SUMMARY REPORT OF THE TRAFFIC DATA COLLECTION AND WEIGH-IN-MOTION EXPERT TASK GROUPS

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Final Report

for Purchase Order #19823

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818 Connecticut Avenue, 4th Floor
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October 14, 1988

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SUMMARY REPORT OF THE TRAFFIC DATA COLLECTION AND WEIGH-IN-MOTION EXPERT TASK GROUPS

This report documents the conclusions of the Traffic Data Collection and WIM Expert Task Groups (ETGs). It summarizes the data collection plan for the SHRP LTPP project, lists the primary actions required by the SHRP executive committee, describes the reasoning behind the selection of the preferred alternative, gives advice on the selection of equipment, provides insight into the intent behind the various recommendations, describes the major points made during the meetings of the two ETGs, and provides general guidance to SHRP on the collection, submittal, and manipulation of traffic data for the LTPP project.

The paper is divided into the following major sections:

- Introduction,
- Traffic data needs,
- Description of the required data collection plan,
- Alternative data collection plans considered,
- Submittal of historical traffic data,
- Limitations of the traffic data,
- Weigh-in-motion considerations, and
- Actions to be taken by SHRP.

Additional input on subjects discussed in this paper can also be obtained by contacting Mr. Mark Hallenbeck at (206) 543-6261.

INTRODUCTION

The states will be collecting traffic data for the LTPP project to measure the loadings applied to specific test pavements. The LTPP planned experiments are intended to improve the industry's knowledge of the causes of pavement failure by analyzing pavement degradation with known traffic loadings, pavement structures, and environmental conditions at each test location. A better understanding of the causes of pavement failure

should lead to better design and construction of pavement and, thus, substantial savings to the public in construction and maintenance costs.

The ideal traffic data for the SHRP LTPP study would comprise weigh-in-motion data for all days since each selected pavement section opened for traffic. Unfortunately, for no site does such a database exist. In most cases, a minor amount of traffic volume and classification information has been kept by state agencies for GPS pavement sections, and in a few cases, vehicle weights have been taken at sites near the GPS locations. Even in future years, few states will be able to deploy and operate WIM permanently at GPS sites because the costs of WIM equipment and data collection are so high. Therefore, SHRP must rely on a sample of traffic volumes and weights to reduce the required amount and cost of data collection to a level which more acceptably matches available funding and resources.

When considering traffic data collection issues, the ETGs determined that data from two time frames were relevant, "historic data" (i.e., those data previously collected on or near GPS sites from the time they were constructed until the present) and "new data" (those data which could be collected after GPS sites were selected and SHRP traffic data collection activities could begin).

In the recommended ETG plan, the data to be submitted from these two time periods differed. Little choice was available to the ETG on the type and quantity of historical data that could be submitted. Therefore, the ETG has recommended that the states submit what data <u>are</u> available, along with descriptions of how those data are manipulated to represent average annual traffic and traffic loadings. (See the description of the historical data submittal starting on page 19.) Theoretically, ideal data could be collected during the "new" period, but funding constraints limit the "new" data that can reasonably be requested from states specifically for SHRP purposes. Therefore, the ETGs developed the methodology described in this paper, with the intent of providing sufficient data at a lower total cost.

TRAFFIC DATA NEEDS

SHRP researchers require estimates of traffic loadings that have been (and are being) applied to the various LTPP test sections. In addition, they require insight into the seasonal distribution of those estimates. (Loadings during freeze/thaw conditions have a greater impact on pavement deterioration than those occurring outside of the freeze/thaw period.)

One potential way of measuring loadings would be to use WIM equipment to directly weigh axle loadings. If such equipment were available at all sites, the only requirement of a data collection plan would be to evaluate the initial year's data at each site and determine the number and hours of WIM data collection required during a year to adequately estimate annual loadings for each desired time period. Because costs prevent such equipment from being located at each GPS site, an alternative data collection plan must be developed. To provide a means of relating axle loads to the design process, the plan must be tied to traffic data. The traffic data needs for calculating loads are as follows:

- the volumes of vehicles crossing SHRP sections,
- the make-up of vehicles in that traffic stream (vehicle classification), and
- the weight of the axles for each of those types of vehicles.

DESCRIPTION OF THE REQUIRED DATA COLLECTION PLAN

Introduction

As noted above, the ideal traffic data for the SHRP LTPP GPS study would comprise weigh-in-motion data for all days since a pavement section opened for traffic. This scenario was envisioned by many of the researchers who initially conceived the GPS study. Unfortunately, the low-cost WIM equipment required to allow collection of these data has not yet been adequately developed and is not currently usable at many GPS sites.

The purchase, installation, and operation of traditional WIM equipment for the planned 1,200 GPS sites would cost roughly $48,000,000 over the next six years.[1] Even if the current low-cost equipment were suitable for all GPS locations, the cost of 1,200 sites would be roughly $21,000,000. These costs significantly exceed the funding available through SHRP plus the funds most states expect to contribute to the SHRP effort. As a result, the Expert Task Groups considered a number of alternative data collection plans. A summary of some of these plans is shown on the attached Exhibit 1.

After reviewing these alternatives and the WIM equipment limitations, the ETGs task groups developed the plan outlined below. This plan provides the minimum level of data collection the group believes is necessary for the successful completion of the LTPP project. The ETGs estimated that the cost of this minimum plan is roughly $14,000,000 for the purchase, installation, and operation of automatic vehicle classification (AVC) equipment and another $13,000,000 for the purchase and operation of weigh-in-motion equipment. However, the WIM equipment cost for this recommended plan could be reduced with the use of existing portable equipment already owned and operated by the states.

Recommended Data Collection Plan

The states should collect continuous WIM data at each GPS site, if possible.[2] Where such data collection is not realistic, the combined task group recommends the following data collection plan:

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[1]This cost does not include the cost of telephone charges for remote data collection, the cost of transmitting the data to SHRP, the cost of transforming the data submitted into a single SHRP database, or the cost of equipment and site maintenance. These costs may be substantial.

[2]A site is similar for weighing if the traffic experienced by the sensor at the WIM site is the same as that experienced by the pavement at the GPS site. That is, 50 miles may separate the two sites, but the same basic traffic stream that passes the WIM point passes the GPS section. (No major intersections should alter the flow of traffic between the weigh station and the GPS site.)

