Evaluation of a Statewide Highway Data Collection Program

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This paper is a discussion of an in-depth evaluation study of highway data development and analysis activities of the Washington State Department of Transportation. Statistically based procedures and recommendations that were developed to streamline the highway data collection program are described. Opportunities to reduce manpower and equipment costs, streamline work activities, improve the quality of data collected, and provide accurate and timely data for the various users were identified. Given the focus on highway data, a major effort was devoted to the department's traffic-counting program. However, many data items and programs were considered, and the following items received particular attention: traffic volume counting, including estimation of annual average daily traffic at any location throughout the state highway system; associated seasonal, axle, and growth factors; vehicle classification; truck weight; and the relationships between the statistical sampling requirements recommended for these items and those associated with the FHWA Highway Performance Monitoring System (HPMS) in the state. Employing statistical sampling methods that complement the HPMS sample offers a strong potential for significantly improving the cost-effectiveness of a statewide highway data collection program.

In 1981, as a result of major budget cutbacks, the Washington State Department of Transportation (WSDOT) created a high-level committee to review the amount of highway data collected. The committee recommended a sharp reduction in the level of traffic counting. This decision was based primarily on stated data needs by upper-level management. The committee did not, however, address the statistical validity and quality of the data collected. Neither did the committee attempt to integrate the remaining data collection effort.

Thus, in recent years, considerable concern has existed about the appropriate level of resources to be allocated to various data collection activities and about the statistical basis for these activities. The shifting emphasis in WSDOT'S highway program from construction to maintenance and rehabilitation is another important factor. These issues are of concern to many state DOTs.

In this paper are presented the results of a research study that was undertaken to evaluate WSDOT's data collection and analysis activities. The statistically based procedures and recommendations that were developed to streamline these activities are described. The primary purpose of this program was to satisfy the internal needs of WSDOT, although all major users and uses were identified. A rigorous statistical approach to program design and data collection was necessary to permit estimation of data accuracy and to provide a rational basis to assist in allocating limited resources among the various possible data collection activities. Thus the study results should also be of interest to many other state DOT officials, particularly in evaluating their own programs and in complying with requests of the FHWA to integrate statewide traffic-counting activities with the Highway Performance Monitoring System (HPMS) *(1)*. In addition, the issues identified were of special significance to WSDOT given the development of a new Transportation Information and Planning Support (TRIPS) system. TRIPS is essentially a computerized, on-line, data base management system for assembling, maintaining, and reporting information about the state's highway network *(2)*.

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BACKGROUND

Overview of Previous Work

Historically, highway data and specifically traffic count data have been collected by state transportation agencies to support a wide range of programs and needs. These have included the use of traffic count data to develop estimates of annual average daily traffic (AADT), vehicle miles of travel (VMT) and design hour volume (DHV) for individual highway sections, and functional classifications of highways and regional or other divisions of the state highway system. In addition, the FHWA has required submission of various traffic and truck data and estimates for use by FHWA and other federal agencies. These have been required in order to establish national travel trends, prepare reports requested by Congress, plan for future transportation needs, and assess the overall efficiency of various programs and policies.

Several studies have been reported in recent years that relate to general efforts to develop more cost-effective approaches to statewide highway data collection. These include the work of Hallenbeck and Bowman *(3)*, which proposed a general statewide traffic-counting program based on the HPMS *(1)*; the study by Wright Forssen Associates *(4)*, which evaluated and developed improvement recommendations for the highway traffic data program of the Alaska Department of Transportation and Public Facilities; and work by the New York State Department of Transportation to streamline and reduce the cost of its traffic-counting program *(5)*. Although each of these studies provided useful background and guidance for this project, the conceptual basis of Hallenbeck and Bowman *(3)*, using the HPMS framework for purposes of statewide highway data collection, appeared particularly promising.

