The Metamorphosis of Long-Term Pavement Performance Traffic Data

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The traffic data collection activities of the Long-Term Pavement Performance (LTPP) program have undergone a transformation. The original plan of the late 1980s envisaged the installation and management of low-cost traffic data collection systems by state highway agencies at approximately 2,500 LTPP test sites.

The plan proved unachievable and was revised to collect research-quality traffic data from a smaller number of test sites. The revised plan has generated the largest repository of high-quality traffic data ever collected.

Above: Workers install a bending plate for an LTPP program study site in Virginia. LTPP data collection began in 1989 under the first Strategic Highway Research Program; in 1992, the Federal Highway Administration assumed leadership of the program.

LTPP's History and Mission

The LTPP program started out as an ambitious, 20-year study of in-service pavements in North America to examine how and why pavements perform as they do. Approximately 2,500 pavement test sections in the United States and Canada were selected for monitoring the performance of different types of structures and materials in various climatic regions.

The need for information on how pavements perform over time came to the fore in the early 1980s, when highway agencies began to be concerned about the deterioration of highways built two or three decades earlier. The Transportation Research Board (TRB), the American Association of State Highway and Transportation Officials (AASHTO), and the Federal Highway Administration (FHWA) advanced the mission to study performance data systematically across the country and to promote extended pavement life.

Photo courtesy FHWA

A researcher checks an LTPP site in this image from the late 1990s. Early data collection lacked standardized procedures—a problem that was soon recognized and corrected.

Supported by Congress, the LTPP program was launched in 1987 under the first Strategic Highway Research Program (SHRP), a 5-year applied research program funded by the 50 states and managed by the National Research Council. The LTPP program's mission (*1*) was to

- Collect and store performance data from a large number of in-service highways in the United States and Canada over an extended period, to support analysis and product development;
- Analyze the data to understand how pavements perform and to explain why; and
- Translate the insights into knowledge and usable engineering products related to pavement design, construction, rehabilitation, maintenance, preservation, and management.

After the development of an experimental plan, data collection began in 1989. Since the conclusion of SHRP in 1992, the LTPP program has continued under the leadership of FHWA, with the participation of highway agencies in all 50 states and 10 Canadian provinces.

Photo courtesy FHWA

A truck passes over a bending plate weigh-in-motion (WIM) sensor. The LTPP program monitors pavement performance in all 50 states and 10 Canadian provinces, gathering data from a full range of North American climates and environments.

Valuable Lessons

In the past 20 years, the LTPP program has monitored the performance of nearly 2,500 pavement test sections throughout the United States and Canada, representing the range of climatic and soil conditions across the continent. An array of fixed instrumentation and special measuring vehicles is used to monitor each test section until the end of its design life or until it is taken out of the study by the participating agency.

The performance of these pavements over time is providing researchers with insights into how and why pavements perform as they do. Valuable lessons are gained for building better, longer-lasting, more cost-effective pavements. Because the traffic input is needed to understand the pavement performance information, traffic data collection is critical to the success of the LTPP program.

Program Objectives

The goal is to extend the life of pavements by investigating the long-term performance of different pavement designs, as originally constructed or rehabilitated, under various conditions. The LTPP program established six objectives (*1*):

- Evaluate pavement design methods;
- Improve the design methods and strategies for rehabilitating pavements;
- Improve the design equations for new and reconstructed pavements;
- Determine the effects of loading, environment, material properties and variability, construction quality, and maintenance levels on pavement distress and performance;
- Determine the effects of specific design features on pavement performance; and
- Establish a national long-term pavement performance database.

Test Sections

Test sections are the heart of the LTPP program. State and provincial highway agencies nominated the sections in accordance with statistically robust experimental matrices designed to achieve the program objectives. The nearly 2,500 test sections, including asphalt concrete (AC) and portland cement concrete (PCC), were designated throughout all 50 states, Puerto Rico, the District of Columbia, and Canada.