CANDIDATE DATA COLLECTION SCENARIOS

	PROS	CONS
Desired Data Collection Plan		
Permanent WIM at each GPS site Cost[1] = $48,000,000 for 1,200 sites Probable Error[2] = 10%	Directly measures traffic volumes and axle loadings at each site	Requires WIM purchase, installation, and operation at each site Cost is prohibitive
Recommended Data Collection Plan		
Permanent WIM at some sites Short Duration WIM at each GPS site Permanent AVC at each GPS site Cost = $27,000,000 Probable Error = 18%	Provides a good baseline database Provides some site specific weight data Provides some measurement of seasonal variation of weight data Reduces the number of WIM devices required Allows use of existing state WIM equipment	Cost still exceeds SHRP funding Lose some accuracy by transferring seasonal variation from "master" stations to specific GPS sites Requires examination of transfer process States will need assistance selecting permanent WIM locations
Alternative Data Collection Plans		
Four Short WIM counts at each site each year Permanent AVC at each site Cost = $53,000,000 Probable Error = 18%	Provides some site specific weight data Provides some measurement of seasonal variation of weight data Reduces the number of WIM devices required Allows use of existing state WIM equipment Provides a good baseline database	Cost still exceeds SHRP funding Lose some accuracy by lack of year year-round weight data collection States will need assistance selecting permanent WIM locations
Annual Short Duration WIM at each site Permanent AVC at each site Cost = $25,000,000 Probable Error = 35%	Provides some site specific weight data Provides a good baseline database Reduces the number of WIM devices required Allows use of existing state WIM equipment	Cost still exceeds SHRP funding Lose some accuracy by lack of year-round weight data collection States need assistance selecting permanent WIM location No information on seasonal variation of truck weights
Annual Short Duration WIM at each site Short Duration AVC at each site Cost = $18,000,000 Probable Error = 50%	Provides some site specific weight data Reduces the number of WIM devices required Allows use of existing state WIM equipment	Cost still exceeds SHRP funding Lose accuracy by lack of year-round weight data collection States need assistance selecting permanent WIM locations No information on seasonal variation of truck weights Poor baseline for historical traffic levels and loadings

[1]Cost estimates are for the total four years remaining in the current SHRP funding period. They include equipment cost, installation and operation of the AVC and WIM equipment, but do not include the cost of telephone charges, or of data manipulation both before and after submittal to SHRP.

[2] Probable Error is a crude estimate of the magnitude of error likely to be present in the calcuated number of total loadings (i.e., 2,000 axles in the 1,000 lb category, 3,000 axles in the 2,000 lb category) at each GPS site. It is presented here only as a means of providing some assistance in comparing the quality of data likely to be produced by the different data collection scenarios. It is not a true measure of the actual confidence limits of the data collection plan.

- Automatic vehicle classification equipment, operating 365 days per year, should be installed at each GPS site by June 1992. The earlier this equipment is installed and operating, the better for the SHRP project.
- Axle weights should be collected at each GPS site. By December 30, 1992, axle weights should be collected for a minimum of 48 continuous hours during weekdays and 48 continuous hours during weekends for each truck season.[3] (One week of continuous data is preferred but is not practical in many states.)
- In addition to the site specific weighing, SHRP requires the installation and operation of a limited number (minimum of 30) of WIM sites that operate 365 days per year for measuring the temporal variation in weight data ("master" locations). These sites do not necessarily have to be at SHRP GPS locations.
- 365-day WIM sites should be located to collect data that are representative of regional truck weight patterns (i.e., patterns that are present in one or more states), as well as the patterns of the host state. In many cases, data collected at these sites will be used by SHRP at GPS sites in more than one state.

Once installed, AVC equipment should be left operating at GPS sites if possible. If funding limitations are severe, a single year of AVC counting is acceptable, although not desired by the ETGs.

Weighing sessions should be performed with WIM devices that meet the accuracy standards chosen by SHRP. The ETGs recommend the adoption by SHRP of the standards HELP and/or ASTM are currently developing.

3A "truck season" is defined as any significant change in commodities or expected truck weights which occurs during a calendar year. For example, truck weights for specific vehicle types may change several times each year in agricultural areas as different crops are harvested.

Background for the Plan

The intent of the data collection program recommended above is to provide sufficient (but cost-effective) data to SHRP researchers so that variations in traffic characteristics caused by fluctuating traffic levels can be estimated and included in the pavement deterioration analyses to be conducted in the LTPP program. The data to be collected for each GPS site must pertain to that GPS site and can not be a "system average." This is because the actual loadings experienced by each GPS site are expected to vary significantly from site to site because of variations in the number of trucks, the types of trucks, and the weight of trucks between sites. Because the LTPP project is concerned with site specific pavement deterioration, the pavement performance of respective sites must be well matched with the actual loadings impacting that pavement.

To understand existing variations in traffic, measurements must be taken to determine the fluctuation of traffic characteristics across hours of the day, days of the week, and seasons of the year. This is because traffic characteristics vary from site to site, depending on such factors as

- local economic development,
- the amount of "through" traffic,
- levels of weight enforcement and
- a variety of other variables.

While some traffic trends are probably fairly constant between similar sites, local changes in economic or enforcement activity may cause significant changes (both long- and short-term) at some sites while not impacting others. Consequently, data collected at one location may or may not be applicable to other locations. Thus, a reasonable amount of data collection must take place at each site.

This need for site specific data collection must be balanced against the cost of collecting data at those sites. Sampling of traffic characteristics at each site would reduce the number of traffic data that might need to be collected and processed, but a good sampling plan requires prior knowledge of the population being sampled in order to

adequately match the sample size to the expected sample accuracy. In most cases, the available traffic data at each GPS site are considerably less than what would be necessary to decide on a valid sample. Furthermore, in order to collect adequate amounts of traffic data to develop a sampling plan, equipment would need to be placed on a long-term basis (i.e., a minimum of one-year) at these sites.

Once this database existed, a good sample design could reduce the amount of data collection required to adequately measure the traffic characteristics. However, once the data collection equipment was in place, it would be less costly to let the equipment run continuously than to send traffic counting staff to the site to perform short duration sampling counts. Thus, the concept of sampling has only limited application to the LTPP effort.

To address the need both for site specific information and limited data collection cost, the ETGs designed a data collection plan that features both short and long duration, on-site data collection, as well as some regional long-term data collection. This plan is structured so that sufficient site specific data can be collected at each site to allow the appropriate "pattern" information determined at regional sites to be identified for and applied to individual GPS locations.

Site Specific Data Collection

Two types of site specific traffic data collection are requested in the recommended plan, vehicle classifications and truck weights. Vehicle classification data will be collected from 365-day per year traffic recorders. Truck weights at each site will come from short duration measurements in most locations.

The collection of vehicle classification data provides SHRP researchers with the total traffic volume on SHRP sections by vehicle category. Thus, traffic volumes are a "free" output of the classification counts.

Because vehicle class information also provides volume data, the use of continuous automatic vehicle classification counters at each site eliminates the need for "traditional" ATR stations. The permanent AVC stations will provide the same data on traffic

fluctuations by time of day, day of week and season as an ATR station, while at the same time providing information on the number and type of vehicles passing those points.

The cost of a permanent AVC site is only marginally greater than that of an ATR site. (The ETGs estimate that an AVC costs $2,000 more per site than an ATR.) Thus, while an ATR station was originally envisioned by many professionals, the ETGs determined that the benefits gained by having an AVC in place of an ATR would significantly improve the usefulness of the data, while adding only marginally to the cost of the data collection effort.

