Feasibility of Using Freeway Service Patrol Trucks as Probe Vehicles

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Abstract: This research assessed the feasibility of using trucks in an existing Los Angeles Freeway Service Patrol (FSP) fleet as probe vehicles to measure ambient speed on freeway segments. Floating car speeds were the basis of comparison with other speed data. Loop detector-based segment speeds and FSP truck speeds were compared against a common baseline. Unfortunately, FSP truck speed data available from the existing system are of insufficient quality to estimate ambient speeds. Comparisons between floating car and FSP truck speed records reveal that FSP truck speed is a poor measure of floating car (ambient) speed. FSP truck speed records underestimate floating car speeds overall, and covariance between the two is weak.

DOI: 10.1061/(ASCE)0733-947X(2002)128:6(528)

CE Database keywords: Highway management; California; Trucks; Traffic speed; Traffic surveillance.

Introduction

From a user perspective, speed is the most important level of service (LOS) measure on roadways, and one of the most difficult to assess. System managers may be more interested in traffic volumes, but users make travel decisions based on knowledge or expectations concerning delays. Advanced Traveler Management Information Systems (ATMIS) that provide information to users focus on information about speeds.

California Department of Transportation (CALTRANS) District 7, Los Angeles and Ventura Counties, fields a large Freeway Service Patrol (FSP) truck fleet in cooperation with the Los Angeles County Metropolitan Transportation Authority (LACMTA) and the California Highway Patrol (CHP). These FSP trucks are equipped with mobile data terminals (MDTs) that have the capability to report speed and direction data. However, no vehicle speed data is currently gathered from FSP trucks.

Instead, speed data is collected from the extensive single loop detector system deployed on freeways in CALTRANS District 7. Single-loop detector systems make direct measurements of volume (vehicles/hour) and occupancy (percent time the loop is covered by a vehicle). Density (vehicles/kilometer) must be inferred from a combination of occupancy and historical data describing average vehicle length. Speed is calculated as the quotient of volume and density.

More recent double-loop systems permit speed to be observed directly, by dividing the short, fixed distance between loop pairs by the time between sequential loop pulses associated with the front of a single vehicle signature. Thus, double-loop systems do not require data about vehicle lengths, and there is no risk of relying on potentially obsolete data, nor of the distortion introduced by representing a distribution of vehicle lengths with the mean of the distribution.

Double-loop arrangements have been deployed in Northern California and elsewhere, but not in Los Angeles. Double-loop systems offer the basic simplicity of single-loop systems, but are subject to the same failure modes. Loops deform and connections break due to pressure from routine traffic. Loops are routinely damaged when the guideway is resurfaced or repaired. The loop inventory and associated cable plant are, in general, expensive to maintain.

Problem Statement

Most road networks are not as heavily detectorized as the Los Angeles network. This research assesses the feasibility of using the existing fleet of Freeway Service Patrol (FSP) trucks as probe vehicles for measuring level of service (LOS) on Los Angeles freeways and, by extension, elsewhere. This research produces and compares empirical estimates of ambient speeds on Los Angeles freeways based on data from three sources. These include floating car studies, single-loop detectors, and data from mobile data terminals on FSP trucks. If the information FSP trucks provide is of sufficient quality and quantity to measure level of service on the network, then similarly equipped fleets would be useful for measuring LOS in other locations where loop detectors have not been installed.

Literature Review

The use of probe vehicles to measure traffic flows is routine in an experimental context, but the literature provides no large-scale operational examples of public fleets being used as probe ve-
vehicles, though there is considerable theoretical interest in using transit fleets in this capacity. General conjectures about the probe vehicle potential of public fleets aside, there is no empirical literature on the use of FSP trucks as probes.