The HPMS was introduced by FHWA in 1978 to consolidate many previous federal data requirements and to strengthen the methods used by the states for collecting, estimating, and reporting traffic count data. It involves a sample of highway sections that provide a basic set of traffic count locations for which geometric, operational, and traffic volume data are to be available on a continuing basis. Employing statistical sampling methods that complement the HPMs sample appeared to offer a strong potential for significantly improving the efficiency of a highway data collection program by coordinating the collection of traffic count data, vehicle classification data, and truck weight data. This approach

was explored in this study as a possible basis for overall program design.

There are a number of other relevant and useful works in the general area *(6–13)*.

Study Approach

Given the focus of this study on highway-related data, a major effort was devoted to the department's traffic-counting program. A number of data items and programs were considered. Data uses and users and their needs were determined by building on work previously performed within the department as a result of the 1981 budget cutbacks. This also involved reviewing available literature on the subject of statewide traffic data collection. The two primary literature sources were

- FHWA's *Draft Traffic Counting Guide (14)* and
- The technical basis for that guide, *Development of a Statewide Traffic Monitoring Guide Based on the Highway Performance Monitoring System (3).*

A total of 45 major uses of traffic information were identified. These uses were broken into the categories given in Table 1. In all, 14 types of traffic information were identified and could be further categorized as belonging to five groups:

1. Volume
   - Average annual daily traffic (AADT)
   - Design hourly volume (DHV)
   - Peak-hour traffic percentage (K)
   - Directional split (D)
   - Peak-hour volume turning movements
   - Vehicle miles of travel (VMT)
2. Vehicle classification
   - Average daily truck traffic (ADTT)
   - Percentage of trucks in peak (T)
   - Percentage by vehicle class
3. Truck weight
   - Truck weights
   - Equivalent 18-kip axle loads (EAL)
4. Speed data, percentage of vehicles by speed range
5. Accident data, state highway patrol accident reports

Vehicle speed information was dropped from the analysis when it was determined that the department was performing speed studies as mandated by federal regulation and had no desire to refine or expand this data collection process. Further, the department does not perform the field data collection for accident analyses. This information is supplied by the state patrol on computer tapes. It was concluded that existing procedures and data were sufficient to meet the department's needs.

The specific data items to be addressed in the study were determined to be the "system" traffic data estimates (not project-level estimates) collected by the Data Office of the department's Planning, Research and Public Transportation Division. Roadway information and pavement condition data were excluded from the scope of the project.

One of the most difficult tasks in the study was the attempt to establish appropriate statistical levels of confidence and precision to serve as objectives in the sample design process. The study team went back to all identified users of traffic information to elicit their data quality needs. As a result of this effort, it was soon realized that the vast majority of the data users could not articulate a need for a specific level of data precision for their analyses. All available literature was then reviewed in an attempt to learn if statistical standards had been suggested by other researchers. To a large extent, this also proved to be fruitless.

Because such sources failed to provide the needed guidance, a selected number of sensitivity analyses and statistical derivations were undertaken to examine the effect of data quality on the results of particularly important analyses. Among the analyses examined were

- Priority array determination (a complex set of ranking procedures used by WSDOT to objectively establish the need for highway system improvements),
- Pavement overlay calculations,
- New pavement design,
- Bridge design,
- Pavement management system, and
- Determination of level of development.

This information was supplemented by the small amount of guidance available from data users and published literature and a large amount of professional judgment on the part of project staff and a WSDOT technical committee.

While the investigation of data needs proceeded, the project team reviewed the current activities of the Data Office. Included were data being collected, methods for determining locations of data collection, and manipulations performed on the data collected before they are provided to users. This information was later compared with the data needs determined at the beginning of the project to investigate the strengths and weaknesses of the existing data collection procedures.

Information was also obtained from both the department and FHWA to assist in assessing the variability of data (i.e., the variation in traffic volumes, truck travel, etc. among days, locations, and seasons). Current costs of data collection were also gathered. This information was used to estimate the sample sizes needed to meet the department's needs for accuracy (precision) and to determine the approximate cost of meeting those needs.

After this information was gathered, several alternatives were developed to meet the identified needs of the department. This information was presented to the study's steering and technical committees for review.