The need for 365 day counts at each site is a result of two issues. First, it is important to understand how truck volumes at each site vary over the year. Truck volumes at some sites will vary considerably as a result of the activities in the surrounding region, while other sites will show relatively minor seasonal changes. Without a measure of seasonality at each site, short duration counts would likely provide misleading information concerning annual volumes at that site. (For example, if the short count was taken during a high truck volume period, the total number of axles impacting the road would be over-estimated.) Vehicle counts over 365 days will provide seasonal fluctuation data for all truck types throughout the year.

This information is also important for examining historical traffic data. While traffic volumes change continuously, changes from year to year are fairly small. (For example, a high growth rate for a site is above 5 percent per year, whereas, the difference between January and June traffic levels are often as large as 50 percent.) Thus, a single year of 365 day AVC counts will not only provide invaluable information on the fluctuation of traffic from January to June, it should significantly improve the estimates of total traffic loadings on a GPS section since the section was opened by providing a baseline against which historic short count data can be compared and evaluated.

Thus, knowledge of the yearly patterns of traffic at each GPS location and a "true" measure of annual traffic (not relying on seasonal factors of any kind) will markedly

increase the accuracy with which SHRP researchers can estimate total traffic volumes experienced by that section of pavement.

Truck weight data have the same variability problem as vehicle classification data. However, the cost of permanent WIM systems tends to be much higher than AVC systems. Piezo-electric WIM scales offer some promise of WIM at a cost only marginally higher than AVC, but research to-date has not shown that piezo WIM can be confidently installed in U.S. asphalt pavements, and only one concrete cement pavement installation is currently functioning in the U.S. Until piezo-electric WIM has been proven, or another low cost WIM system has been developed, SHRP will need to limit the number of weight data it collects to reduce the resource requirements of the project.

The ETGs decided that an acceptable method for collecting weight data would require at least a limited number of weighing sessions at each GPS site. These weighing sessions would then be supported by a limited number of WIM locations at which weights would be measured year-round.

The recommended plan calls for WIM at each GPS site at least once for every trucking season during the initial SHRP funding period. This data collection is intended to calibrate the WIM data for each GPS location. That is, it will determine how much trucks of a specific axle configuration weigh at a specific GPS site. How these weights change over time will be measured in two ways.

First, since truck weights will be measured for each truck season at each site, the site specific weighings will indicate how weights change over time at a specific location. Second, the long term weighings will reveal the year's seasonal trends. The ETGs believe that the combination of seasonality from the AVC counts at each GPS site, the site specific weighings at each GPS site during each truck season, and the variation of weights at the regional 365-day WIM sites will provide sufficient data to adequately measure the seasonal variation of weights and axle loadings at each of the GPS sites.

To further enhance the site specific nature of the data, the ETGs recommend that a minimum of 48 hours of continuous weighing take place during both weekdays and

weekends for each of the truck seasons. These data are important for measuring the site specific fluctuations of weights between weekdays and weekends and for comparing site specific weight variation with 365-day weight variation. Forty-eight-hour counts were selected as a compromise between the desire for week long measurements and the high staffing costs of collecting WIM data with portable equipment.

The ETGs would prefer that weighing take place for one week at a time at each GPS site, but the staffing requirements for such an effort seem to make this impractical for most states. Still, the collection of week long data by the states should be encouraged by SHRP.

Site specific WIM data will not only serve to measure current vehicle weights at each GPS site. They may also be useful (under the direction of SHRP researchers) in "calibrating" the old truck weight data collected previously and submitted to FHWA. Because of the nature of static weighing, the existing FHWA truck weight estimates under-represent the number of heavy vehicles using U.S. highways. The WIM data should include a more representative sample of trucks. The collection of WIM data at each site provides an opportunity to factor the historical data to better represent the number of overweight vehicles actually on the road, as compared to the number of overweight vehicles measured with static scales. In this manner it may be possible to more accurately estimate the historical weights of vehicles driving on GPS pavements.

Regional Data Collection

Regional data collection takes the form of long-term weight measurements at a limited number of WIM sites. These regional 365-day data will be needed in conjunction with the site specific weight and classification data to estimate the actual annual wheel loadings for each section of pavement. These "master" locations will be used to adjust the site specific weights to represent average annual conditions, much as "master" traffic count locations will be used for converting short duration volume counts into estimates of AADT. For example, if weights in July are consistently lower than the annual average, a factor may

be developed to adjust short duration measurements taken in July to better represent the annual average.

Use of the Data

Because very few continuous weight data exist, it is difficult to estimate the impact that trade-offs between site specific, short duration weighing sessions and regional, long-term counts will have on the accuracy of the weight data collected for SHRP. Therefore, as part of the SHRP effort, researchers must compare the 48-hour data collected at individual GPS sites against the patterns shown in the 365-day counts at regional locations. If the 48-hour measurements, combined with the pattern information collected at the long-term stations, are insufficient to provide accurate estimates of annual, site specific weights (i.e., because axle weights are too variable to be measured with 48-hour counts), then additional weight data will have to be collected at each GPS site during the second 5-year SHRP funding period.

Data Submittal

No forms have been specified by the ETG for "new" traffic information. Truck weight data should be submitted on computer readable tape. The format of the data on that tape should be provided, along with descriptions of the vehicle classes used by the WIM equipment, and the means by which the state converts those classes into the FHWA 13 reporting classifications.

ALTERNATIVE DATA COLLECTION PLANS CONSIDERED

The recommended data collection scenario was developed as a result of a review of a number of alternative data collection plans. The quality of data each plan could provide and the cost of collecting that data were analyzed. The recommended plan is the ETGs' attempt to best match data needs with resource availability.

Description of Preliminary Alternatives

The costs of some of the preliminary scenarios are briefly summarized in Exhibit 2. This table shows the first year costs of each scenario, assuming that all installation costs are

EXHIBIT 2
DATA COLLECTION COSTS
FIRST YEAR COST OF SITES PER SITE

	Low	High
WIM @ each Site (permanent)	$17500	$40000
4 WIM/Yr + AVC @ each site (e.s.)	30208	37108
4 WIM/Yr + 4 short AVC / site	18308	18308
4 WIM/ 3 yr + AVC @each site	20336	27236
4 WIM / 3 yr + 4 short AVC / site	10932	10932
1 WIM / truck season + AVC @ e.s.	26506	33406
1 WIM /truck season + 4 AVC / yr @ e.s.	15230	15230
4 WIM/Yr + 4 short AVC / site + ATR	28208	32708
4 WIM / 3 yr + 4 short AVC / site + ATR	16728	21228
1 WIM /truck season + 4 AVC / yr + ATR	27002	31502
AVC Only (WIM from existing stations)	11900	18800
Semi-permanent AVC Only	5924	5924

born in the first year. Exhibit 3 shows the cost of these scenarios after six years. The costs in the exhibit include those for equipment, installation, and staffing to operate the WIM and AVC equipment. The assumptions used in developing the scenarios include the following:

- **(Scenario 1) Weigh-in-motion (WIM) at each GPS site, operating year round.** This scenario requires WIM installation at each GPS site, plus installation of power and telephone. Costs are based on WIM being installed at one lane only.
- **(Scenario 2) Four WIM measurements per year at each GPS site, along with a permanent AVC (automatic vehicle classification) installation at each site.** This scenario requires portable WIM and sufficient staffing resources to operate WIM equipment at GPS sites for four, one-week periods each year. Roughly 4.5 persons are required to operate the WIM system each week. (The estimate is three persons per day for seven-day sessions, or 21 person-days per session. This, divided by five days per person per week, leaves 4.2 persons. If some time is included for travel, the results are roughly 4.5 persons per week-long WIM session.) In addition to the WIM, AVC will require installation, power and telephone access at each site.
- **(Scenario 3) Four WIM measurements per year, along with four short duration (one-week) AVC counts at each site.** This is similar to Scenario 2, except that no power or installation of AVC equipment are required. Portable AVC equipment is assumed to be placed by the WIM crew so the cost of AVC is negligible. Duration of WIM sessions and staff requirements are assumed to be the same as in Scenario 2.
- **(Scenario 4) Four WIM counts per three-year period at each GPS site, plus a permanent AVC installed at each site.** This is

EXHIBIT 3
DATA COLLECTION COSTS
SIX YEAR COSTS PER SITE

WIM @ each Site (permanent)	$40,000
4 WIM/Yr + AVC @ each site (e.s.)	111,148
4 WIM/Yr + 4 short AVC / site	92,348
4 WIM/ 3 yr + AVC @each site	33,116
4 WIM / 3 yr + 4 short AVC / site	48,092
1 WIM / truck season + AVC @ e.s.	88,936
1 WIM /truck season + 4 AVC / yr @ e.s.	73,880
4 WIM/Yr + 4 short AVC / site + ATR	106,748
4 WIM / 3 yr + 4 short AVC / site + ATR	35,372
1 WIM /truck season + 4 AVC / yr + ATR	99,512
AVC Only (WIM from existing stations)	18,800
Semi-permanent AVC Only	10,544

similar to Scenario 2, above, except that WIM must only be measured during one of the next three years, rather than during each of those years. (One weighing session includes one week of measurement in each of the four seasons.) Because of the reduced WIM measurements, AVC data collection is no longer "free."

- **(Scenario 5) Four WIM counts per three-year period, plus four short duration (one-week) AVC counts at each site.** This is similar to Scenario 4, except that portable AVC equipment is used. It is also similar to Scenario 3 but requires one third of the effort for WIM measurements.
- **(Scenario 6) One WIM session per truck season per year, plus permanent AVC installed at each site.** This scenario is similar to Scenario 2. The scenario is designed to more accurately match the number of WIM measurement sessions to the number of "seasons" in the truck weight population. That is, if truck weight patterns do not have a seasonal fluctuation at a GPS site, then only one week-long weighing session is required. If a GPS site has six distinctive truck weight patterns during the year, six weighing sessions are required. The cost estimate for this scenario assumes three weighing sessions per year for each GPS site.
- **(Scenario 7) One WIM session per truck season, plus four short duration (one-week) AVC counts at each site.** This alternative is similar to Scenario 6 but uses portable AVC equipment instead of permanent counters.
- **(Scenario 8) Four WIM measurements per year, along with four short duration (one-week) AVC counts and an ATR installation at each site.** This alternative is similar to Scenario 3, above, except for the addition of an ATR at each site. The ATR would

provide better information on the fluctuation of total volumes during the year at each site.

- **(Scenario 9) Four WIM counts per three-year period, plus four short duration (one-week) AVC counts and an ATR at each site.** This scenario is similar to Scenario 5, except for the addition of an ATR.
- **(Scenario 10) One WIM session per truck season, plus four short duration (one-week) AVC counts and an ATR at each site.** This alternative is similar to Scenario 7 but includes an ATR at the GPS site.
- **(Scenario 11) WIM at available sites, plus permanent AVC at each GPS location.** This alternative is similar to Scenario 9, but WIM is not required at the individual GPS sites. This alternative assumes that weight values per vehicle type can be measured at sites remote from the GPS locations and transferred to the GPS location.
- **(Scenario 12) WIM at available sites, plus rotating AVC at each GPS site.** This alternative resembles Scenario 11, except that in this scenario, 365-day AVC counts are taken for only one year during the initial five-year period. Electronics for collecting data are rotated between GPS sites to minimize the need to purchase equipment. Short duration AVC counts are taken at GPS sites in those years that 365-day counts are not made.

Review of the Scenarios

On the basis of a review of these exhibits and the data that would be collected under each of these scenarios, the ETGs came to the following conclusions:

- WIM equipment is too expensive to be installed at all sites,
- week-long portable WIM is too expensive for most states,

- a reduction in the number of times weighing could be done at a site with portable equipment would have to be accepted for budgetary reasons,
- ATRs are not cost-effective when compared to permanent AVC equipment, and
- some site specific weighing must be done to maintain the integrity of the site specific axle load estimates.

When reviewing these scenarios, the ETGs were able to group them into several categories. Scenario 1 was the the best alternative from a data collection standpoint but required too many resources to be practical.

Scenarios 2, 3, 6, 7, 8, and 10 substituted annual, seasonal portable WIM equipment in place of the permanent WIM used in Scenario 1. The exhibits show that these alternatives required too many portable WIM measurements to fit within the resource constraints of SHRP, even though they required considerably smaller capital investment. In many cases, the cost of performing a limited number of weighing sessions with portable equipment exceeded that of installing permanent equipment.

Scenarios 4, 5, and 9 attempted to reduce the number of weighing sessions to a level at which the resource requirements would not be overwhelming. However, as can be seen in Exhibits 2 and 3, even this level of data collection would be expensive, while the reduction in seasonal truck weight information would create serious questions about the validity of the weight estimates.

Finally, Scenarios 11 and 12 were developed to show the impact of not collecting site specific weights but of simply using weight estimates from existing weigh stations. The ETGs rejected these alternatives because they would provide truck weight information that was considered unreliable for the individual GPS sites.

SUBMITTAL OF HISTORICAL TRAFFIC DATA

This section describes the submittal of traffic data collected before the implementation of the SHRP data collection plan described above. This data submittal is

intended to provide SHRP researchers with access to the best available data maintained by the states. It is also intended to provide researchers with the background necessary to manipulate the data in their continuing work.

Exhibits 4 and 5 are draft forms for submitting the required data. A minimum of one of each form is required for each GPS site. These forms include space for

- estimates of average annual daily traffic,
- annual growth factors (if employed) in non-count years,
- actual (raw) traffic counts made on the SHRP section (or same volume-defined section),
- factors applying to the counts made of that location (seasonal, axle correction, lane distribution, truck distribution),
- truck classification data,
- the basis for classifying trucks, and
- the agency's method for collapsing the collected truck classifications into the 13 FHWA reporting categories.

It is important that SHRP test these forms on a limited number of states to determine whether they are sufficiently clear or whether revisions should be made before they are transmitted to the remainder of the states. It is important that states provide their best available data but that they do not "invent" numbers. Where data are not available (e.g., they can not be found in the files) states should simply indicate this fact. This will allow the researchers to make any necessary decisions on how best to use the available

Historical Volume Submittal

Exhibit 4 presents the Historical Traffic Volume and Distribution Sheet. On this form, the following data are to be entered.

