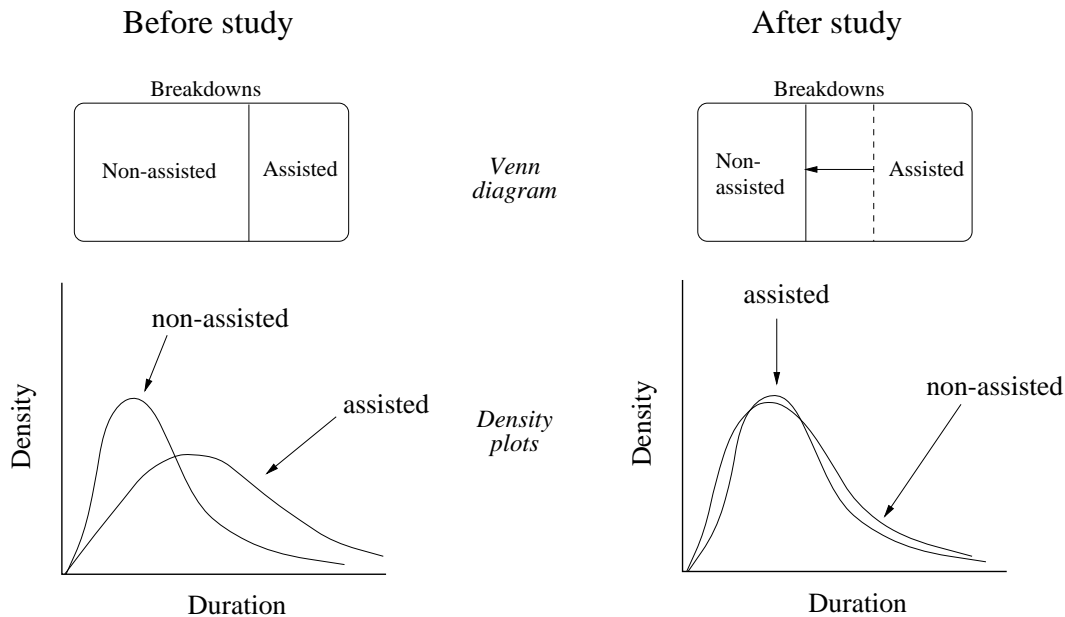


Figure 4.4: Density distributions for assisted breakdowns

study. Each diagram represents the entire set of breakdowns. The left half are the non-assisted breakdowns and the right half are the assisted breakdowns. The assumption is that in the after study the FSP tow trucks not only assisted all of the incidents that would normally have needed assistance, but they also assisted a significant fraction of the incidents that would normally have **not** needed assistance. Hence, in the Venn diagram for the after study, the assisted breakdown pool on the right has grown to include some of the normally non-assisted incidents. This can also be seen in the density plots on the bottom of Figure 4.4. The non-assisted breakdowns by nature have a shorter duration than the assisted breakdowns. Hence their densities are concentrated at a lower duration than the assisted breakdowns. This can clearly be seen in the density plots for the before study. But in the after study the distributions are basically right on top of each other. What this shows is that the distribution of the assisted breakdowns in the after study is incorrect.

By assumption we know that the pool of assisted breakdowns in the after study has some incidents in it that would normally not have been assisted. To correct this we need to subtract

²Note that a lower average delay corresponds to a cumulative distribution plot that is farther to the left on the graph.

these incidents from the pool of assisted breakdowns. This will get rid of the over sampling bias that is being introduced by the nature of the FSP tow trucks. Our first step is to determine the amount that the short incidents were oversampled. This can be done by examining the fraction of assisted incidents for each duration. This should tell us what percentage of incidents, at each duration, were assisted. A generalization of these curves is given in Figure 4.5. On the left side