EXISTING DATA COLLECTION AND MANIPULATION PROCESS

Volume Data

Permanent Traffic Recorders

Currently, about 80 pieces of permanent traffic recorder (PTR) equipment collect data year round at approximately 65 locations (more than one counter is necessary at some locations to handle multiple lanes or several different legs of intersecting roadways).

The PTR data provide information for calculating

- Seasonal adjustment factors for converting short-duration counts to AADT estimates,

TABLE 1 USERS' DATA NEEDS

Use	AADT	Average Daily Truck Travel	DHV	Peak-Hour Fraction	Directional Split	Truck Percentage	Peak-Hour Volume	Equivalent Axle Loading	Truck Weight	Turning Movement	Vehicle Class (%)	VMT	Speed	Accidents
Project-level traffic forecast	1		1	1	1	1	1			1	1			
Highway geometric design	2		2	2	2	2	2			2				2
Highway pavement design	3					3		3	3		3			
Project-level bridge design	4	4												
Signal warrants	5									5	5			5
Intersection design	6									6				
Traffic engineering control and operation	7												7	7
Speed study analysis	8												8	
Vehicle weight enforcement	9					9			9					
System-level traffic forecasting	10											10		
System-level bridge design	11													
Long-range transportation system planning	12											12		
Capacity needs analysis	13			13	13	13	13							
Highway performance monitoring system	14			14	14	14					14	14	14	14
Pavement management system	15					15								
Model calibration and validation	16		16											
Survey control	17													
Freight analysis movement	18			18	18	18	18							
VMT determination	19											19		
Flow maps	20													
Priority array	21			21	21	21								21
Project-level investment analysis	22						22							22
Maintenance programming	23													
Maintenance scheduling	24													
Accident analysis	25											25		25
Safety studies	26											26		26
Air quality	27					27					27		27	
Water quality	28													
Noise quality	29						29				29		29	
Economic impact of development	30													
Energy consumption	31										31			
Economic studies and analyses	32										32		32	32
Revenue	33										33			
State patrol	34											34	34	34
Traffic safety commission	35											35	35	35
Commerce and economic development	36													
AAA	37													
Motel chains	38													
Service station chains	39													
Chamber of commerce	40													
Outdoor advertising	41													
Litigation of tort claims	42		42	42	42	42	42			42	42		42	42
Damage recovery	43													43
Construction manpower planning	44													
Maintenance manpower planning	45													

- Estimated design hour (and other design) factors for non-PTR locations, and
- Growth trends.

PTRs also provide volume information (in terms of vehicles, not axles) for the sections of highway on which they are located.

Currently, these data are collected using a telemetry system, to which the department recently converted. This conversion has reduced the amount of manpower needed to collect and manipulate PTR data.

Short-Duration Counts

The majority of traffic volume counts taken by the department falls into this category. Short-duration axle counts usually last 72 hr but may also be of 48- and 24-hr lengths. Because of budget cutbacks in 1981, short-period counts are currently collected only when requested for specific projects or when manpower is available to place and retrieve counters while other tasks are being performed. In 1983, 2,281 such counts were made.

The data collected from these counts are seasonally adjusted and entered into the existing traffic volume data base for future reference. Volume data already in the data base, and not replaced by a new volume count, are adjusted annually to reflect VMT growth in the state. The seasonal factors applied to each raw count are derived from available PTR data. A transportation data office engineer or technician determines the particular PTR or PTRs to be used for the factor on the basis of his knowledge of the road being counted, the roads that contain PTR stations, and a book containing previous estimates of seasonal factors for various road sections (based on old PTRs, old control counts, and professional judgment).

In most cases, axle correction factors have not been applied to the raw axle counts, which results in systematic overestimation of vehicular traffic on state highways.

Vehicle Classification Counts

Vehicle classification data are collected at both project and PTR locations. For project-specific counts, vehicle classification counts are either 6-hr manual counts or part of 4-hr manual intersection counts.