Nonrecurrent congestion is widely considered to be as large a source of highway delay as recurrent congestion. Queue delay increases with the square of incident duration. FSP services are a low capital-intensity management option intended to reduce nonrecurrent delay by reducing the period of time disabled vehicles remain on shoulders or in lanes. Not surprisingly, the costs and benefits of FSP have received substantial investigation. Fenno et al. (1996) reviewed the Chicago Minuteman, Minneapolis Highway Helper, Denver, Houston Motorist Assistance Patrol, and Los Angeles FSP and Samaritan programs to develop guidelines for establishing a new FSP service.

Skabaridons et al. (1995) evaluated an FSP program on a 14.5 km (9 mi) section of Interstate 880 in the City of Hayward (Alameda County) in the San Francisco Bay Area. The study estimated a benefit-cost ratio of 3.4:1 for the FSP program at this test site on the basis of observed incident delay savings, and reductions in fuel consumption and pollution emissions. Corresponding work in Los Angeles (Skabaridons et al. 1998) described an FSP evaluation on a 12.6 km (7.8 mi) segment of Interstate 10 (Los Angeles FSP Beat 8). In this location, the estimated benefit-cost ratio is greater than 5:1. In addition, daily reductions in air pollutant emissions include a total of 60 kg of hydrocarbons, 472 kg of carbon monoxide, and 122 kg of oxides of nitrogen.

Latosi et al. (1999) estimated benefit cost ratios for 24-h and daytime operation of the Hoosier Helper FSP in Indiana. The study yielded a benefit-cost ratio greater than 4.7:1 for the daytime program and a benefit-cost ratio of almost 13.3:1 for the 24-h program operation. The difference in these two values is primarily due to economies of scale resulting from further allocation of fixed costs. This was a relatively comprehensive attempt to assess FSP costs and benefits. Estimating benefits involved computing a dollar savings value for nonrecurrent congestion delay savings, secondary crash reduction, and vehicle operation costs savings.

As noted above, the use of public fleets as probe vehicles has received less empirical attention than the cost effectiveness of FSP deployments. Titan Systems (1993) used probe vehicles to demonstrate the feasibility of collecting real-time vehicle trip data for origin-destination (O-D) studies. Volunteers drove probe vehicles equipped with AVL systems from home to work (CALTRANS District 8 headquarters). These systems recorded trip information, including vehicle route and speed data. Data gathered during the demonstration period showed that probe vehicles are a cost-effective alternative to conventional O-D surveys and demonstrated that probe vehicles can be used to collect comprehensive data on personal and fleet vehicle travel behavior.

Wei et al. (1995) investigated the prospective role and potential of FSP data, when combined with other data sources such as loop detectors or closed circuit television, to improve traffic management center surveillance and monitoring capabilities. The authors reported that FSP trucks are the most effective tool for detecting and clearing incidents, suggesting that FSP truck data such as incident information and average speed could be fed into an Advanced Traveler Management Information System (ATMIS). Incident information can predict incident occurrences and impacts.

Westerman et al. (1996) examined whether and how to combine loop detector and probe vehicle data to enhance the quality of real-time traffic information, and how to use probe vehicle data to enhance the reliability and accuracy of travel time estimates. This study was based on the assumption of a dedicated fleet of vehicles operating exclusively or principally as probes, and it assessed three approaches to obtaining data for ATMIS: (1) infrastructure-based induction loop detectors; (2) probe vehicles; and (3) a combination of the two. The authors showed that integrating loop detector and probe vehicle data enhances the reliability and accuracy of travel time estimates and incident detection. When integrated with loop detector data, probe vehicle location and speed data can (1) enhance the quality of loop detector data to accurately determine the location of a disturbance in the traffic flow; (2) provide observations of traffic flow irregularities more quickly; and (3) provide updates to adjust loop detector measurement errors.