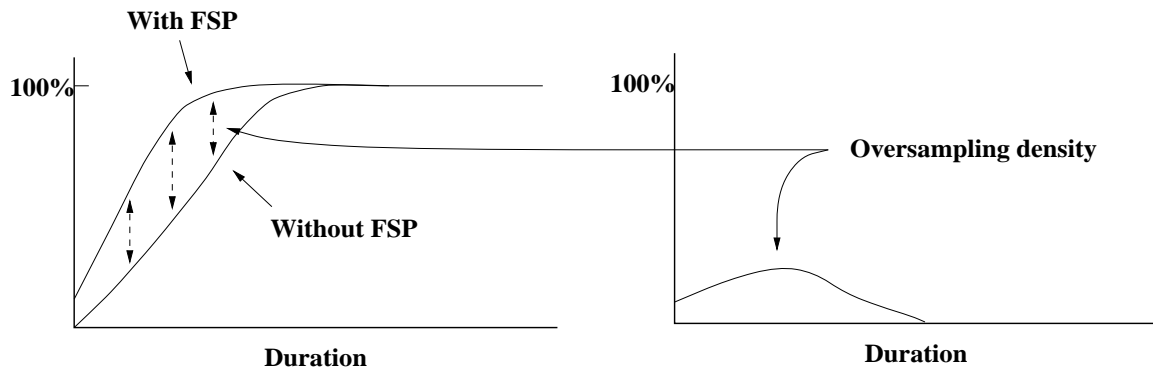


Figure 4.5: Fraction of assisted incidents and density of oversampling.

of Figure 4.5 is a plot of the fraction of assisted breakdowns per duration for the before study and the after study. As you can see, the fraction of assisted breakdowns in the after study is higher for shorter duration incidents. This reflects the fact that the FSP tow trucks were helping more short duration incidents. The difference between these two curves can be viewed as the fraction of incidents that are oversampled by the FSP tow trucks. This difference is given on the right side of Figure 4.5. This will be referred to as the oversampling density. The key point is that if you multiply the oversampling density by the density of the non-assisted breakdowns then this will give you the density of non-assisted breakdowns that were oversampled. This is the density distribution at which the non-assisted breakdowns were added to the assisted breakdown pool by the FSP tow trucks. So this is the distribution that we need to subtract off of the assisted breakdown distribution to correct for the oversampling. The process of oversampling is given in Figure 4.6. The upper left plot of Figure 4.6 is the density of the non-assisted breakdowns, the middle plot of Figure 4.6 is the oversampling density and the plot on the lower left is the product of the two. This is the over-sampled non-assisted breakdown density. This is what is added to the “true” assisted breakdown density to get what we have observed. So to fix the problem of the FSP tow trucks oversampling the short duration incidents we simply need to subtract off the density given in the lower left-hand plot of Figure 4.6.

The problem is that we don’t know how much to subtract. Since we are saying that the reduction in duration is due to two parts, the oversampling and the quick FSP arrival time, we need a way to determine the contribution of each part. Indeed, we could subtract off the over-sampled non-assisted breakdown density until the average duration of assisted breakdowns for the after study was the same as for the before study. But this would imply that the reduction in assisted breakdown duration was due entirely to oversampling short duration incident. This would clearly be incorrect.

A better approach would be to assume that the fraction of breakdowns needing assistance is