Each test section is classified in the General Pavement Study (GPS), which analyzes existing pavements and overlays, or in the Specific Pavement Study (SPS), which analyzes newly constructed pavements and overlays (see list, page 11). GPS test sections were selected from in-service pavements designed and built according to good engineering practice by highway agencies. The SPS test sections, smaller in number, were designed and constructed to answer specific research questions (*1*).

Research-Quality Data

High-quality traffic data are needed to develop a robust relationship between traffic loading and pavement performance. The requirements for traffic data collection, operations, processing, and reliability, however, are demanding and burdensome. Midway through the 20-year LTPP program, the procedures for collecting traffic data at the LTPP test sites were reevaluated.

Highway agencies had been collecting traffic data in a nonuniform manner. Although other monitored data collected by LTPP—such as distress, profile, and falling weight deflectometer data—followed standard equipment requirements and quality control measures, none were in place for traffic monitoring. The traffic data came from a variety of collection equipment—some met quality control criteria, but most did not.

The highway agencies collected the traffic data with their own resources and knowledge of the equipment, but many lacked the time, money, and skilled staff to provide research-quality data. The early LTPP program managers under SHRP had thought that the states and Canadian provinces would be able to install permanent weigh-in-motion (WIM) systems for $5,000 at each LTPP test site to collect accurate axle loadings—but this was wishful thinking.

Collecting research-quality traffic data over an extended period requires considerably higher capital outlay, as well as substantial recurrent expenditure to manage the installation and the large amount of data generated. The early program objective to have all 2,500 LTPP test sites instrumented with permanent WIM equipment was not possible.

Photo courtesy FHWA

A pavement profiler gathers information at a Florida test site. LTPP traffic data collection has required the use of special measuring vehicles and instrumentation.

Photo courtesy FHWA

Researchers tested truck speed at a Maryland pilot site in 2001.

Pooled-Fund Study

The SHRP planners formed an expert task group to advise the LTPP program managers about collecting, processing, and storing traffic data from the test sites. Now under the auspices of TRB and its Long-Term Pavement Performance Committee, the Expert Task Group (ETG) for LTPP Traffic Data Collection and Analysis (Traffic ETG) continues to provide input to the LTPP program on all issues concerning traffic data collection, quality control, and storage and identifies traffic research projects and products.

With the realization that installing permanent WIM systems at every LTPP test site was impossible because of the costs and the additional staffing to maintain, calibrate, and operate the systems properly, the Traffic ETG and LTPP focused on collecting traffic loading data for the SPS test sections, to gain the "biggest bang for the buck." An action plan was developed in October 1999 (*2*).

The action plan recommended a centralized management of the traffic data collection and processing

LTPP Specific Pavement Study (SPS) Experiments

- SPS-1. Strategic Study of Structural Factors for Flexible Pavements
- SPS-2. Strategic Study of Structural Factors for Rigid Pavements
- SPS-3. Preventive Maintenance Effectiveness of Flexible Pavements
- SPS-4. Preventive Maintenance Effectiveness of Rigid Pavements
- SPS-5. Rehabilitation of Asphalt Concrete Pavements
- SPS-6. Rehabilitation of Jointed Portland Cement Concrete (PCC) Pavements
- SPS-7. Bonded PCC Overlays on Concrete Pavements
- SPS-8. Study of Environmental Factors in the Absence of Heavy Loads
- SPS-9. Validation of SHRP Asphalt Specification and Mix Design (Superpave)

Note: For more information about the LTPP experiments: www.fhwa.dot.gov/research/tfhrc/programs/infrastructure/pavements/ltpp/index.cfm.

Pilot studies in 2001 evaluated action plan protocols for the pooled-fund study that followed. A Specific Pavement Study site in Arizona tested the installation of weigh-in-motion systems.

PHOTO COURTESY FHWA

to eliminate the quantity and quality issues associated with the earlier traffic data collections. The plan specified the type of WIM equipment to collect reliable loading data, described the ideal pavement structure for installing the WIM equipment, and suggested how frequently the equipment should be calibrated.