Overview of Los Angeles FSP System

The MTA/CALTRANS/CHP Metro Freeway Service Patrol program is the largest in the nation, operating 144 service vehicles on 40 beats covering 633 center-line freeway kilometers (393 mi) in Los Angeles County. The CALTRANS District 7 Transportation Management Center (TMC) exercises FSP fleet control via the California Highway Patrol’s computer aided dispatch (CAD) system. Each freeway service patrol truck is equipped with an MDT that is periodically polled by the automatic vehicle location (AVL) system. The system includes a Transportation Management Solutions Incorporated (TMSI, now Orbital TMSI) geo positioning system (GPS) that can identify transponder locations to within 100 ft. There is good potential for using the GPS and/or the AVL information to determine FSP truck speeds automatically because field units are polled frequently and GPS locations are sufficiently accurate.

The CHP controls FSP truck dispatch from its facility at the Los Angeles Communications Center (LACC). The Los Angeles FSP Communication and Automatic Vehicle Locator System enables FSP truck drivers and dispatchers at the LACC to communicate with each other. Dispatchers at the CHP LACC use the AVL system, connected to the Level II CAD system, to monitor and communicate with vehicles through mobile data terminals and GPS antennas. An AVL terminal displays real-time incident and status information on a map of Los Angeles County freeways delineating each FSP beat, location, and vehicle status. The Los Angeles County Metropolitan Transportation Authority maintains this system. CALTRANS District 7 monitors and evaluates FSP program effectiveness. CALTRANS also collects statistical data on FSP assists.

FSP Truck Dispatching

Tow truck drivers circulate on assigned freeway beats, traversing the beat in loops. A driver can self-dispatch upon identifying an incident; otherwise, dispatchers at the CHP LACC assign drivers to incidents on each driver’s beat. After servicing an incident, FSP drivers send a voice or MDT conformation message to dispatchers for clearance. Dispatchers append selected contents of these communications to an historic log. Drivers continue on their beats once they receive clearance from dispatchers.

Data Communications

MDTs and AVLs communicate with formatted, coded data. MDT systems are becoming prevalent because they are relatively
interference-free and transmit, process, and display status messages automatically. Communication takes a fraction of a second rather than the minutes required to complete voice communication.

All MDT-equipped FSP trucks also have GPS receivers and antennas for linking to a public-access satellite system to determine a vehicle’s location. Location data transmits over radio and updates automatically every 2 min. The system can also track specific vehicles. A modem converts both GPS and MDT data into signals for transmission to LACC.

**FSP Truck Operating Characteristics**

Contractors providing FSP service are responsible for reporting vehicle status, and each truck is equipped for this task. Since most FSP trucks are self-dispatched, the CAD system is important for ensuring that contractors are executing work agreements, patrolling beats, and providing services to motorists. This process already involves extensive status checking of FSP trucks.

Given the nature of the work, it seems likely drivers can easily announce their status when operating as probe vehicles. However, drivers employed by contract companies and their employers may be reluctant to add to driver responsibilities, whether by announcing route status or by altering driving behaviors to permit trucks to operate effectively as probe vehicles. These would constitute additional tasks relative to the responsibilities called out in existing FSP contract agreements, and contractors would be unlikely to agree to such a change without additional compensation.

**Minimum FSP Truck Density for Probe Vehicle Applications**

The number of FSP trucks required to obtain an appropriate sample size is directly related to the length of an FSP truck beat, the speed reporting frequency, and the overall speed on the beat. Ideally, FSP truck speed reports should be evenly distributed spatially, and sufficiently frequent to impute overall beat speed (a space mean speed) from FSP truck speeds (point speeds).

Since FSP trucks operate in various modes, only a fraction of FSP truck operating time is suitable for probe vehicle activities. Further FSP truck speed averages based on less than three observations are poor estimators of ambient speeds. Three or more observations provide more accurate average speed estimates with considerably less variance than a single observation. Consequently, larger sample sizes and more accurate truck working status classifications are needed when deploying FSP trucks as probe vehicles.

**Availability of FSP Trucks**

The FSP Statistical Reports (CALTRANS 1996a,b, 1997a,b, 1999a,b) contain information on FSP activities, including service areas, incident frequencies, and durations. The service activities data reveals the expected proportion of time FSP trucks can run as probe vehicles and the spatial density of probe vehicle FSP trucks. Fig. 1 illustrates the division of FSP truck activities during operating hours.