At PTR stations counts are now performed on a quarterly basis to better understand the vehicle mix present on the state highway system. Consideration is also being given to automatic vehicle classification, based on vehicle lengths, at PTRs. However, the department's usable vehicle classification data base is currently insufficient for estimating seasonal or locational variation in truck travel for most of the state highway system.

The principal vehicle classification need of the department was judged to be the number (or percentage) of trucks in each of the following categories:

- Two-axle trucks (not including pickups),
- Three-axle trucks,
- Four-axle trucks,
- Five-axle trucks, and
- Trucks with six or more axles.

These categories are more aggregate than those now requested by FHWA for use in data submittals and the manual classification categories actually collected by department field crews.

Truck Weight Data

Currently, truck weight data for purposes other than enforcement are only collected as part of the FHWA's long-term pavement monitoring (LTPM) program. These weighings are being used in lieu of truck weighings that would normally be performed as part of the federal biennial truck weight survey. This program has been temporarily suspended by FHWA pending the outcome of ongoing research on various weigh-in-motion (WIM) strategies. Data are collected using low-speed WIM scales at specific sites selected for the LTPM study.

Data resulting from this effort are sent to FHWA. After analyzing the data, FHWA provides vehicle weight, average equivalent axle load (EAL), and equivalent wheel load (EWL) data to the department for use in construction and pavement management functions.

PROGRAM EVALUATION

Overview

In a limited sense, the existing data collection program fulfills the majority of the department's current needs. The program can be characterized as the lowest possible level of data collection permissible to meet immediate data needs with resources concentrated in those areas that most significantly affect departmental finances. Although this low level of data collection results in the lowest short-run cost to the department, it also causes some data deficiencies that quite possibly could cost more money than is being saved. A summary of findings follows.

- The department generally has relatively good project-level data but an old and increasingly obsolete base traffic data file;
- The department does little traffic counting other than at project locations;
- An axle correction factor is not currently applied to raw axle counts (although this is being changed);
- Ad hoc seasonal factors are applied manually, as opposed to statistically derived factors and an automated approach;
- No HPMS data are collected by WSDOT off the state highway system;
- The state currently lacks an adequate vehicle classification data base, and existing programs are insufficient to significantly improve that data base;
- The only vehicle weighings being performed for planning purposes are part of the federal LTPM study and are inadequate for cost-effective pavement design; and
- It is unclear how statistically valid the data from these efforts are when used for analyses covering the entire state because the data are not being collected in a statistically rigorous manner.

Volume Counting

As was stated earlier, volume counting consists primarily of project-related traffic counting. This means that non-project-related counts tend to cluster around project locations because field crews do not have the time or travel allowance to move away from the project area when collecting these counts.

Although any one nonproject data need might not appear that "important," the combined impact of these analyses can be significant. Further, because traffic counting is centered around project

sites, those parts of the state not involved in major projects will have little or no traffic counting performed. As the counts in these areas grow older, users of those data start to question (sometimes rightly) the validity of the available traffic estimates. Considering that these estimates are included in such analyses as the priority array, the HPMS submittal (which includes the information used to apportion Interstate 4R funds), and other non-site-specific analyses, the state has a need to maintain the quality of traffic information on road sections that are not project locations. In addition, system-level data have, in recent years, been used for pavement overlay design purposes when location-specific data could not be collected in time. This represents a very significant use of system data.

Factoring and Data Manipulation

Currently, most of the factoring and data manipulation performed by the department is done manually. The department supplies traffic estimates in terms of automobile equivalents and an estimate of the percentage of truck travel, but it does not automatically apply an axle correction factor.

The current seasonal factor process also requires a considerable amount of judgmental intervention. This can lead to inconsistencies because two different engineers or technicians using the same volume counts might develop considerably different AADT estimates based on their individual perceptions of what the "correct" seasonal factor should be.

Thus a consistent, statistically valid seasonal factoring procedure is required. TRIPS *(2)* provides an ideal tool for automatically performing all necessary factoring procedures for converting raw data into useful traffic estimates. The data for calculating the necessary factors are already collected as part of the ongoing traffic-counting program. Therefore such factors could be stored and utilized as a series of tables created within TRIPS. These tables could then be used on a look-up basis for application to any raw traffic count.