Average daily traffic estimates are requested for each year from the construction year of the GPS section through 1987. More than one data sheet may be required for older pavement sections. Up to eight years of historical traffic estimates may be placed on an inventory data sheet. The estimates of AADT are summary data. All other

Exhibit 4

Inventory Data
LTPP Program

State Code [_ _]
SHRP Section ID [_ _ _ _]
Date of Form Completion _____
Person Completing Form _____

HISTORICAL TRAFFIC VOLUME AND DISTRIBUTION

1. Estimate of Average Daily Traffic: (begin with construction year, then add each year through 1987. Please use additional sheets if required)

	Construction Year	Each following year, through 1987 →									
a. Year											
b. AUT											
Directional											
c. Distribution											

2. Annual Growth factors (if employed) in non-count years: (begin with the first non-count year after construction, then add each non-count year through 1987)

	Initial non-count Year	Each following non-count year, through 1987 →									
a. Year											
b. Non-Count Year											
c. Annual Growth Factor											
Source of Growth											
d. Factor											

3. Actual Traffic Counts on the SHRP Section or same volume-defined road segment (if data unavailable, please leave blank. Begin with the first actual count starting with the construction year, then add each count year through 1987

	Construction Year	Previous Years' Actual Count →									
a. Count Year											
b. Date [month & days(s)]											
c. Period (hours)											
d. Raw Count											
e. Adjustment Factors											
(1) Seasonal Source											
(2) Factor Used											
(3) Axle Correction Source											
(4) Factor Used											
(5) Other _____ Source											
(6) Factor Used											
(7) Other _____ Source											
(8) Factor Used											
(9) Other _____ Source											
(10) Factor Used											
f. Directional Distribution if Collected during Count											
g. Directional Distribution if Estimated											
h. Truck Lane Distribution if Collected during Count											
i. Truck Lane Distribution if Estimated											
j. Type of Counter Used											
k. Route and Milepoint of Count											

Exhibit 5

Inventory Data
LTTP Program

State Assigned ID [_ _ _ _]
State Code [_ _]
SHRP Section ID [_ _ _ _]
Date of Form Completion _____
Person Completing Form _____

HISTORICAL VEHICLE CLASSIFICATION

A. Please complete with data collected using your state's truck type definitions. Begin with construction year. Use additional sheets if necessary. Attach your state's truck type definitions. If different than the federal truck classification format, attach your state's procedure for summarizing these data in the federal thirteen truck classifications.

		PERCENT OF TRUCK VOLUME BY TRUCK TYPE							
		TRUCK TYPES							
	2.	3.	4.	5.	6.	7.	8.	9.	10.
1.		— —	— —	— —	— —	— —	— —	— —	— —
		— —	— —	— —	— —	— —	— —	— —	— —
		— —	— —	— —	— —	— —	— —	— —	— —
		— —	— —	— —	— —	— —	— —	— —	— —
a. YEAR Construction Year	% HC of ADT								
b. — —	— —	— —	— —	— —	— —	— —	— —	— —	— —
c. — —	— —	— —	— —	— —	— —	— —	— —	— —	— —
d. — —	— —	— —	— —	— —	— —	— —	— —	— —	— —
e. — —	— —	— —	— —	— —	— —	— —	— —	— —	— —
f. — —	— —	— —	— —	— —	— —	— —	— —	— —	— —
g. — —	— —	— —	— —	— —	— —	— —	— —	— —	— —
h. — —	— —	— —	— —	— —	— —	— —	— —	— —	— —
i. — —	— —	— —	— —	— —	— —	— —	— —	— —	— —

B. Basis for the classification: (If more than one method was employed to obtain the classification data, please note each method below and the years the methods were used.)

1. Permanent counter at SHRP Section _____
   1a. Milepoint _____
2. Individual permanent counter _____
   2a. Route and Milepoint _____
   2b Functional classification of individual permanent counter site _____
3. Mean for permanent counters on same Functional Classification _____
   3a Number of counters used to compute mean statistic _____
4. Short-term count at SHRP Section _____
   4a. Milepoint _____
   4b Date [month,day(s)] _____
   4c Period (hours) _____
   4d Manual _____
   4e Mechanical _____
5. Mean for short-term counts on same functional classification
   5a Number of counts used to compute mean statistic _____
   5b Number of locations of counts used to compute mean statistic _____
   5c Dates (months,days) _____
   5d Period (hours) _____
   5e Manual _____
   5f Mechanical _____
6. Other (Detail)

C. What vehicle classifications does your agency currently collect?
(List) _____

information elements on the Exhibit 4 data sheet are intended to identify how these values were developed.

Annual growth factors are requested for any year for which volume estimates are supplied but during which a volume count was not actually performed. States should also indicate the source of the growth factor (i.e., it came from a single ATR, a group of ATRs, was estimated from total statewide gasoline sales, or some other process.)

Traffic counts are requested for either the SHRP section, or the "same volume-defined" road segment. This means that the count(s) may have been on a nearby road segment that could reasonably be used to represent the traffic volume characteristics of the SHRP segment. Such a nearby segment may have different pavement characteristics but must have similar volumes. Sites may be considered similar if the volume difference between the two sites does not exceed their combined system-level confidence interval at a 85 percent confidence level. This should be calculated as described in the Traffic Monitoring Guide (Federal Highway Administration, 1985).

The year during which each count was taken should be indicated using the same procedure as described above for AADT. The duration of the count (month, days, and hours) for ATR sites and the number of valid days of data collected during the year should be included.

The raw count is also requested for each short duration measurement. This is the total raw count for the data collection period. If the raw counts were adjusted, the adjustment factors should be indicated. Space is left for two specific types of adjustments, axles and seasonality. Space is provided for additional adjustments (e.g., an equipment adjustment factor or daily adjustment factor) specific to the jurisdiction. If more factors were used than the number for which room is provided, a separate piece of paper should be attached to provide the additional detail.

Directional distribution is requested for each volume estimate. These data can come from the actual count or be estimated by other means. The direction of travel should be indicated, as well as the percent of distribution, for example: N 48%, S 52%.

Truck lane distribution is requested for multi-lane facilities. As with directional distribution, these estimates may come from actual count data or be estimated from other sources. The lane and percent of distribution (e.g., N1 93%, N2 7%; S1 92%, S2 8%) should be indicated. Lane number 1 is the the right lane as viewed from the same direction that traffic moves. Lane 2 is the next lane to the left.

The **type of counter unit** is requested. This will allow the database to be examined in relation to data collection equipment.

The **specific route and milepost** at which the count was done is also requested. This will clarify whether the count was actually within the boundary of the SHRP section.

Truck Classification Submittal

Exhibit 5 presents the Historical Truck Classification Data Sheet. Items requested on this form are described below.

Historical truck classification data include all available truck volume information from the opening of the pavement section until 1987. The first column of this section of the form is for the year in which data were collected. The second column is the percent of trucks in the traffic stream. It is calculated by dividing all trucks by total volume.