The number of FSP truck in-service working hours is the time limit for using the trucks as probe vehicles. Since the standard operating procedure allows drivers a 15 min break per shift, net working hours per vehicle equals 7.5 h. Net patrol hours (NPH) equals net working hours (7.5) less service time and time needed to change direction. This is actually an upper bound on NPH, because this value includes periods during which an FSP truck is slowly approaching an incident. However, field observations indicate that this is a relatively tight upper bound. The FSP Statistical Report is a good reference for estimating average total service time. This estimation indicates that, on average, an FSP truck can operate as a probe vehicle for 70% of its weekday operation, or an average of 5.6 h.

**FSP Truck Density**

The density of loop detectors in CALTRANS District 7 is relatively high. This provides a good environment in which to compare the respective level of service estimates provided by loop detectors and by FSP mobile data terminals from which probe vehicle data have been extracted. However, even if FSP trucks make acceptable probe vehicles, the question of whether the FSP fleet can provide a useful representation of network level of service may be moot if the quantity of information provided by an FSP truck is very small relative to the quantity of information provided by the loop detectors on the truck’s beat. A probe vehicle may be better than nothing if no loop detectors are available, but it may not be much better.

**Current Density**

FSP trucks scattered throughout the service area are point speed estimators when operating as probe vehicles. FSP truck density gives the approximate density of these point estimators on the freeway. Over 630 freeway center-line kilometers (393 mi) in Los Angeles County are patrolled by 144 FSP trucks. Only truck densities and headways for FSP trucks patrolling under normal conditions are relevant for probe vehicle purposes. The average probe vehicle density (APVD), the density of FSP trucks that can serve as probe vehicles in the study area, is 0.08 probes/directional kilometer (0.13 probes/mi). The reciprocal of this value is average probe vehicle distance headway (APVDH), or 12.4 directional kmi/probe (7.7 mi/probe).

An APVD of 0.08 probes/km is only about 10% of the average loop detector density on corresponding Los Angeles freeway segments. Thus, even the relatively large, MDT-equipped fleet of FSP trucks operating in Los Angeles must provide considerably less data than freeway segment loop detectors (Table 1). However, Los Angeles freeways are heavily detectorized. Many more remote areas, such as San Francisco, have many fewer or no loop detectors, and public fleets might still provide useful LOS estimates in these locations.

**Determining Requisite Number of Trucks for Probe Operations**

The following example estimates the number of FSP trucks needed for probe vehicle operations on a freeway beat not equipped with loop detectors. Assuming that beat length is 11.9
Table 1. Detector Density on Selected I-5 Segments in Los Angeles

<table>
<thead>
<tr>
<th>Freeway</th>
<th>Segment</th>
<th>Length of detectors (km)</th>
<th>Number of detectors (detectors/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-5 NB</td>
<td>Artesia--Western 2</td>
<td>44.9</td>
<td>54</td>
</tr>
<tr>
<td>I-5 NB</td>
<td>Alameda 1--Hungry Valley</td>
<td>43.0</td>
<td>33</td>
</tr>
<tr>
<td>I-5 SB</td>
<td>Hungry Valley--Broadway</td>
<td>93.9</td>
<td>56</td>
</tr>
<tr>
<td>I-5 SB</td>
<td>Marengo--Osmond</td>
<td>29.8</td>
<td>41</td>
</tr>
<tr>
<td>Total (average)</td>
<td></td>
<td>211.6</td>
<td>184</td>
</tr>
</tbody>
</table>

Center km (7.4 mi), average speed on the beat is 64.4 km/h (40 mi/h), FSP trucks report speed at 2-min intervals, and the minimum required sample size is three trips in either direction, the one-way travel time is

\[ t = \frac{l}{v} = \frac{1}{60} = 11.1 \text{ (min)} \]  

(1)

During time period \( t \), an FSP truck will report speed \( t/2 \) times per beat direction. The number of FSP trucks, \( X \), needed to report speed information for a sample size of three is

\[ xX\frac{t}{2} = 3 \text{ (observations)} \]  

(2)

Therefore

\[ x = \frac{2}{11.1} \times 3 \times 11.9 \text{ km} = 1.08 \text{ (probes/beat)} \]  

(3)

Thus, 1.08 probe vehicles are required per beat to generate the minimum relevant sample size for estimating ambient directional beat speeds.