Vehicle Classification

The department collects few vehicle classification data, and the majority of these are stored in a manner that makes them unavailable to most users of departmental data.

The biggest difficulty with the existing data collection effort, however, is that the department has no knowledge of how truck travel changes seasonally, from month to month, or from day to day on its highway system. Because of this, short-duration counts (e.g., 6-hr manual counts at project sites) cannot be expanded to an average annual total at that location with any degree of accuracy or confidence. Designs based on the collected data are therefore not likely to be as precise as they should be.

A further problem with the current data collection method is that no statistically valid estimate can be made of truck travel in the state or on the state highway system. This becomes a serious problem when viewed in conjunction with traffic forecasting for pavement design. The pavement design process allows for the changing of truck travel percentages over time (e.g., if truck travel is expected to grow, more EALs will be applied to the pavement over its design life, and the pavement will need to be correspondingly thicker). At this time, the department has no knowledge of how those percentages have changed and, consequently, has little basis for forecasting such travel.

Truck Weighing

The department's truck weighing consists of the LTPM data collection described previously. This data collection is probably insufficient for the department's needs, but it is appropriate given the equipment and resources currently available to the department.

The biggest problem with this data collection procedure is that it cannot account for biases that are apparent in every above-ground weighing system. Heavy and overweight trucks tend to avoid scales, even when those scales are not used for enforcement purposes. As a result, the weights that are obtained tend to underestimate the average weight of trucks on the highway system.

To collect the data that are really needed, the department will need to acquire a weighing system that is unobtrusive to truckers so that avoidance of the scales is not a problem. When such equipment is available, the state can expand on the LTPM sample for weighing. The LTPM sites are a good start for an appropriately sized sample, but the existing sample size is relatively small for estimating statewide averages.

RECOMMENDATIONS

Overview

If the department wished to collect all of the data requested by users, it would need to collect volume counts at 0.1-mi intervals on all state highways (requested as an input into the priority array) as well as similar amounts of vehicle classification data and lesser amounts of vehicle weight data. This is obviously an impossible task for a state highway system approximately 7,000 mi in length. The recommended program therefore consists of two data collection tiers:

- Project-specific data collection and
- Statistically based statewide sampling.

The intent of this program structure is to ensure the minimum base of information necessary to supply system estimates, maintain the quality of the most important department analyses, and minimize the total cost of the program.

The statewide element consists of taking counts at a limited number of locations on a routine basis to provide the department with statistically valid estimates of statewide vehicle travel. The detailed statistical basis of this program is described in the paper by Ritchie in this Record. Direct uses of this statistical sample include estimating

- Statewide VMT,
- Average percentage of travel by truck versus automobile,
- Statewide axle correction factors, and
- Truck weights.

These data are needed as the best alternative to site-specific data. Nowhere is the use of these system averages more prevalent than for estimating truck travel for pavement overlay purposes, one of the major tasks of the department (approximately $100 million is spent annually on pavement resurfacing).

Statewide data collection, in particular, needs a statistically valid sample. This provides the department with a rational means for understanding the quality of the data it is using for factors and defaults in all of its analyses. The department's sample is most appropriately taken as part of the FHWA's HPMS data base.

Although the HPMS sample has limitations, it provides the most cost-effective basis for choosing samples for statistically valid data collection.

Unlike the first tier of project-specific data collection, in which only volume and vehicle classification data are collected, the second or statewide tier should collect volume, vehicle classification, truck weight, and speed data. The department's volume-counting locations already exist in the form of the HPMS volume sample. The vehicle classification locations should be taken as a subset of the volume count locations. The truck weight sample should in turn be taken as a subsample of the vehicle classification sample.

It is recommended that the statistically valid sample be taken on a 3-year cycle. That is, only one-third of the total number of sample locations should be counted in any given year. This cycle length is recommended by FHWA because

- Traffic changes (on a systemwide level) occur relatively slowly and
- The 3-year cycle is reasonable in terms of the amount of data that needs to be collected in any given year.