The remaining columns are for the individual truck categories used in the data collection effort. For each year, for each truck type, the ratio of that truck type to all trucks is entered. This is calculated by dividing the total number of a given truck type by the total number of trucks of all types. If additional columns are required to enter all of the truck classifications, additional forms can be used.

A description of the classification scheme used should be attached to this form. If the classification scheme is different than the FHWA Scheme F classification, the way the truck classes used in the form are to be combined or expanded to match the federal reporting needs should be indicated.

The basis of the classification is the detail behind the classification counts presented on the top half of the form. This section of the form describes how the data were

collected. If more than one method was used over the years represented in the top half of the form, all methods used and the years during which those methods were applied must be listed. Additional paper may be needed for these explanations.

What vehicle classifications the agency currently collects means information on the classification schemes and methodologies currently used by the agency. These schemes may be the same as those described in the second part of the form or may be different based as a result of new equipment acquisition.

LIMITATIONS OF THE TRAFFIC DATA

SHRP researchers preparing to analyze the impacts of traffic loadings on pavement need to be aware of the strengths and weaknesses of the traffic data they will be using. The reasoning behind the selection of the recommended data collection plan provides a lot of insight into the limitations of the data, but this section will summarize the specific weaknesses of the available data.

As with the data collection plan, historical and "new" data will be addressed separately. "New" data will be discussed first.

Limitations of New Data

The limitations of the data to be collected using the SHRP data collection plan occur primarily in the area of truck weights. The largest problem that will occur here will be the result of differences among truck weighing installations. While the HELP and ASTM performance specifications may help provide some data uniformity, the differences among the equipment and site characteristics of each GPS weigh station location will create some differences in weighing results. That is, the same truck weighed at multiple sites will invariably exhibit different axle and gross vehicle weights at these sites.

Depending on how these weight estimates are used and how well the weighing stations are installed and maintained, the differences in scales could have either minor or major impacts on the results of the LTPP study. If the WIM weights are directly translated

into ESALs with the current FHWA Truck Study software, weigh sites with high calibration standard deviations (the standard deviation of the difference between WIM and static axle weights) will have higher ESAL values per truck than sites with small calibration standard deviations for similar truck populations. ("Use of WIM Data to Calculate ESALs," given at the National WIM Conference, St. Paul, Minn., October 17 through 20, 1988.) The size of this error has not been adequately defined at this time.

Information on each scale site (calibration information, site profile, etc.) has been requested specifically to allow SHRP researchers to address the differences between scale sites. How these differences can be accounted for has not yet been determined.

The next limitation in truck weights comes from the relative lack of data by season for each site. While each GPS site will have a small sample of weights for each season, some accuracy will be lost as a result of the small sample size. The use of regional stations to help expand these measurements to represent annual figures should provide some improvement in the data accuracy, but this area of data collection and manipulation is still untested at this time.

Limitations of Historical Data

Vehicle Classification. Historical data submitted by the states will have a number of major limitations, primarily because of the lack of data collection done for most pavement sections. Few historical vehicle classification data exist for most GPS sites. Until the 1980s, automated vehicle classification equipment either did not exist or was very expensive to own and operate. Consequently, vehicle classification counts were done by hand. This led to a very high cost per count and a general inability to count for long durations at many sites. On top of the small number of classification counts is an even poorer understanding of the impacts of seasonality on truck volumes. Most classification counts are not adjusted for seasonality, and for most locations it is unknown whether truck percentages remain constant throughout the year.

Some of this limitation should be alleviated by the 365-day AVC counts done for SHRP. This baseline information will provide the data necessary to answer the question of

truck classification seasonality at each GPS site. These data should be used to examine, and if necessary, modify estimates of truck percentages used in historical traffic loadings.

To complicate matters, the change in the allowed truck sizes and weights in the last two decades have resulted in a gradually increasing vehicle size and weight in most states. This trend is matched by a perceived increase in the number of heavy vehicles and vehicle miles of travel by trucks. Both of these trends are well accepted, but few data exist to document them on a facility by facility basis. Thus, even with the 365-day baseline, it will be hard to estimate with any accuracy the number of vehicles of particular types that have previously crossed a given pavement section.

Truck Weights. The next major limitation in historical data is truck weights. While FHWA has required the biennial truck weight survey for a number of years and these data have provided the vast majority of historic truck weight information, the survey has a number of well known limitations.

Primary among these limitations is the fact that the weighing for the survey has been traditionally performed at static scales. Overweight trucks often by-pass these scales, and thus the weight data collected under-represent the number of heavy axles actually on the highway.

While the use of WIM data to estimate the bias inherent in FHWA truck weight data is possible, the factoring of these data to represent "unbiased" weights will itself introduce uncertainty into the dataset. Therefore, the WIM ETG urges that historical weights be used with care by researchers.

Compounding this problem is the fact that no historical weight data have been collected at many of the GPS sites. Thus, "representative" weights from weigh stations elsewhere in the state will have to be applied to those locations. Available data show that substantial errors can result from this transfer of weight data between locations. The size of these errors varies considerably from site to site, and the only means of estimating these errors will be by examining the site specific weights collected as part of the "new" data collection effort.

WEIGH-IN-MOTION CONSIDERATIONS

The Weigh-in-Motion ETG reviewed the availability of WIM equipment and discussed the preliminary findings of a number of ongoing research efforts. The group concluded that it is difficult to provide "hard" recommendations in many of the WIM subject areas because WIM technology is still evolving, and the different technologies available for performing weigh-in-motion have a wide variety of different characteristics, strengths, and weaknesses. While unable to supply SHRP with "The Answer" to its WIM needs, the ETG can provide its conclusions, recommendations and advice, which should benefit the program. The subjects covered below include the following:

- equipment selection,
- site selection,
- installation and calibration,
- care of the WIM systems after they are functioning, and
- AVC equipment and site selection.

It is important to note that the conclusions and recommendations of the ETG are not a comprehensive description of the art of weigh-in-motion. A battery of reports on the subject can be found in the normal transportation literature. Interested agencies are especially encouraged to review the papers presented at the various weigh-in-motion conferences held since 1983, as well as literature from the ongoing efforts in the HELP demonstration program currently being conducted by a number of states in the western portion of the U.S. and the American Society of Tests and Measurement's (ASTM) efforts to produce a WIM specification.

WIM Equipment Selection

The SHRP WIM ETG does not recommend a specific type or brand of WIM equipment for use within the SHRP project. Neither does the ETG recommend that SHRP should develop its own set of WIM accuracy specifications. Instead, the ETG recommends that SHRP and participating states adopt one of the emerging WIM specifications being

developed by national organizations and then select and purchase equipment which both meet those specifications and best meet the agency's needs. In particular, the ETG recommends that states adopt the WIM specifications being developed by either HELP, ASTM, or both organizations.

While neither of these specifications have yet been completed and adopted, both specifications should be finalized in the near future. Drafts of the two specifications are very similar. Exhibit 6 provides the draft HELP specifications published in the draft final report, "Development of Weigh-in-Motion Performance Specification," by Wiley Cunagin, of TTI, in June 1988. Completion and acceptance of the HELP specification are due in the fall of 1988.