However, not all FSP trucks can operate as probe vehicles simultaneously, because they do not move continuously. Given the 5.6 net patrol hours available per eight truck working hours, it follows that the total number of required FSP trucks, \( X \), is

\[ X = \frac{8.0}{5.6} = 1.54 \text{ (trucks/beat)} \]  

(4)

Thus, in this case, at least two FSP trucks would be needed to generate the required minimum sample size of three speed observations in either direction on the subject beat.

Data

Processing Single-Loop Detector Speed Data

Detector log speed entries are point speed estimates averaged over the reporting interval (once per minute). Each individual speed value in a loop detector log file represents traffic speed at a specific location on the freeway at a particular point in time. Consequently, measures such as floating car speeds should not be compared directly to loop detector log spot speeds (Coifman 1997). It is necessary to convert loop detector speeds to a more aggregate measure. There are two methods for transforming loop detector spot speeds to average speeds that are consistent with the spatial and temporal characteristics of floating car speeds. These methods produce:

- A simple average speed (SAS), and
- A travel time-based average speed (TTAS).

Simple Average Speed

Computing SAS requires two steps. First, for time periods identical to those of the corresponding floating car survey, compute an average point speed (APS) for each loop detector location

\[ APS_i = \frac{\sum_{i=1}^{T} S_i}{T}, \quad i = 1, 2, 3, \ldots, N \]  

(5)

where \( T \) = travel time of the corresponding probe vehicle (min); \( i = \) \( i \)th working loop detector in the survey segment; \( N \) = number of working loop detectors in the segment; and \( S_i \) = speed at \( i \)th working loop detector at time \( t = 1, 2, \ldots, T \).

Second, compute the simple average segment speed (SAS) by averaging all APS\(_i\) over the entire freeway segment

\[ SAS = \frac{\sum_{i=1}^{N} APS_i}{N} \]  

(6)

Eq. (6) is a simple, unweighted average of the speeds over all working detector locations. Unfortunately, when variance in spot speeds is large, SAS tends to underestimate the impact of low speeds and may bias travel time estimates downwards.

Travel Timed Based Average Speed

The TTAS method is introduced here to overcome some of the bias in SAS values by better accounting for the impact of low-speed road segments. The selected freeway segment is divided into subsegments equal to the number of working loop detectors. Each loop detector is located at the midpoint of each subsegment. Speeds are weighted by subsegment length. Total travel time for the segment is the sum of subsegment travel times, so

\[ L = l_1 + l_2 + \cdots + l_N \]  

(7)

\[ T = \sum_{i=1}^{N} T_i \]  

(8)

and

\[ TTAS = \frac{L}{T} \]  

(9)

where \( l_i \) = length of \( i \)th subsegment; \( T_i = l_i / APS_i \); \( APS_i \) = average point speed at \( i \)th working loop detector from Eq. (5); and \( N \) = number of working loop detectors.

Comparing SAS and TTAS Estimates

If a comparison of SAS and TTAS estimates based on the same data demonstrates the expected bias in the SAS values, this is evidence that the TTAS estimates offer improvement. Fig. 2 compares SAS and TTAS values computed for the loop detector log data. If spot speeds are constant for all loop detector locations along a freeway segment, then SAS and TTAS values should be equal. However, SAS values consistently exceeded TTAS values, and are more likely to exceed TTAS values when TTAS is less than 32.2 km/h (20 mi/h), TTAS and SAS values are similar for TTAS values greater than 32.2 km/h (20 mi/h).