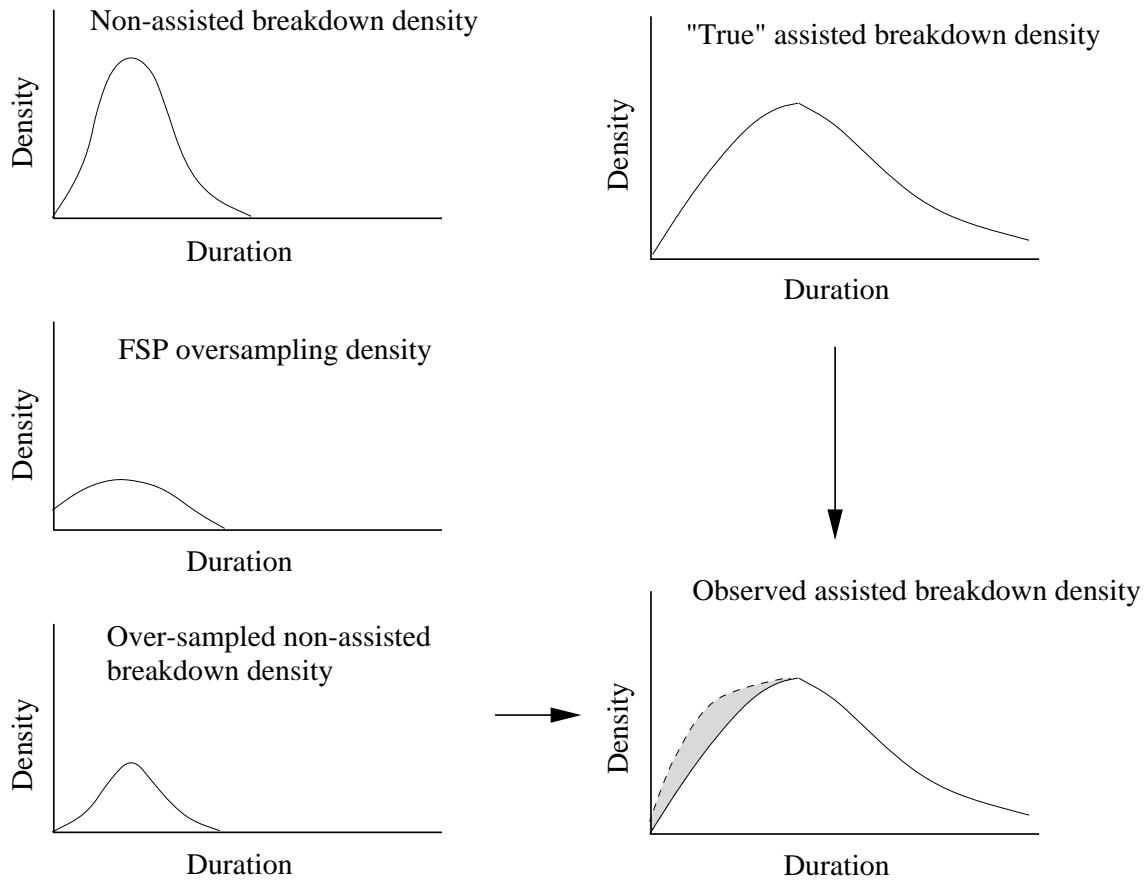


Figure 4.6: The process of oversampling.

a constant. Since it would be hard to imagine that the FSP tow trucks caused an increase in breakdowns needing assistance, this seems reasonable. Hence we should subtract off the over-sampled non-assisted breakdown density until the fraction of assisted breakdowns in the after study is the same as the fraction of assisted breakdowns in the before study. The resulting density distribution will be the correct distribution of assisted breakdowns. Therefore the true effect of the FSP tow trucks on the assisted breakdowns would be the difference between the average of this new distribution and the average of the assisted breakdowns in the before study. This two part process is given in Figure 4.7. The left side of Figure 4.7 represents the shift due to the oversampling of the short duration normally-non-assisted breakdowns. The right side of the figure represents the shift in the assisted breakdown distribution due to the FSP tow trucks arriving on the scene faster than radio dispatched tow trucks.

This two part decomposition of the assisted breakdown duration reduction was done on the I-880 FSP data. From Table 4.1 you can see that the original reduction in duration was 16.5 minutes. But when the decomposition is done the results are as follows:

- Reduction due to oversampling short duration breakdowns: 9.8 minutes.

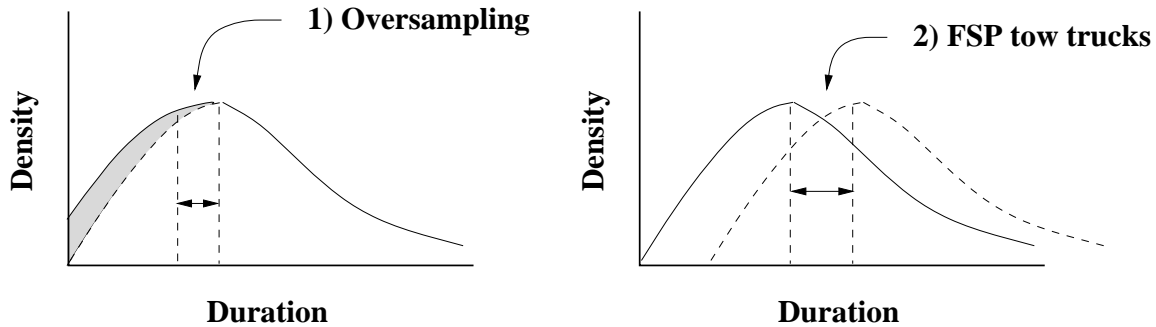


Figure 4.7: Effect of FSP tow trucks on assisted breakdowns.

- Reduction due to quick FSP tow trucks: 6.7 minutes.

