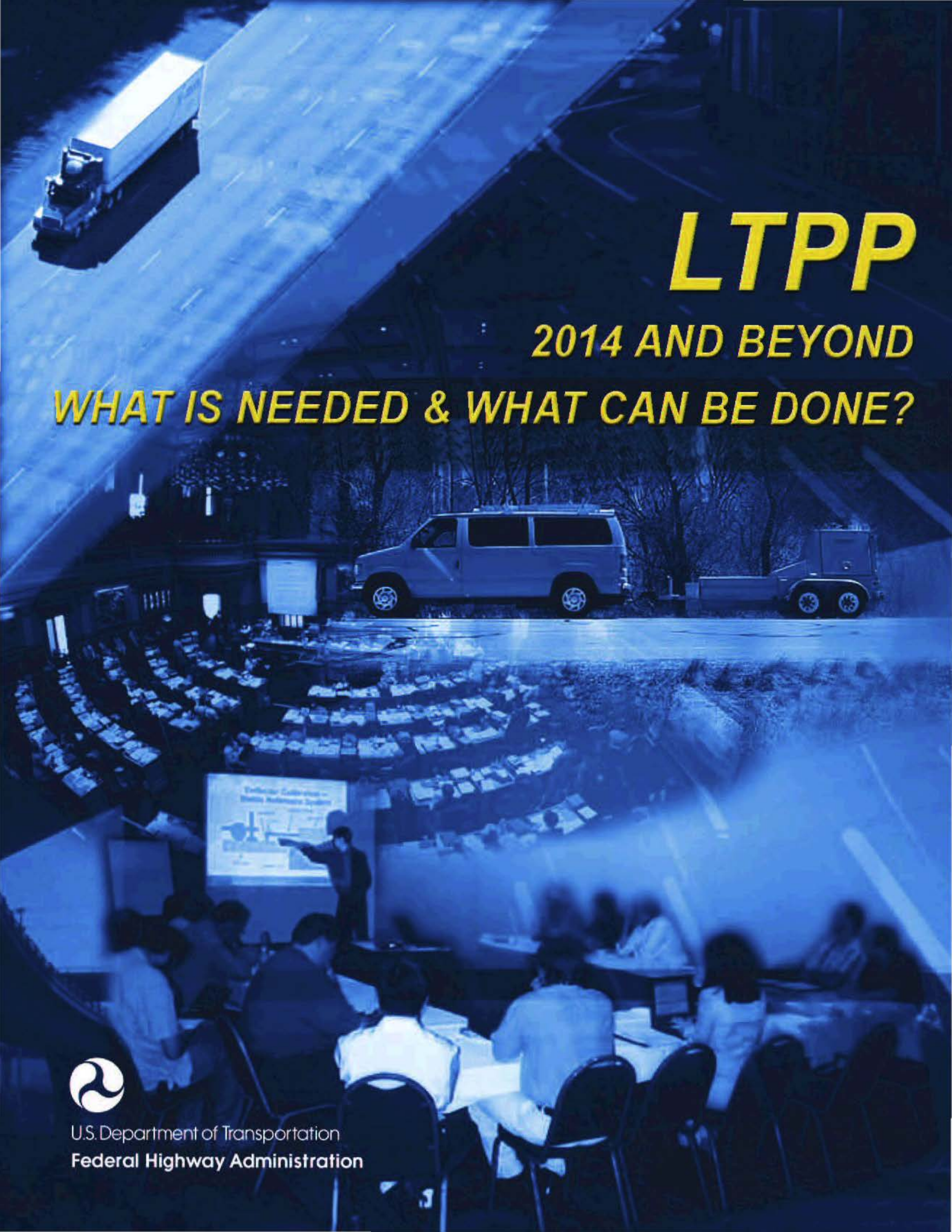
LTPP

2014 AND BEYOND

WHAT IS NEEDED & WHAT CAN BE DONE?