Figs. 3(a and b) compare SAS and TTAS values for westbound and eastbound travel, respectively. In this sample, the difference between TTAS and SAS is related to travel direction. The series of speed observations shows significantly higher westbound traffic speeds at upstream locations. This wide variation in westbound speeds (and delays) causes the simple average segment speed to bias estimated segment speed upward in the case of westbound flows [Fig. 3(a)].
digital audio tape (DAT) tape. CHP LACC personnel provided data for the last two weeks of April 1999 and the second half of September 1999.

**Filtering CAD Data**

Unlike the near real-time AVL terminal FSP speed data, the LACC historic FSP data file does not include FSP truck status details. As a result, historic average speed data includes FSP trucks in working status (Code 1098), as well as trucks “approaching to attend an incident,” and “towing a vehicle.” Approaching or towing trucks are actually in working status Code 1097. Field observations show that FSP truck speeds are highest when trucks are cruising on the freeway looking for vehicles to assist. FSP truck speed is slower in any other work status. Consequently, historic FSP truck speed data tends to underestimate ambient traffic speed, with greater variance than ambient speed data.

Historic log speed data for four weekdays in September 1999 were cleaned to delete observations unlikely to reflect ambient speeds. The first step in this process was discarding speed data for which truck status is not coded 1098. Code 1098 indicates that the FSP truck is roving. However, code 1098 does not necessarily mean that the FSP truck is operating in a fashion appropriate for a probe vehicle. Rather, the FSP truck is not servicing a vehicle, nor dispatched to an incident. For example, an FSP truck driver may take a short break while in 1098 status. However, the LACC log file shows that some trucks are stopped for several minutes while in status 1098. This is understandable. It is easy to imagine traffic conditions requiring a driver to stop even while in roving status.

Consequently, it was necessary to filter and order the log data using two additional criteria. First, if data indicate an FSP truck was stationary for two minutes or longer, the team determined the truck was not roving and omitted corresponding speed data from the analysis. Second, direction of travel data indicate whether FSP truck movements were unusual, e.g., inconsistent with the roadway orientation. The analysis omits data describing trucks with unusual movements. Specifically, the azimuth component of a roving truck’s movement should fall within a particular range for an FSP truck on a given beat. This reading depends on truck travel direction on the freeway. FSP trucks with azimuth readings...
outside these ranges are likely executing maneuvers other than normal (Code 1098) cruising.

The final filtered data set certainly includes some observations that do not correspond to roving behavior. However, the filtering criteria are conservative. It is more likely that some legitimate roving exercises were excluded than it is that observations associated with other activities were included.

Floating Car, Probe Vehicle, and Single-Loop Detector Speed Estimates

It would be ideal to simultaneously collect data describing the same traffic stream from single-loop detectors, FSP trucks operating as probe vehicles, and floating cars. However, this is logistically difficult under the best circumstances and was impossible in this case, because the investigators' access to electronic CAD data was interrupted during the course of study. Limited data describing FSP truck speeds was available continuously from the AVL station in the CALTRANS District 7 TMC, but this information must be extracted manually in near real-time and could not be generated in sufficient quantity to replace the data in the CAD log files. Since access to CAD data was delayed for institutional reasons, it was necessary to compare loop detector data to floating car data in one survey, and then to compare loop detector data to CAD log data describing FSP truck speeds in a second survey.

Study Location

The location for both surveys is the section of Freeway I-10 between Vermont Ave. and Washington Blvd. (11.9 cemenline km, 7.4 mi) west of downtown Los Angeles, as shown in Fig. 4. This is the same FSP beat selected by Skabardonis et al. (1998) and Bertini et al. (1997). Flow and speed conditions are similar for all lanes of the selected freeway segment, allowing a single floating car to measure ambient speed accurately. The research team collected speed data during a field survey in November–December 1997, conducted from 8:00 to 9:15 A.M. weekdays.