This recommendation applies to all HPMS counts (volume, vehicle classification, and truck weights) but does not include the speed survey, which is based on a 1-year sampling cycle.

The department needs to review the HPMS sample count locations it collects data for and divide those sections into three roughly equivalent count groups, for counting over the 3-year cycle. The department then needs to institutionalize a yearly review of proposed project count locations and HPMS count needs. This should be done at the time project counts are being scheduled. The review simply entails the comparison of proposed project count locations and those HPMS locations that are scheduled for counts that year. The HPMS sections not scheduled for project counts will then need to be added to the yearly count schedule as most appropriately fits the department's manpower scheduling.

Finally, all traffic data collected by either the WSDOT Data Office or the districts should be input into the new TRIPS system, which would make these data available for other departmental uses. In this manner systemwide data collection will be supplemented by the more extensive counts taken at project locations. The result will be a more up-to-date traffic-counting base file.

Volume Counting

HPMS Needs

The data collected for the HPMS submittal meet the needs of the department and the FHWA for Interstate 4R appropriations and priority array calculations.

The current FHWA request for HPMS volume data consists of yearly traffic counts on all Interstate sample sections and new counts on one-third of all other sample sections. New volume counts are requested for 48 hr at one time at each location.

This annual level of traffic counting represents a need for 483 short-duration count locations (or 781 traffic counter settings):

- 222 sample sections on Interstates (444 traffic counter settings) and
- An average of about 261 locations (337 traffic counter settings) on other state roads.

Each year some of these locations will be counted via project counts and existing PTRs. The department does not directly collect information on HPMS sections off the state highway system. If FHWA were to insist on the department collecting this information as well, the second of the previous estimates would increase to approximately 700 locations or 1,050 counter settings per year.

Project Counts

In fiscal years 1984 and 1985, the Data Office provided project counts at roughly 110 and 100 separate locations, respectively. These numbers are similar to expected levels of project counting for the near future.

Counting for the average project includes roughly

- Ten 72-hr machine axle counts,
- One 6-hr manual vehicle classification count, and
- Two 4-hr manual intersection counts.

This process requires 1 man-week of field crew effort, including travel time but not including supervision or data reduction.

Manpower Needs

It is estimated that the Data Office needs about 3.5 full-time-equivalent (FTE) employees to perform the field data collection for the HPMS and project-specific counts described. This estimate is based on the following considerations:

- Between 100 and 130 projects per year will require project-specific information (i.e., approximately 1,300 counts);
- For each project, 1 man-week of field effort is required to provide the necessary data, for a total of 130 person-weeks; and
- For HPMS, roughly 600 counter settings not included in the project counts will be necessary; conservatively, these HPMS counts will require 45 person-weeks of field data collection to perform.

This proposed reorganization represents a total of 175 man-weeks of effort, or 3.5 FTEs, which is roughly equivalent to current levels. However, in addition to these 3.5 FTEs, personnel time will be needed for office support, data reduction, and supervision of field crews, as is now the case.

Permanent Traffic Recorders

One of the most important uses of PTRs is for estimating seasonal factors.

The factor process currently used by the department makes extensive use of subjective selection of seasonal factors. The recommended factor process (see paper by Ritchie in this Record) places PTRs in the following groups for the estimation of seasonal factors:

- Rural Interstates,
- Urban roads,
- Other rural roads in the northeastern part of the state,
- Other rural roads in the southeastern part of the state,
- Other rural roads in the southwestern part of the state,
- Other rural roads in the northwestern part of the state, and
- Central mountain passes.

Each of the counties in the state is assigned to one of the four "other rural" factor groups.

To supply the data necessary for estimating seasonal factors, the department needs between three and eight PTRs in each of the seven factor groups (*13* and paper by Ritchie in this Record). Strictly on the basis of need for seasonal factors, the department could eliminate at least 10 PTR locations. This would result in savings of roughly $300 per month ($3,600 per year). This is a fairly small sum given the amount of data the counters generate and their potential for providing other useful vehicle classification information to the department.