In accordance with the plan, LTPP and the Traffic ETG developed protocols for the calibration and verification of scale performance; requirements for pavement smoothness; specifications for WIM systems, including accuracy requirements and construction guidelines; and procedures for data collection and processing.

Approximately 2 years after the development of the action plan, a national pooled-fund study—combining the funds of several agencies to support the research effort—began to implement the ideas and protocols. The LTPP SPS Traffic Data Collection Pooled-Fund Study is led by FHWA in partnership with 28 states and one Canadian province.[1] Data collection began in earnest in 2003.

Validating Protocols

In 2001, before the official work began on the pooled-fund study, LTPP ran pilot studies in Arizona, Florida, Maryland, Michigan, and Texas to evaluate the protocols developed to implement the action plan (*3*).

The Arizona SPS-6 site tested the WIM installation process. In Florida, a side-by-side comparison of the performance of piezoelectric cable and bending plate sensors at a non-LTPP site showed that the piezoelectric cable did not perform as well as the bending plate. The remaining three pilot sites—Maryland SPS-5, Michigan SPS-1, and Texas SPS-1—tested the field procedures.

The results from the pilot studies showed that the protocols worked correctly. The equipment performance specifications were achievable, and the recommended field calibration methods—for accuracy, speeds, temperatures, and vehicle conditions—were validated.

The pavement smoothness specification, however, was too restrictive for field conditions and required revision (*3*). After testing in several states, the revised LTPP specification for smoothness became the AASHTO Standard Specification for Smoothness of Pavement in Weigh-in-Motion Systems, released in 2008.[2]

Many of the protocols tested in the pilot study were consolidated in the *LTPP Field Operations Guide for SPS WIM Sites* (*4*). The guide has served as the primary reference for collecting quality traffic data at the SPS sites since 2003.

[1] TPF-5(004), www.pooledfund.org/.
[2] AASHTO MP 14-08, www.techstreet.com/cgi-bin/detail?doc_no=aashto%7Cmp_14_08;product_id=1583807.

A load cell WIM system in Ohio. The pooled-fund study collects data for volumes, classifications, and weights at its test sites.

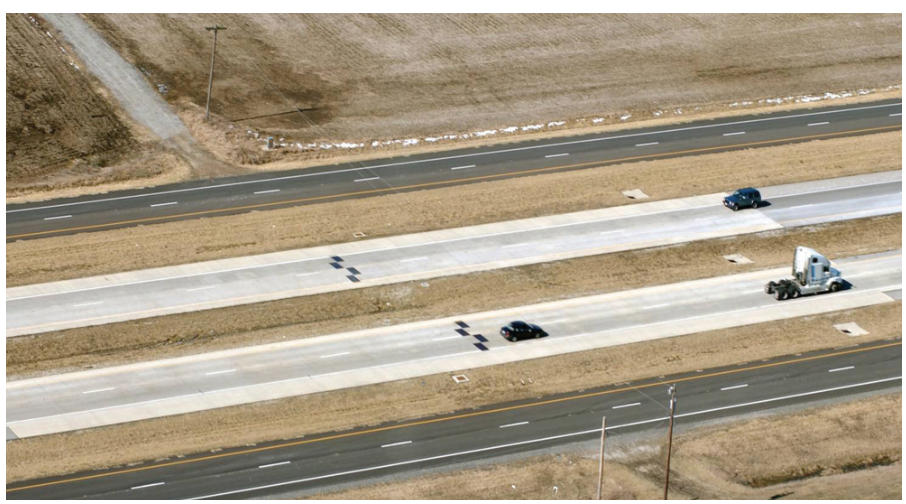

PHOTO COURTESY FHWA

Traffic Data Collection

The objective of the traffic pooled-fund study is to collect research-quality traffic data for volumes, classifications, and weights at LTPP SPS test sites. The sites include the structural factors of flexible and rigid pavements (SPS-1 and SPS-2), as well as the rehabilitation of both pavement types (SPS-5 and SPS-6). Installation of WIM systems was excluded from the SPS-8 test sites, which are used to investigate environmental effects on a pavement structure in the absence of heavy loads.