This shows us that the major factor in the reduction of duration is due to the oversampling of short duration breakdowns by the FSP tow trucks.

4.2.2 Estimating Incident Duration Without a “Before” Study

The steps given above work great if you have the results from both a before and an after study. But how would they apply to a situation like the LA study where you have only the after study results? In order to use the method above, a few assumptions about the characteristics of the incidents need to be made:

1. The correct percentage of assisted breakdowns is given from the I-880 before study. This is assumed to be a constant 18% for all locations and all freeways. Previous studies have shown that this is a viable percentage for the LA area.
2. The correct sampling density for the assisted breakdowns without the tow trucks can be recovered from the LA area CAD logs.

If this is the case, then we can proceed from the discussion above with the following steps:

1. Take new sampling distribution.
2. Find difference between new sampling distribution and sampling distribution for the I-880 before study.
3. Multiply this distribution by the distribution of the before study non-assisted breakdowns.
4. Subtract off resulting distribution until the proportion of assisted breakdowns matches the proportion of assisted breakdowns in the before study.

These steps should allow us to correct for the over-sampling of the short duration incidents by the FSP tow trucks.

Chapter 5

Preliminary Findings

5.1 Application of Methodology

Before we begin with the final calculations, let's review the steps that we have taken to get here:

1. In Chapter 3 we discussed ways to measure the delay caused by specific incidents. We mentioned that although the overall method of computing delay will be the same as in the I-880 study, we have to use the probe vehicles instead of loop detectors to obtain traffic stream speeds. This seems to be a reasonable approach.
2. In Chapter 4 we discussed our approach to modeling incident delay based on only a few characteristics, such as incident duration and traffic volume. We assumed that a standard queuing model would fit the data and we calculated the incident capacity, C_I , for each incident.
3. In Section 4.2.1 we pointed out that the I-880 study indicates that the tow trucks were oversampling the short duration incidents. This effect pulls down the duration of the assisted incidents without really reducing the delay. Hence, we need to compensate for this effect. This effect was also noted in Chapter 4 where we found parameterized models for the two distributions and noted that they were significantly different. We presented a method for correcting the duration as well as the delay of incidents effected by this phenomena.

This leads us to the last steps in the methodology which will be to determine the durations for the before and after case. These values will then be used to determine the new delay for our incidents. In Figure 5.1 we can see how this process will be done. On the left side of Figure 5.1 we have the model for the incident that we obtained in a previous step. When we increase the duration of the incident by some amount the model gives us a new value of delay, which is shown on the right side. Note that this graph is only a drawing used to convey the basic idea.

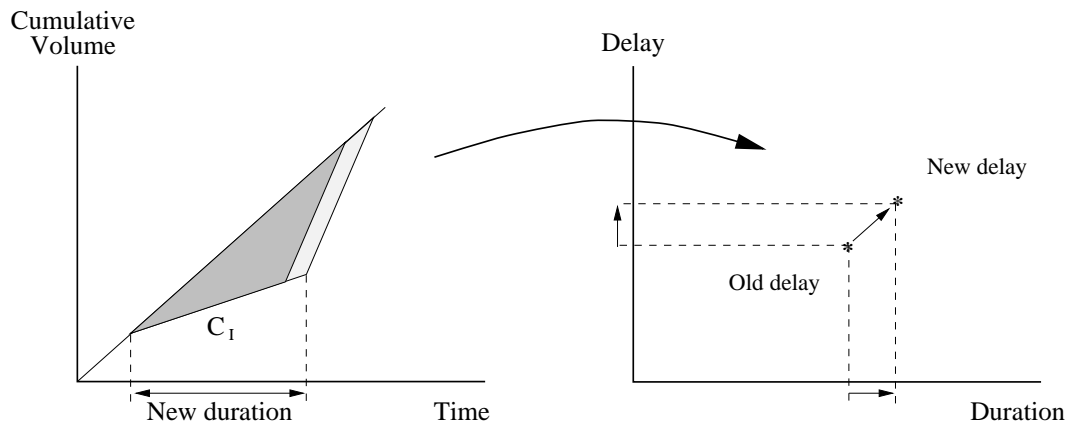


Figure 5.1: Estimating delay from different durations.