Comparing Floating Car and Single-Loop Detector Speed Estimates

Survey 1 compares floating car speed estimates with speed estimates from single-loop detector log files downloaded from the mainframe computer in the CALTRANS District 7 TMC. One investigator drove a floating car along the freeway segment to collect speed data. Immediately following each survey period, the team downloaded corresponding loop detector log data. Figs. 5 and 6 compare floating car speeds with corresponding loop data SAS and TTAS values. The floating car speed is the reference speed. The vertical distance between each coordinate and the 45° line indicates the magnitude of the error term in each speed estimate. The root mean square error (RMSE) for SAS estimates is approximately three times that for TTAS values. The coefficient of determination ($R^2$) is also far smaller for SAS than TTAS, which is approximately 0.92. This suggests that TTAS is a more accurate speed estimate than SAS under the (representative) peak conditions observed during the survey period.

FSP Truck/Probe Vehicle and Single-Loop Detector Speed Estimates

Survey 2 compares speeds estimated from loop detector and probe vehicle data. Floating car speeds are not available in this case for simultaneous comparison with loop detector and FSP truck speeds. However, floating car speeds and TTAS values co-vary closely. As before, the CALTRANS District 7 mainframe computer generated loop detector volume and speed data at 1-min intervals. These observations corresponded to the beats, dates,
and time periods in the postprocessed FSP historic log data set. In some cases, loop detector data were not available because loop detectors were not working.

Fig. 7 shows the comparison between all historic FSP truck speeds and all corresponding loop detector log speeds. Covariance between these measures is weak. Directional and aggregate RMSE values for FSP/loop comparisons are significantly higher, and $R^2$ values significantly lower, than corresponding values for comparisons of TTAS estimates and floating car speeds. In addition to the higher variance, historic FSP truck speeds tend to underestimate speed significantly as compared with loop detector estimates. Given the close covariance between loop detector TTAS estimates and floating car speeds, FSP trucks operating in the fashion captured by the CAD log file are providing LOS information of much lower quality than the information provided by floating cars. Los Angeles FSP trucks are not roving in a fashion that makes them good candidates for use as probe vehicles.

As a result of the disparities in these comparisons, research assistants conducted FSP truck tracking surveys by following FSP trucks on various freeway beats during different time periods to gather further statistical data. These observations provide further qualitative assessment of how truck speeds relate to ambient speeds, what proportion of time trucks might act as probe vehicles, and what changes in FSP procedures would be required. The tracking surveys reinforce the result that current FSP truck operations would not support use as probe vehicles. FSP trucks do not necessarily travel at the same speed as ambient traffic, particularly when a driver is searching for or towing a disabled vehicle. Most trucks are not centrally dispatched because the FSP fleet is so large and incidents are so frequent; drivers usually identify disabled vehicles first and report the incident via the CAD system. This suggests that FSP drivers conduct considerable ongoing surveillance of the shoulders and guideways. When level of service is high, the attention necessary to provide surveillance may limit FSP cruising speeds. If so, the probe information trucks provide may be misleading. However, this mismatch was less likely under congested conditions when traffic, rather than driver attention, constrains FSP truck vehicle speed.

It is unclear from the qualitative observation if the differences between ambient traffic and FSP truck movements are systematic enough to be parameterized. If these differences are systematic enough to be predictable, then FSP trucks might still make effective probe vehicles. Unfortunately, this is not the case. Fig. 7 shows that these differences are mostly random and thus unpredictable.

The usefulness of FSP trucks operating as probe vehicles is limited, even when CAD log data is readily available. Combining FSP truck speeds with loop detector speeds to obtain ambient speed is not recommended. The quality of the probe data is such that this approach does not improve the accuracy of detector speed estimates.

**Conclusion**

This research assessed the feasibility of using trucks in an existing Los Angeles FSP fleet as probe vehicles to measure ambient speed on freeway segments. Floating car speeds were the basis of comparison with other speed data. Loop detector-based segment speeds and FSP truck speeds were compared against a common baseline.