To meet the study's research-quality standards, data of known calibration, meeting LTPP's accuracy requirements—for steering and tandem axles, gross vehicle weight, bumper-to-bumper vehicle length, vehicle speed, and axle spacing—must be collected for 210 days within a year.

The WIM technologies recommended and used by the pooled-fund study include bending plate, load cell, and quartz sensors, all of which meet the specifications for a Type I WIM system.[3] These WIM sensors are now collecting research-quality data for 28 of the 64 LTPP SPS-1, -2, -5, and -6 test sites in 22 states.

Many pooled-fund studies use the funds contributed by participating states for any area of the study. In the LTPP traffic data collection pooled-fund study, however, each state's contribution goes to its own data collection needs at its SPS sites. An SPS site was included in the study if a state contributed funds and if adequate pavement performance and materials data were available for the site.

Six of the 28 states recognized the value of the multiyear study—as well as the potential for advancing their own traffic data collection activities—and decided to become donor states. This allowed FHWA to use the donor money for other states that needed additional funds.

Field Calibration and Validation

The LTPP program decided that the contractor installing the WIM system should not also validate the system. Two contractors therefore were solicited for the two different but concurrent aspects or phases of the research. Although the activities for each phase are distinct, together they ensure that the equipment is installed, calibrated, maintained, and operated correctly to generate the highest quality of data at each site.

The Phase I activities involve site assessment, performance evaluation, and calibration of WIM sites. In the early years of the study, the WIM systems were assessed for their ability to meet LTPP accuracy requirements and to produce at least 5 years of quality data. If the assessment indicated that a site would not meet the requirements, the Phase I contractor would recommend a correction. The contractor, however, was only responsible for reporting the issue, not resolving it. The highway agency would have to make any correction.

If the corrective action called for replacing the WIM system, then either the highway agency or LTPP—through the Phase II contractor—was responsible for installing a new WIM system to meet LTPP's accuracy requirements for quality loading data.

With the national data collection now well under way, assessments at the SPS test sites are no longer necessary. The Phase I contractor's primary focus is to make sure that the WIM systems collecting traffic data at the SPS test sites are operating at peak performance by calibrating when necessary and by validating the systems annually.

For the field calibrations and validations, two test trucks drive over the WIM site—a fully loaded, Class 9, 5-axle tractor-semitrailer and a partially loaded truck of the configuration predominant in traffic at that site. The trucks are measured and weighed on certified scales. The drivers then drive down the center of the traffic lane at or below the posted speed limit without stopping or braking. Without adjusting the WIM system, the contractor evaluates the initial performance by having the drivers make a

[3] ASTM E1318-02: Standard Specification for Highway Weigh-in-Motion Systems with User Requirements and Test Methods, Section 4.1.1.

Photo courtesy FHWA

A Class 9 test truck drives over a new WIM scale at the Arizona SPS-6 site.

Photos courtesy FHWA

WIM technologies used in the study include bending plates (*left*) and quartz sensors (*right*).

PHOTO COURTESY FHWA

Phase II contractors install an inductive loop at a Kansas test site.

minimum of 20 runs per test vehicle; the speeds can range from 40 mph to 65 mph and the temperatures from 10°F to 116°F, as outlined in the field operations guide (*4*).

If the initial performance evaluation shows that the WIM system is functioning with sufficient accuracy, calibration is not necessary. The runs from the initial performance evaluation are used to complete the validation process. If the initial performance evaluation shows insufficient accuracy, however, the system is calibrated according to the equipment manufacturer's recommended procedures to achieve the best possible accuracy.

Immediately after calibration, validation of the WIM system begins. At minimum, 10 additional test vehicle passes—five passes per truck—are performed. The data are analyzed and the WIM system is recalibrated, if necessary. After successful calibration, the validation process is completed with a minimum of 20 additional runs per vehicle.