The value of incident duration for the after study we get for free; it's the value that we measured (and then adjusted) in LA. The before value of incident duration we have to estimate from other sources - which makes this value significantly harder to obtain than the after value. These other sources include the LA area CAD logs, previous research done in the LA area [2], and the results from the I-880 study. The calculation for the before value is going to depend crucially on the quality and availability of the LA area CAD logs. At this time it is difficult to predict what effect this might have on our calculations.

5.2 Preliminary Benefit to Cost Ratios

Using the above method we can compute some preliminary results. These are called preliminary results because we don't have the analysis of the CHP CAD data completed as of yet. Hence the amount to increase the incident durations is unknown. What is also unknown is the amount of oversampling for this site.

Never-the-less, we can proceed with a simple calculation. We will assume that the increase in duration is either an absolute, in terms of time, increase, or the increase in duration is a fractional increase. In either case we will increase the incident duration, use the models developed for each incident to predict the new delay, and then determine the benefit. The calculation for the benefit is as follows:

$$\text{Benefit} = (\text{Before delay} - \text{After delay})K_1K_2. \quad (5.1)$$

Where K_1 is a conversion factor that converts veh-hrs to dollars. For these calculations this factor is $K_1 = \$10$. The factor K_2 is a conversion factor that takes into account the number of incidents per hour that the tow trucks are assisting. The costs for the LA area are \$118/hr of FSP tow truck operation.

We present two preliminary results in Figures 5.2 and 5.3. It should be noted that neither one of these plots is a very good substitute for figuring out the correct oversampling distribution.

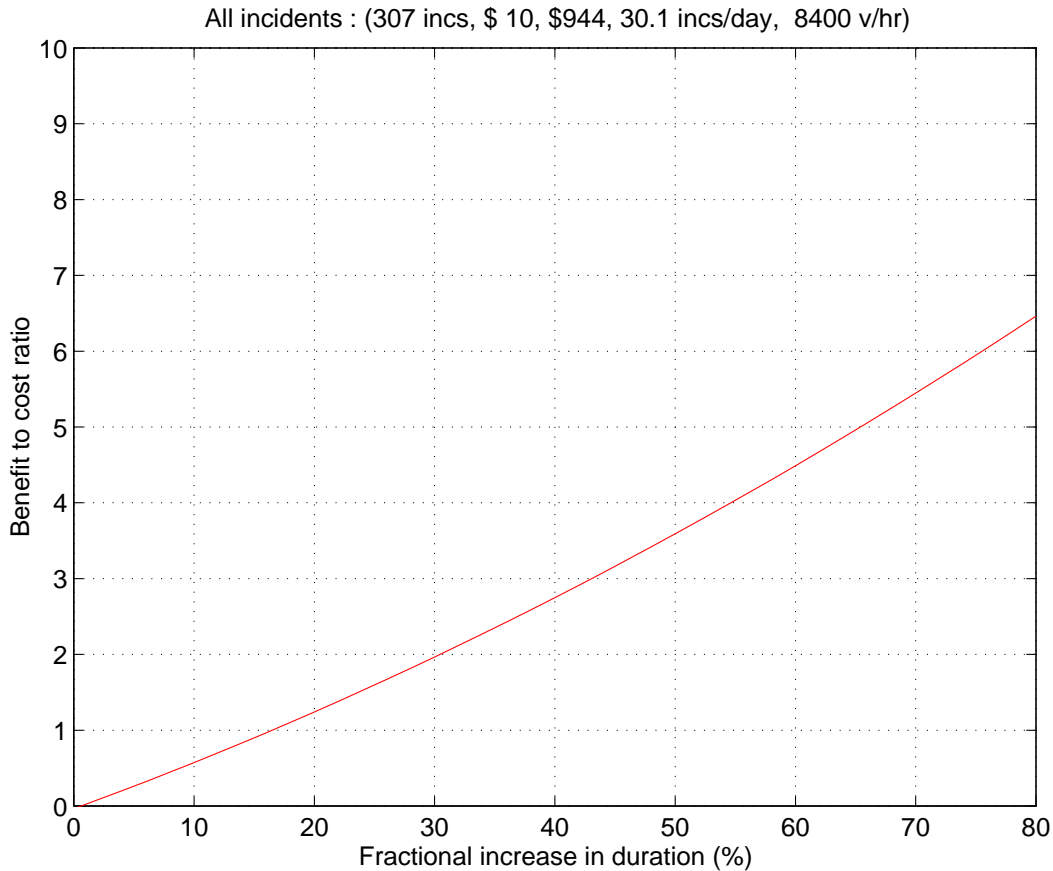


Figure 5.2: Benefit to cost ratio versus fractional increase in incident duration.