**Findings**

To be useful LOS measures, FSP truck speeds should represent ambient speeds. If this is not the case, then the difference between FSP truck speeds and ambient speeds must be systematic enough to allow ambient speed to be inferred through appropriate statistical adjustments to truck speeds. Current log records of Los Angeles FSP truck speeds do not satisfy this requirement. FSP truck speed data available from the existing system are of insufficient quality to estimate ambient speeds.

Comparisons between floating car and FSP truck speed records reveal that FSP truck speed is a poor measure of floating car (ambient) speed. FSP truck speed records underestimate floating car speeds overall, and covariance between the two is weak. Travel time average speed estimates extracted from loop detector data do covary closely with floating car speeds. Differences between the FSP and other speed estimates do not appear system-
atic. FSP truck speeds can differ from ambient speeds for several reasons, including driving characteristics and beat geometry.

Even when FSP trucks are patrolling normally (status 1098), truck speeds rarely represent ambient speeds. Current status classifications do not sufficiently differentiate various FSP truck operations. Further subdividing FSP truck working status codes to incorporate details distinguishing probe-like truck operations would be needed to improve measurement of ambient speeds.

Sample size necessarily affects the accuracy of FSP speed estimates. A maximum of 70% of FSP truck operating hours are available for probe vehicle operations (Los Angeles County MTA 1995; CALTRANS 1996a,b, 1997a,b, 1999a,b). This is an upper limit. A sample of at least three FSP truck speed readings is needed to produce a meaningful estimate of ambient speeds on an FSP beat. It may be possible to increase sample size by increasing the rate at which FSP truck speeds are polled.

**Recommendations**

The results of this study are not encouraging. Los Angeles FSP trucks do not constitute an adequate source of probe vehicle data as deployed. However, the potential benefits of success are substantial, because it is much simpler to equip public fleets with telemetry than it is to retrofit roadways with telemetry. The research indicates that the following steps would have to be taken before the Los Angeles FSP fleet could be put into routine service as probe vehicles:

- Identify the different operations subsumed in FSP working status Code 1098 and assign new status codes to these conditions. This will help determine when trucks are operating in a fashion consistent with the role of probes.
- Program the host computer at CHP LACC to automatically record and postprocess FSP truck speed information. For system-wide reporting, the host computer should be able to poll all FSP trucks frequently and simultaneously, and to process the data to provide near real-time speed information. A separate study is needed to establish the necessary system requirements and hardware/software capabilities to achieve this.
- Perform an experiment making deliberate use of FSP trucks as probes rather than passive use.
- Provide additional training to FSP truck drivers on driving requirements while operating FSP trucks as probe vehicles. Revise operational and institutional components of FSP operating procedures accordingly.

**Acknowledgments**

The California Partnership for Advanced Transit and Highways (PATH) sponsored this research. This interagency project would have been impossible without the generous assistance and cooperation of the California Department of Transportation, the California Highway Patrol, and the Los Angeles County Metropolitan Transportation Authority, the three agencies that sponsor and operate the Los Angeles Freeway Metro Service Patrol. The writers are particularly indebted to Captain Ron Newton, John Keller, Patrick Burnett, and Robert Nannini of the CHP Office of Special Projects; to Marghi Davidson, Sandy Hill, and Sharlene Turner of the CHP’s Los Angeles Communication Center; to CALTRANS’ New Technology and Research Program; to Steve Leung, David Lau, Hasan Safari, Trieu Nguyen, and Amahayes Dimiru of CALTRANS District 7, and to Sue King of District 11; and to Byron Lee, Al Martinez, Daniel Ramirez, and Jeff Brabender of the LACMTA Congestion Relief Program. John Lopez, formerly of Orbital TMSI, and Robert Leimbach, of Orbital TMSI, wrote the software program that created the special AVL log file needed to record FSP truck movements. This work does not necessarily represent the opinion of the cooperating agencies. Any errors are the responsibility of the writers.

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