If a WIM system does not calibrate after three attempts, the validation activities stop. The Phase I contractor records the statistical accuracy of the WIM system before leaving the site and provides LTPP with a detailed report on the field activities and findings.

PHOTOS COURTESY FHWA

In 2001, data from the Florida pilot site were collected with ceramic piezoelectric sensors (*above*) and in 2005 with quartz piezoelectric sensors (*below*).

Installation, Maintenance, and Data Services

The Phase II contractor is responsible for site evaluation, equipment installation, ongoing maintenance, and daily quality control (QC) checks. At the beginning of the pooled-fund study, the Phase II contractor evaluated sites for suitability for WIM system installation. The evaluations considered the pavement condition and surface profile; the grade and alignment of the test section; the access to utilities such as power and telephone lines; and the observation of entry and exit ramps near the WIM site.

Other Phase II activities involved installing, calibrating, and maintaining the WIM system at the SPS test site and providing a 5-year warranty. Once the work began, LTPP staff noted that the data from these sites needed to be checked frequently. With input from the Traffic ETG, LTPP modified the Phase II contract to include daily QC checks of the data. The daily QC checks are listed in the box on this page.

This contract modification also required the Phase II contractor to provide the vendor software to the traffic engineers in the highway agencies when a new WIM system was installed. This ensures that the highway agencies are able to access the systems for current and future use. At the conclusion of the pooled-fund study, the highway agencies will assume responsibility for maintaining and calibrating the WIM systems.

Phase II activities recently have focused on maintaining and providing on-call repairs of the WIM systems and on the daily QC checks of the data. The Phase II contractors perform semiannual maintenance on the WIM systems they installed; the high-

Daily Quality Control Checks of Weigh-in-Motion Data

1. Total daily count by vehicle.
2. No lane has a value of 0 in a specific hour.
3. No lane has a traffic count of 2,500 or more in any specific hour.
4. Percent of error vehicles per day—errors detected in weighing a vehicle or an unreliable measurement can prevent the WIM system from generating a vehicle record.
5. Percent of status clear vehicles per day—that is, a valid vehicle record was created, showing weights and axle spacing.
6. Total daily count of Class 9 vehicles.
7. Percent of Class 9 vehicles per day.
8. Percent warning count of Class 9 vehicles per day—although a valid vehicle record with weights and axle spacing may be created, a warning message can indicate some irregularity in how the vehicle passed over the system.
9. Average gross vehicle weight of Class 9 vehicles per day.

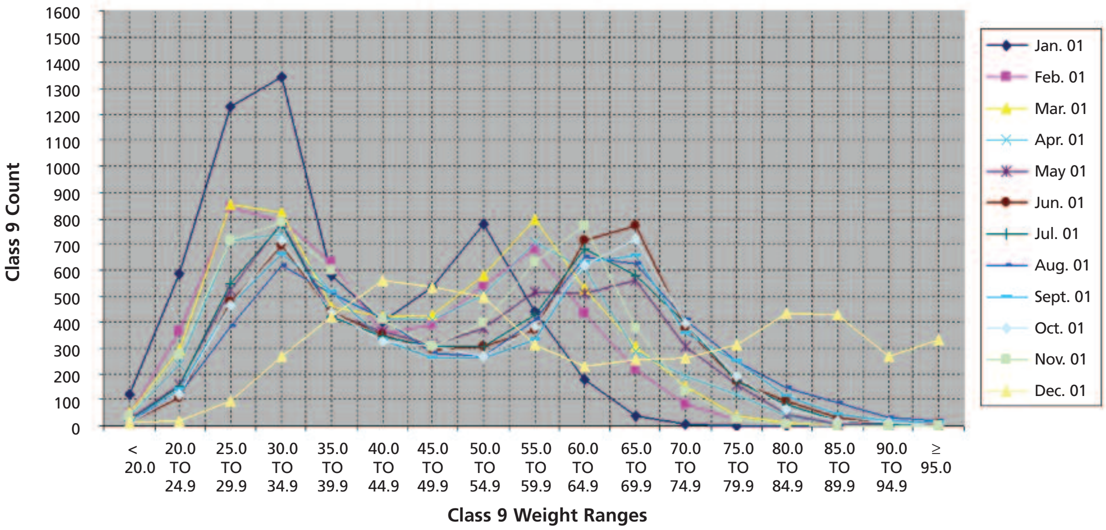

FIGURE 1 Weight data in 2001: histogram of gross weights of Class 9 trucks at an LTPP site in Florida before the Traffic Pooled-Fund Study protocols were developed.