U.S. Department of Transportation

Federal Highway Administration

LTPP 2014 and Beyond

What is Needed and What Can Be Done?

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LTPP 2014 and Beyond

Introduction

The Long-Term Pavement Performance (LTPP) Program was formally established by the U.S. Congress in the Surface Transportation and Uniform Relocation Assistance Act of 1987, as part of the first Strategic Highway Research Program (SHRP). While most of the SHRP initiatives ended after the first five-year SHRP effort, the Federal Highway Administration (FHWA) was formally authorized by Congress in the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 to continue management of the LTPP Program to complete the mission of performance observations over full pavement construction (new or rehabilitation) cycles. In 1992, FHWA assumed management and administrative responsibilities to continue the LTPP Program and complete the planned pavement performance monitoring in partnership with the State transportation agencies that own the LTPP test sections, the Association of State Highway and Transportation Officials (AASHTO), and the Transportation Research Board (TRB). With the 2014 data collection cycle completed, a dataset reflecting two-and-a-half decades of data collection will soon be available. The mission of the LTPP Program is to promote increased pavement life through:

- Collecting and storing performance data from a large number of inservice highways in the United States and Canada, over an extended period, to support analysis and product development.
- Analyzing the data to describe how pavements perform and to explain why they perform as they do.
- Translating these insights into knowledge and usable engineering products related to pavement design, construction, rehabilitation, maintenance, preservation, and management.

The program's goal is to understand how and why pavements perform as they do. As highway agencies transition to a performance-based approach to managing highway investments, this goal is more important than ever.

This document discusses the LTPP Program as it exists today, the program's contributions to date, and a vision for its future.

LTPP in 2014

Through LTPP research, data characterizing 2,509 inservice pavement test sections and documenting their performance over a time period of up to 25 years have been collected, processed, and made publicly available.

The pavement test sections studied are organized in 17 scientifically designed field experiments within two broad sets of studies: General Pavement Studies (GPS) and Specific Pavement Studies (SPS). The GPS are a series of studies on selected existing pavement structures. These studies are restricted to pavements having materials and designs representing good engineering practices and having strategic future importance because of widespread use throughout North America. The SPS are studies of specially constructed, maintained, or rehabilitated pavement sections incorporating a controlled set of experimental design and construction features. The SPS experiments were designed to provide a broader range of pavement factors than those available from pavements designed to meet local conditions. For example, some SPS pavement structures include thin pavements under heavy traffic and thick pavements under light traffic. The GPS and SPS were designed to complement and supplement each other.

The status of these experiments, as well as of the LTPP data collection, data storage, data dissemination, data analysis, and product development activities, are addressed next.

Ongoing Experiment Status

A total of 2,509 LTPP test sections on inservice pavements were established throughout North America. The geographic distribution of those test sections is shown in figure 1, while tables 1 and 2 list the experiments within the GPS and SPS, including the total number of sections per experiment and the number of active test sections within each. As shown in tables 1 and 2 and in figure 2, 701 (28 percent) test sections remain active in 2014.