Vehicle Classification Counts

Like volume counting, vehicle classification information needs to be provided on both a systemwide and a site-specific basis. The existing program element provides a limited amount of project data and very little systemwide information.

The recommended vehicle classification program is similar to the volume count program. The HPMS is used as the basis for providing a statistically valid estimate of travel by vehicle type, and project-specific counting is performed as necessary for individual analyses. The use of permanent vehicle classifying counters (i.e., 365-day-per-year counts by vehicle type) at PTR locations is also recommended to provide the state with knowledge of the seasonal variation of truck travel throughout the year. Existing PTRs have the capability of collecting vehicle length information, but they cannot yet be interrogated by the telemetry system to provide classification information. An interim recommendation was made for 20 existing PTR locations to be upgraded to further investigate seasonality.

It was recommended that the department collect a statistically valid statewide sample of 452 vehicle classification counts on six strata:

- Rural Interstates,
- Urban Interstates and other freeways and expressways,
- Rural principal arterials,
- Urban principal arterials,
- Rural minor arterials and collectors, and
- Urban minor arterials and collectors.

The recommended counts and levels of precision for each of these strata are given in Table 2. For rural Interstates this level of precision means that the percentage of travel by five-axle trucks on rural Interstates can be estimated within 15 percent with 90 percent confidence. These levels of precision were chosen primarily on the basis of

- Similarity to suggested levels of precision expressed by FHWA in the draft counting guide *(14)*,
- The importance of each stratum of highways to the department, and
- The cost-to-benefit ratio of collecting better or worse information for each stratum.

TABLE 2 RECOMMENDED NUMBER OF VEHICLE CLASSIFICATION COUNTS AND LEVEL OF PRECISION FOR THE MEAN PERCENTAGE OF TRAVEL BY FIVE-AXLE VEHICLES

Roadway Category	No. of Counts	Relative Precision[a] (%)	Level of Confidence (%)
Rural Interstates	104	±15	90
Urban Interstates	99	±15	90
Rural principal arterials	99	±20	80
Rural minor arterials and collectors	83	±20	80
Urban principal and minor arterials and collectors	67	±20	80

[a]In estimating the average percentage of travel by five-axle combination trucks on the stated roadway category.

The counts in Table 2 would be taken during the 3-year counting cycle. These counts involve a single count day at a given location, randomly selected from all days in the count year including weekend days as well as weekdays.

These counts would be taken at HPMS volume sample locations. They would preferably be 48-hour, automatic (i.e., machine as opposed to manual) counts. The purchase of 10 additional vehicle classifiers was recommended for this purpose. These counts would also meet the need for volume counting at those locations to meet the systemwide needs described in the previous section. It was estimated that 0.75 FTE would be required for this counting element, an increase of 0.4 FTE over current manpower. Until the PTR classification program is in place, the department should probably use 6-hr manual counts in conjunction with its 48-hr HPMS volume counts. Although the longer count duration is preferable, the benefits to be gained by taking vehicle classification counts for 24 to 48 hr in place of 6 hr do not exceed the costs of performing that counting manually.

It was also recommended that the department update its vehicle classification categories and use FHWA's 13-category classification *(14)*.

Truck Weighing

The truck-weighing program element has a slightly different structure than the volume and vehicle classification elements. Currently, the department does not collect project-specific truck weights. As a result, the recommended program structure is for a statistically valid sample of truck weighings to be carried out at HPMS vehicle classification count locations, including the FHWA LTPM sites. Further research is warranted to determine the feasibility, desirability, and cost of collecting project-specific vehicle weights. Results from current in-state testing of bridge-WIM and piezoelectric cable weighing systems should assist in this analysis.

The interim recommended truck-weighing program is therefore to weigh at least 200 vehicles with five or six or more axles at each of five locations on each of three strata. Thus 15 annual surveys would be involved. It was estimated that this program would save 0.4 FTE over current levels. The three strata for weighing are

- Rural Interstates,
- Urban Interstates, and
- Rural principal arterials.