way agencies maintain any agency-installed WIM systems.

Data Quality Improvement

The resources resulting from the pooled-fund study, listed in the box on page 16, are used by LTPP and are available to highway agencies. Developing resources solely for collecting quality traffic monitoring data reflects the philosophy of data integrity that LTPP has practiced for 20 years with other pavement performance data.

Figures 1 and 2 (on this page) show histograms of gross vehicle weights for Class 9 trucks—a 3-axle tractor pulling a 2-axle semitrailer—for the Florida pilot site in 2001 and 2005. Both figures show monthly totals through the year. The data in 2001 were collected with ceramic piezoelectric cable sensors, and the data in 2005 with quartz piezoelectric sensors, installed and calibrated according to the pooled-fund study's protocols.

Both graphs show two peaks in the histograms. The peak at a weight of approximately 30,000 lb corresponds to unladed vehicles, and the peak at approximately 80,000 lb to laded vehicles. The main difference between the two figures is that the results in Figure 2 show more consistency from month-to-month than the results in Figure 1. The WIM system that generated the data in Figure 1 was installed before standards were adopted and is typical of the data reported by ceramic piezoelectric cable sensors. The data in Figure 2 are typical of those collected at the 28 pooled-fund sites for the past 5 years of the study. Table 1 (page 16) compares the accuracy of the Phase I validation tests in 2001 and 2005.

Study Statistics

The Phase I contractor conducted the first field calibration and validation in 2003 at two agency-

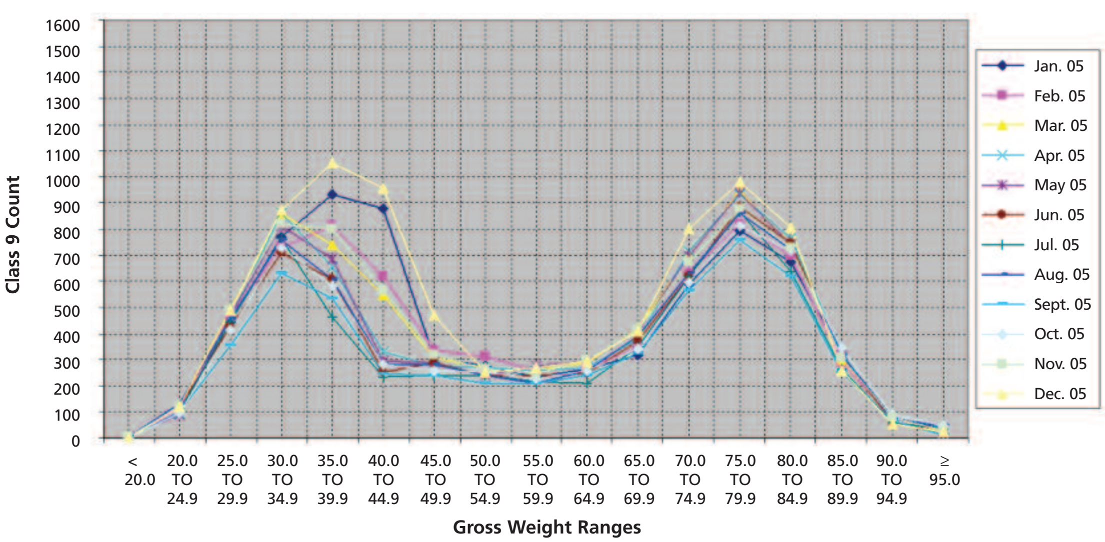

FIGURE 2 Weight data in 2005: histogram of gross weights of Class 9 trucks at an LTPP site in Florida using Traffic Pooled-Fund Study equipment and protocols.