Any equipment meeting the accuracy specifications adopted by ASTM and/or HELP is adequate for use within SHRP. Note, however, that the accuracy of the equipment is not simply a function of the technology of the WIM device and the brand of equipment. Tests have shown that a variety of WIM devices have met these draft standards when operating under appropriate conditions. These same devices have also failed to achieve these accuracy standards when operating under adverse conditions. Thus, the conditions of system operation are a significant issue in the accuracy of the WIM data, the selection of WIM equipment, and the use of those data.

Factors that impact WIM system accuracy and operation include the following:

- pavement profile and condition (see next section),
- vehicle suspension characteristics,
- vehicle configurations,
- vehicle speed,
- tire pressure, and in some cases,
- environmental conditions.

Essentially, the more smoothly a vehicle is traveling on the highway, the more accurately WIM equipment can estimate its static axle weights. The greater the motion of the vehicle, the worse the WIM weight accuracy. (Additional information on this subject can be found

EXHIBIT 6
HELP WIM PERFORMANCE SPECIFICATIONS

HELP System Type	Percent Difference	Absolute Difference
Automatic Port of Entry		
Systematice Error	± 4%	± 400 #
Random Error	± 4%	± 400%
Fixed Site		
Systematice Error	± 4%	± 400 #
Random Error	± 10%	± 1000%
Portable Site		
Systematice Error	± 4%	± 400 #
Random Error	± 12%	± 1200%

in the WIM literature. A good starting point is "Concepts of Weigh-in-Motion Systems," by Dr. Clyde Lee, a paper presented at the National WIM Conference in Denver, Colorado, July 11 through 15, 1983.)

Because of the interaction between WIM equipment, trucks, and pavements, it is impossible to require specifications that are more stringent (more "accurate") than those that HELP and ASTM are currently considering. In addition, the inherent differences among test sites for WIM devices make adequate comparisons of the "accuracy" of competing systems almost impossible.

Therefore, the WIM ETG recommends that the SHRP Executive Committee petition the National Bureau of Standards to test the "accuracy" of the various WIM systems under controlled laboratory conditions. Such a test could control for the variation between sites and simply test the reliability, functionality, and performance of the systems under similar conditions. States would then have an unbiased, comparable series of tests for use in evaluating the reliability of different WIM systems and transducers.

WIM Site Selection

As indicated above, the physical characteristics of a WIM site have a significant impact on the performance of the scale. In general, a WIM site that contains

- smooth pavement (no rutting or major cracking and a smooth profile),
- flat approach profiles,
- straight pavement, and
- a flat cross slope

will produce more accurate results than a site that does not have these characteristics. In addition, some WIM devices operate under only specific conditions. For example, the bridge system requires a bridge to act as the scale platform, and various research has shown that it performs better on specific types of bridges than on others.[4] (It operates best

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[4]WSDOT, Evaluation of the FHWA Bridge Weigh-in-Motion system, 1986, by Mark Hallenbeck, for WSDOT

on short span, simply supported, girder bridges, with moderate to low traffic volumes.) WIM site selection must therefore include an examination of what types of equipment will be used, as well as what condition the pavement is in.

The SHRP WIM sites need not be placed within the "SHRP section" submitted by the state at the beginning of the SHRP site selection process. The weighing station may be as far up- or down-stream from the GPS site as necessary to obtain conditions conducive to accurate weighing. However, the site must meet the following criteria:

- it must be on the same highway as the GPS section;
- it must be weighing the same traffic stream that passes over the GPS section;
- the traffic volumes over the two sections should be similar; and
- there may not be an intersection between the weigh station and GPS section which significantly alters the character or volume of the traffic on the facility.

The ETG recommends that each state work with a traffic "expert" provided by the regional contractors to help them determine WIM sites. This "expert" would be in charge of ensuring the validity of each weigh station site and of ensuring that all states in the region submit data of similar quality.

A submittal to SHRP from each state should include the pertinent data for each WIM site. This includes

- road profile,
- road roughness 200 feet prior to the transducers through 150 feet after the transducers,
- statistics on the calibration accuracy of the scale (see next section),
- approximate average speed of the vehicles crossing the transducers, and
- pavement condition at the start of each data collection session.

WIM Installation and Calibration

WIM should be installed under the direction of a person who is highly familiar with the attributes of the particular system and who has extensive experience in the installation of that WIM device. (This will most likely be a member of the WIM vendor's staff.) Many of the "failures" of WIM devices described in the literature have been a result of the "failures" of the installation and/or site selection process as much as the WIM device itself.

The WIM device can be calibrated by a variety of methods, but SHRP recommends the use of the actual traffic stream passing the WIM device as part of the calibration effort. (That is, a proper calibration effort should include some weighing of the normal traffic stream by both the WIM device and a static scale of known accuracy.) Use of the actual traffic stream, instead of simply using calibration trucks, is recommended because of the impact vehicle configurations and suspension types have on WIM performance. By measuring a sample of vehicles normally passing the scale, the agency can be more assured that the calibration of the WIM device accurately matches the types of vehicles it will be weighing rather than simply the vehicle type represented by a calibration truck.

As with the weigh-in-motion specification, the HELP and ASTM efforts both include recommendations for performing system calibration and acceptance testing. The SHRP WIM ETG recommends that the states adopt these procedures as well as the basic specification. The draft HELP calibration specification recommends that 150 trucks from the traffic stream be weighed as part of the calibration effort.

Pavement rehabilitation is often performed as part of the site installation process. This is particularly true where existing pavement is too rough or rutted to allow for accurate operation of the selected WIM device. The recent report, "Calibration of Weigh-in-Motion Systems Vol.'s 1 and 2", by SPARTA, for the Federal Highway Administration, August 1988, provides guidelines for calculating the required roughness of pavement to achieve desired accuracy levels. While achieving these accuracies is also a function of the WIM system being used, this report does provide an excellent overview of the impacts of pavement roughness on system performance.

The ETG recommends that SHRP request that the calibration data for each WIM site be submitted as part of the WIM site information. This portion of the submittal should consist of the following data:

- mean error for each single axle, tandem axle, and gross vehicle weight (referred to as the "systematic" error in the HELP specifications),
- standard deviation of the single axle, tandem axle, and the gross vehicle weight errors (called "random" error in the HELP specifications),
- number of vehicles weighed in the calibration effort, and
- the style and brand name of the scale being used (e.g., Radian, bending plate scale).

This information will provide researchers with sufficient data to review the reliability of the weight data associated with any given GPS site. An estimate of weight data reliability may be needed to help explain differences in pavement performance at some sites. The information on weigh sites may also be useful in further refining the WIM axle weight estimates and in exploring the relationship between WIM and static vehicle loadings.

Care of the WIM System After Installation

WIM systems, like other traffic data collection devices, require periodic maintenance and adjustment. Many of the devices available on the market contain a self calibration feature which attempts to alter the calibration factor on the basis of some of the vehicle characteristics it is measuring. For example, the system may monitor the average estimated front axle weight of passing 3S2 style trucks. Since this value has remained fairly constant over time, the system compares the measured weight of these axles against the expected weight. If the average of several hundred axles is different from what is expected, the system adjusts the calibration of the device to better approximate the expected value.