This means the department will need two new rural Interstate and four new urban weighing locations. Average weights per vehicle type for urban Interstates would be used for all urban road designs, whereas average weights per vehicle type for rural principal arterials would be used for all non-Interstate rural highways. The department may choose to sample from lower functional class roads as well.

The recommended weighing element also differs from the volume and vehicle classification elements in that the sampling framework is not based on the number of days counting should take place but on the number of trucks that should be weighed at each location. This sampling scheme is currently used by Wisconsin DOT. This scheme was chosen because it is the only method for which data were available to estimate required sample sizes. The recommended weighing program is given in Table 3.

This sampling program involves several basic assumptions:

- Truck weights by vehicle type do not change over the course of the year (i.e., the average 3 S2 truck weighs the same in July as it does in February);
- Truck weights do not vary between weekdays and weekends;
- Truck weights do not change with the time of day;
- Truck weights by vehicle type are not different on high-volume roads than on low-volume roads (i.e., an average 3 S2 on a low-volume rural principal arterial weighs the same as an average 3 S2 on a high-volume principal arterial); and
- The act of weighing does not bias the data being collected (i.e., trucks do not intentionally bypass the weighing location).

The most significant impact of this interim data collection scheme is evident in the amount of field crew time spent at each truck weight location. For high-volume roads, the time needed to weigh the appropriate number of trucks will be fairly small, certainly less than 24 hr. In the case of Interstate highways, one standard shift of the field crew may be sufficient. For low-volume roads, the field crew may need several days to collect the desired number of truck weighings.

TABLE 3 RECOMMENDED TRUCK-WEIGHING PROGRAM

Vehicle Type	No. of Vehicles to be Weighed at Each Location[a]	Resulting Precision[b] (%)	Confidence Limits (%)
Two-axle, four-tire, single units	200	35	80
Two-axle, six-tire, single units	200	16	80
Single units with three or more axles	200	20	80
Three-axle combinations	200	19	80
Four-axle combinations	200	10	80
Combinations with five or more axles	200	10	95
Five-axle doubles	200	11	95
Doubles with six or more axles	200	14	95

Note: Strata are rural Interstates, rural primary arterials, and urban Interstates. Weighing is done at five locations per stratum.

[a]The controlling vehicles should be five- or six-or-more-axle doubles on the Interstate system, and five-or-more-axle combinations on the rural primary system. All trucks for all other categories should be weighed. If more than 200 are weighed per location, the precision estimates should be better than those indicated here. If fewer than 200 are weighed, precision may be worse than indicated here.

[b]Of estimated mean weight per vehicle type.

Calculated Factors

There were three primary areas in which changes were recommended to the existing departmental process for estimating the various factors applied to raw traffic counts:

- Seasonal factors,
- Axle correction factors, and
- Growth factors.

The raw data needed to estimate these factors are already collected as part of the counting strategies. The statistical framework for deriving and applying these factors, particularly the seasonal factors, is described by Ritchie elsewhere in this Record.

CONCLUDING COMMENTS

The statistically based procedures and recommendations that were developed as a result of an in-depth evaluation of the WSDOT highway data collection program have been described. The evaluation framework used (which would be applicable to other state DOTs) focused on data requirements of users; sampling plans for the various components; data collection, count processing, and data management and storage procedures; count and processing equipment requirements; staffing requirements; and procedures for implementation of the recommendations. Opportunities were identified for streamlining work activities, improving the quality of the data collected, and providing accurate and timely data for the various users. Although the overall recommended level of volume counting and total manpower for field collection of those counts are not significantly different from current levels, the recommended program serves the department's needs much more effectively, not only in the short run but, perhaps more important, in the medium and long run. Also, a statistically based approach permits a rational determination of the quality of data being used in important analyses. When resources are limited and insufficient for the desired sample size, the trade-offs among sample size, precision, and level of confidence are explicit. If statistical sampling methods that complement the HPMS sample are employed, a strong potential exists in many states to significantly improve the cost-effectiveness of a statewide highway data collection program.

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