Both of these estimates overestimate the potential benefit to cost ratio. Consider, for example, the plot of benefit to cost ratio versus absolute duration increase given in Figure 5.3. While it may be realistic to assume that the longer duration incidents can have their durations increased by 15 minutes, it is unrealistic to assume that all of the short duration incidents were increased by that amount. Likewise, on the fraction increase graph it is unrealistic to assume that the long duration incidents were increased by 50% of their duration. Hence both of these graphs should be considered and upper bound on the true benefit to cost ratio.

In this paper we have presented a methodology that will allow us to estimate the benefit to cost ratio in the LA area without a before study. This methodology allows us to make very few assumptions and doesn't rely on the delay calculations done in the I-880. We have discussed the problems associated with each step of the methodology and we argue that in spite of these pitfalls we can still obtain reasonable results. Furthermore, we feel that this methodology is general enough that it can be applied to different sites around the state to assess the benefit to cost ratio at those locations.

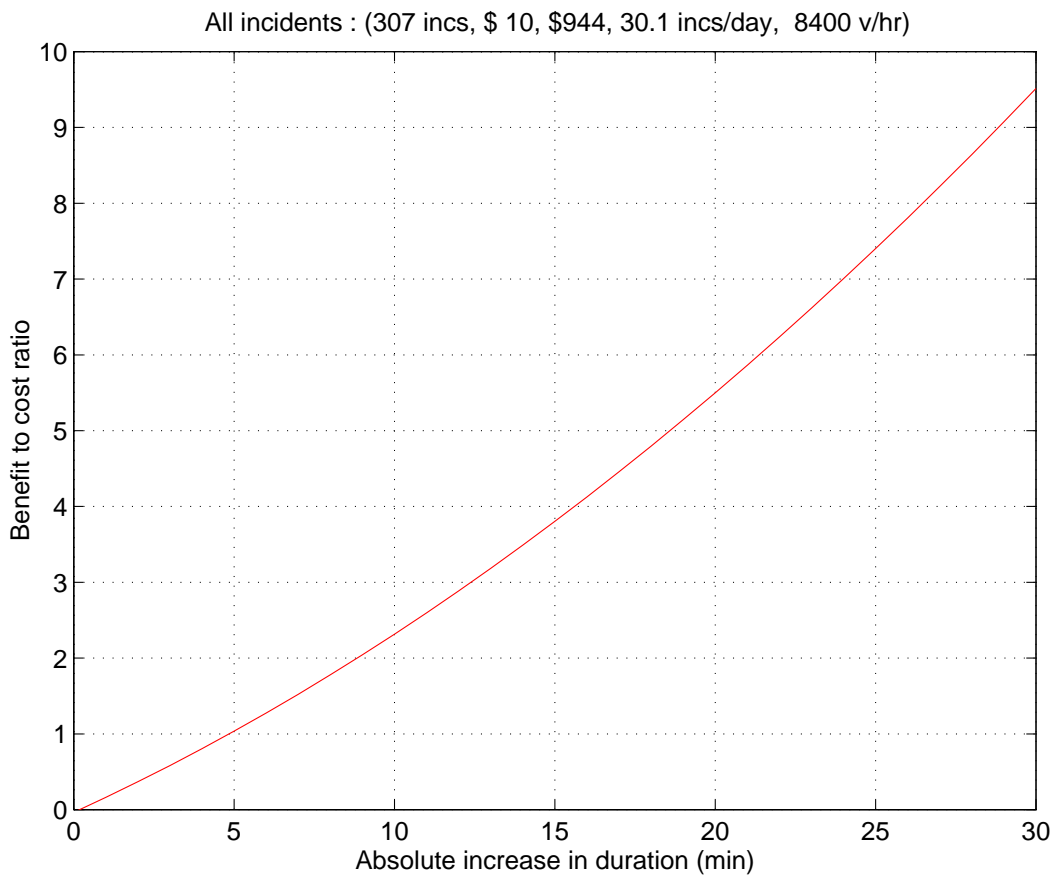


Figure 5.3: Benefit to cost ratio versus absolute increase in incident duration.

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