The Florida pilot site tested gross vehicle weights using Class 9 test trucks.

Resources from the Traffic Pooled-Fund Study

- *LTPP Field Operations Guide for SPS WIM Sites* (*4*)
- Glossary of WIM Terms*
- LTPP Classification Scheme*
- WIM Smoothness Specification*
- WIM Workshops (arranged on request)

* www.pooledfund.org/.

installed WIM systems at the Florida SPS-1 and SPS-5 sites; the Phase II contractor installed the first WIM system in 2005 at the Illinois SPS-6 site. Since the beginning of the pooled-fund study, the Phase I contractor has performed 107 field validations; the Phase II contractor has performed 41 site assessments to determine suitability for installing a WIM system, has installed 19 systems, and continues to maintain and provide daily QC checks of the data for the 19 sites.

A few highway agencies have played an active role in the study by installing the approved WIM sensors at the SPS sites in their states. Seven agency-installed WIM systems are part of the study. All 26 installations are providing research-quality traffic data for 28 SPS sites—two locations have an adjacent SPS site and share the traffic data.

Table 2 (page 17) summarizes the traffic data collected at the pooled-fund study test sites through September 2011. Annual totals are shown for the Arizona SPS-1 and SPS-2 sites, as examples. These results show high levels of data availability from the WIM systems, which is typical of all of the pooled-fund traffic data collection sites.

For most years, research-quality classification and weight data have been collected for more than 90 percent of the days. This represents a dramatic improvement from equivalent statistics collected before the pooled-fund study, when data availability of zero to 10 percent was the norm. Table 2 also shows project totals for the other 26 sites. These sites show similarly high levels of data availability throughout the study years.

A total of 40,287 site-days of traffic data were collected through September 2011. This corresponds to approximately 400 million vehicle records and 2.3 billion individual axle-load records—the largest quantity of research-quality traffic data ever assembled. LTPP's database stores all of the data, which are available to researchers on request, in raw form or summarized as axle-load probability distributions.

Productive Metamorphosis

The LTPP SPS Traffic Data Collection Pooled-Fund Study has succeeded as a collaboration between FHWA, 28 highway agencies, and many other participants and stakeholders. The study has transformed the quality and quantity of the traffic data collected for 28 LTPP SPS test sites.

Many important lessons have been learned about collecting traffic data. Protocols have been developed for site selection; surface smoothness; equipment installation, calibration, and validation; and quality control checks. In addition, the study created novel contracting arrangements so that two contractors could perform mutually exclusive but complementary phases of the project and could verify each other's work.

Although the study turned out to be more challenging and costly than expected, it has shown that

TABLE 1 Accuracy of Data from Phase I Validation Tests (95% Confidence Level)

Parameter	Accuracy Guideline[a]	Data from 2001[b]	Data from 2005[c]
Gross weight	10%	–18% to +30%	0.2% ± 8.2%
Tandem axles	15%	–26% to +41%	0.0% ± 10.2%
Single axles	20%	–31% to +38%	1.2% ± 10.0%

[a] From specification (*4*).

[b] Data collected on the Florida SPS WIM site in 2001 using ceramic piezoelectric sensors (same system as used to collect the data in Figure 1).

[c] Data collected on the same WIM site in 2005 using quartz piezoelectric sensors and the procedures specified by the SPS Traffic Pooled-Fund Study protocols (same system as used to collect the data in Figure 2).

PHOTO COURTESY FHWA

Concrete slab grinding at an Arizona test site. Surface smoothness is one of the protocols developed for the pooled-fund study.

collecting research-quality traffic data with high availability over an extended period is possible. By the end of the study in December 2015, all 28 sites will have generated at least 5 years of research-quality data, with each site-year comprising at least 210 days of classification and loading data.