Periodic checking of the equipment by maintenance personnel is also an essential part of WIM. Routine maintenance of the electronics, power supply, telephone facilities,

transducers, and other components of a WIM system will result in better system performance, less down-time, and better accuracy. (Note that the costs presented in tables earlier in this report do not include maintenance costs.) Periodic maintenance costs will vary considerably from system to system, depending on

- the type of sensors the system uses,
- the level of traffic volumes the system experiences,
- the environmental conditions the system operates under, and
- the quality of the initial installation and equipment construction.

The draft HELP performance specifications call for the median time between maintenance actions for WIM sensors and electronics to be 6 months.

Pavement both preceding and following the WIM site may also need periodic maintenance. This is particularly true for softer asphalt pavements, in which rutting can result from significant impact loadings on the WIM sensors, thus causing significant error in the weight estimates. The cost of pavement maintenance at WIM sites can be substantial, depending on the maintenance effort required.

The potential for pavement repair immediately preceding and following WIM transducers is a good reason for not locating WIM directly within the GPS pavement section, as WIM accuracy may require pavement maintenance that is not part of the GPS test.

AVC Equipment Selection and Site

The equipment and site requirements of AVC are considerably less than those for WIM. An AVC device does not need the measurement precision of a WIM device. It is thus not as heavily impacted by vehicle motion (and therefore site conditions), so long as that vehicle motion does not cause axles to bounce over the axle sensors.

Like WIM systems, AVC systems come in a number of forms. Work done by the state of Maine provides a good review of systems available earlier in the 1980s, as well as

an introduction to most AVC technologies.[5] Essentially, the AVC systems need to measure the number and location of axles on each vehicle and determine where one vehicle stops and another begins. To do this, there are basically three different arrangements of sensors,

- two-axle sensors,
- two-axle sensors combined with one or more loop detectors, and
- two or more loop detectors combined with an axle sensor.

In all cases, the sensors measure the speed of a vehicle, the number of axles associated with that vehicle, and the time between axles. The distance between axles is then calculated (from speed and time) and the vehicle is then classified according to its axle configuration. Classification schemes can vary between manufacturers and according to state needs.

The WIM ETG did not select one style of AVC system over the others. Instead, the ETG recommends that SHRP adopt the HELP vehicle classification specification and allow states to select the AVC system that best meets their needs, while also meeting the SHRP requirements. Further, the ETG recommends that AVC equipment to be used in SHRP should be able to classify vehicles into either the 13 FHWA vehicle categories (scheme F) or a more detailed classification scheme that can be defined by individual states, and that any classification scheme used by the states should be compressible to the 13 FHWA categories.

ACTIONS REQUIRED BY SHRP

In addition to recommending a traffic data collection plan, the combined ETGs determined that the SHRP Executive Committee should undertake four specific actions. These action items are as follows:

- SHRP should supply traffic data collection experts at both the regional and national level to assist the states in the design and fulfillment of SHRP data collection plans.

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[5]"Evaluation of Vehicle Classification Equipment, John Wyman, Maine DOT for FHWA, September 1982

- SHRP should adjust either the scope of the LTPP project or the funding available for the project to better match the resources provided with the data collection effort required.
- SHRP should transmit a letter to the participating agencies that reiterates the benefits of the SHRP program, reinforces the need for and value of traffic information, and reminds them of their previous commitment to provide these data.
- SHRP should petition the National Bureau of Standards to test the "accuracy" of the various WIM systems. States would then have an unbiased, comparable series of tests that could be used to evaluate the reliability of different WIM systems and transducers.

Traffic Experts

Because the recommended plan relies on a sampling plan for the collection of weight data and the use of "representative," regional, long-term WIM sites, expert advice must be provided to assist states in the implementation of the data collection effort. The traffic experts will need to coordinate the selection of long-term WIM sites and assist the various states as they meld the SHRP data efforts into their existing traffic data collection programs. The two overriding concerns of the "regional experts" are that

- the states provide the best data possible, and
- the data collected from the different states are comparable in quality and meet the minimum requirements of SHRP.

In addition, the experts should assist the states in reviewing the specific locations at which traffic data will be collected. The traffic experts will need to work with the states to ensure that the sites selected for collecting WIM data (which are often constrained by the type of WIM equipment available) accurately represent the traffic crossing the GPS site. The traffic expert should also assist in the development and monitoring of each state's data collection plan.

The Expert Task Group recommends that the SHRP regional contractors provide a contact to answer states' questions and ensure that the data each state collects are comparable. SHRP should also provide a traffic expert at the national level to provide technical assistance to the regional contractors and to answer states' questions that fall beyond the qualifications or experience of the regional contractors.

Adjustment of Funding or Scope

Even the reduced level of data collection recommended by the ETGs will cost significantly more than the available funding permits. Consequently, the Expert Task Groups recommend that the SHRP Executive Committee take one of the following two actions:

- reduce the scope of the LTPP program (in terms of the number of GPS sites at which traffic data must be collected), or
- provide additional funding for traffic data collection through transfers of other SHRP funds and a consequent reduction in other SHRP research efforts.

The Expert Task Group believes that a failure to more adequately match the funding available to the scope of the data collection required will significantly degrade the quality and reliability of the traffic data used in the experiments.

Letter Supporting Traffic Data Collection

In addition, the combined Expert Task Groups request that the SHRP Executive Committee transmit a letter in support of the traffic data collection effort to the respective state highway agencies. SHRP was conceived several years ago, and many of the administrators who began the SHRP program are no longer with those highway agencies. Thus, support for many of the SHRP programs is not as strong as it once was. The lack of strong support, coupled with the tight budgets of most of these agencies and the cost of the required traffic data collection raises concerns about whether the required data (at any reasonable confidence level) will be collected and submitted by each state.

The Task Groups feel that the probability of receiving the necessary traffic data from each state is directly related to the support of each Department's upper management. We feel that an effort to enhance the visibility of that support by the Executive Committee will result in improved data collection and submittal by the states. This extra support should result in measurable improvements in the traffic database, and ultimately in the results of the LTPP project.

National Bureau of Standards Request

At this time, only the HELP effort in the western U.S. has worked towards testing and comparing WIM devices. The variations in system performance caused by differences in test sites and conditions makes the comparison of competing WIM systems exceptionally difficult. Therefore the states lack the information necessary to make the "best" equipment choices both for themselves and SHRP.

Given the vital nature of this equipment, SHRP (and the states) would benefit significantly from independent, controlled tests of WIM equipment in a controlled facility. Such tests would provide a standard basis for reviewing the performance of transducers and electronics, would allow the development of more stable accuracy specifications, and should result in better, more reliable, and more consistent equipment.

A logical agency to develop and perform these tests is the National Bureau of Standards. Impetus to develop and apply these tests needs to come from organizations with the size, stature, and support of SHRP. Thus, the Executive Committee is urged to request the Bureau to take on this assignment.