The action plan assembled in 1999, piloted in 2001, and implemented in 2003 has transformed traffic data collection, not only for LTPP, but for the entire traffic community. Although most highway agencies do not have the resources to implement all of the protocols for collecting research-quality data on their own test sites, many are able to apply and benefit from some of the protocols.

In addition to analysis of the performance of the SPS test sections, two traffic analysis projects are using the data collected from the pooled-fund study sites. The projects include the development of new traffic defaults for the *Mechanistic–Empirical Pavement Design Guide* and verification and enhancements to the LTPP classification scheme in use at nearly all of the pooled-fund study sites. Such projects would not be possible otherwise—the traffic data needed to complete them are not available elsewhere.

The metamorphosis of the LTPP traffic data project has yielded traffic data of unprecedented quality and quantity and has provided data that users can trust. The success of this work is a result of the unending support and commitment by the participating highway agencies, current and past members of the Traffic ETG, the LTPP contractors, TRB, and FHWA.

TABLE 2 Summary of Data Available from SPS Traffic Data Pooled-Fund Study Through September 2011

Participating SPS Site		Year	Total Days in Period	Classification Data		Weight Data	
				Days Used	% Used	Days Used	% Used
1. Arizona	SPS-1	2007	241	235	98	99	41
		2008	366	366	100	366	100
		2009	365	315	86	322	88
		2010	365	358	98	359	98
		2011	273	260	95	260	95
2. Arizona	SPS-2	2007	244	239	98	64	26
		2008	366	355	97	358	98
		2009	365	326	89	333	91
		2010	365	352	96	347	95
		2011	273	265	97	267	98
3. Arkansas	SPS-2	2007–2011	1,734	1,439	83	1,026	59
4. California	SPS-2	2008–2011	1,369	1,254	92	1,292	94
5. Colorado	SPS-2	2006–2011	1,982	1,876	95	1,872	94
6. Delaware	SPS-1	2007–2011	1,510	1,397	93	1,409	93
7. Delaware	SPS-2	2007–2011	1,510	1,397	93	1,409	93
8. Florida	SPS-1	2006–2008	843	606	72	608	72
9. Florida	SPS-5	2006–2009	1,078	993	92	996	92
10. Illinois	SPS-6	2005–2011	2,238	2,156	96	2,159	96
11. Indiana	SPS-6	2008–2011	1,170	1,143	98	1,146	98
12. Kansas	SPS-2	2006–2011	1,941	1,668	86	1,693	87
13. Louisiana	SPS-1	2008–2011	1,369	1,299	95	1,303	95
14. Maine	SPS-5	2007–2011	1,529	1,423	93	1,453	95
15. Maryland	SPS-5	2006–2011	2,040	1,931	95	1,975	97
16. Michigan	SPS-1	2005–2011	2,464	2,251	91	2,110	86
17. Minnesota	SPS-5	2006–2011	1,795	1,733	97	1,754	98
18. New Mexico	SPS-1	2008–2011	1,236	1,177	95	1,095	89
19. New Mexico	SPS-5	2008–2011	1,235	1,136	92	1,089	88
20. Ohio	SPS-1	2004–2011	2,830	1,572	56	1,464	52
21. Ohio	SPS-2	2004–2011	2,830	949	34	1,013	36
22. Pennsylvania	SPS-6	2007–2011	1,585	1,492	94	1,507	95
23. Tennessee	SPS-6	2007–2011	1,605	1,495	93	1,454	91
24. Texas	SPS-1	2006–2011	1,971	1,251	63	1,431	73
25. Virginia	SPS-1	2007–2011	1,731	1,640	95	1,649	95
26. Washington	SPS-2	2006–2011	2,099	1,877	89	1,785	85
27. Wisconsin	SPS-1	2007–2011	1,426	1,409	99	1,410	99
28. Wisconsin	SPS-2	2007–2011	1,426	1,409	99	1,410	99

NOTE: Annual data shown for Arizona SPS-1 and -2 for illustration; total results are shown for all other sites.

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