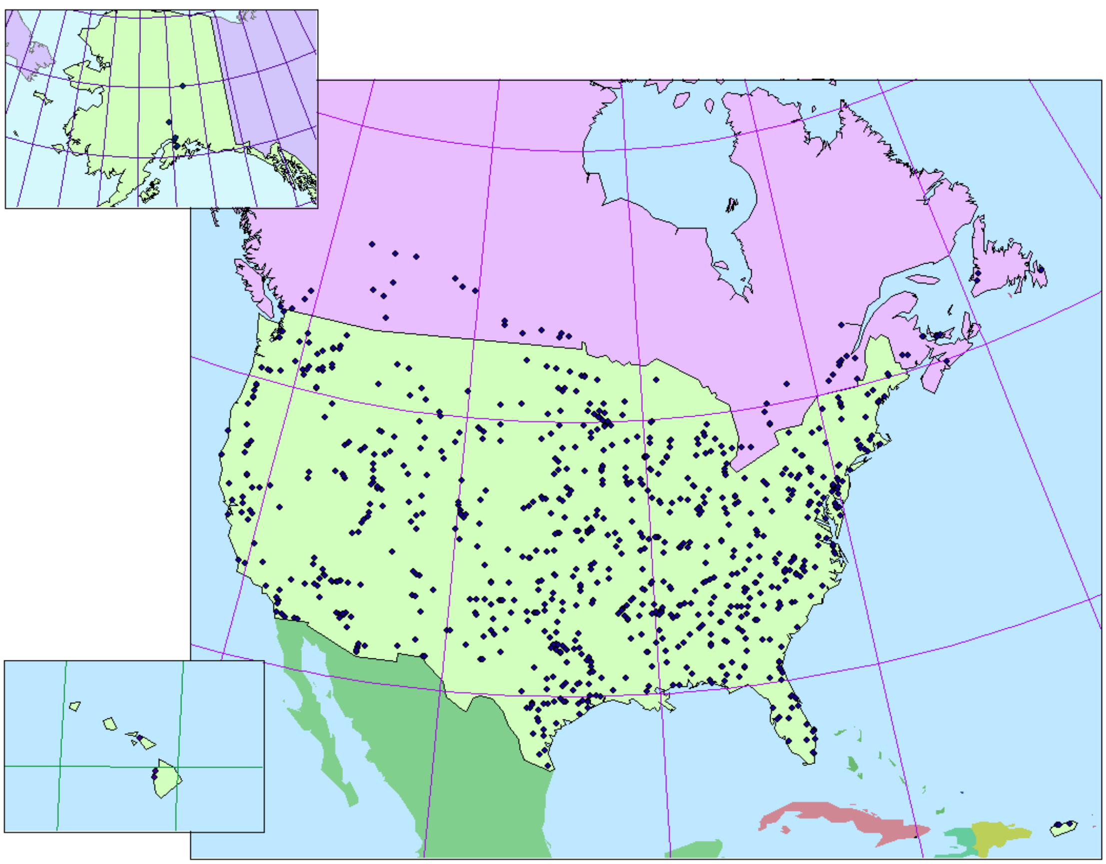


Figure 1. Map. Geographic distribution of LTPP test sections.

Table 1. List of General Pavement Study (GPS) experiments.

Experiment	Experiment Title	Total No. of Sections	Active No. of Sections	Active Sections as Percentage of Total
GPS-1	Asphalt Concrete (AC) Pavement on Granular Base	109	11	10
GPS-2	AC Pavement on Bound Base	65	8	12
GPS-3	Jointed Plain Concrete Pavement (JPCP)	116	65	56
GPS-4	Jointed Reinforced Concrete Pavement (JRCP)	49	16	33
GPS-5	Continuously Reinforced Concrete Pavement (CRCP)	55	29	53
GPS-6	AC Overlay of AC Pavement	371	187	50
GPS-7	AC Overlay on Portland Cement Concrete (PCC) Pavement	129	62	48
GPS-9	Unbonded PCC Overlay on PCC Pavement	24	12	50
Total		918	390	42

Table 2. List of Specific Pavement Study (SPS) experiments by category.

Experiment	Experiment Title	Total No. of Sections	Active No. of Sections	Active Sections as Percentage of Total
SPS-1	Strategic Study of Structural Factors for Flexible Pavements	175	35	20
SPS-2	Strategic Study of Structural Factors for Rigid Pavements	207	166	80
SPS-3	Preventive Maintenance Effectiveness of Flexible Pavements	445	0	0
SPS-4	Preventive Maintenance Effectiveness of Rigid Pavements	220	0	0
SPS-5	Rehabilitation of AC Pavements	182	39	21
SPS-6	Rehabilitation of Jointed Portland Cement Concrete (JPCC) Pavements	150	0	0
SPS-7	Bonded PCC Overlays on Concrete Pavements	39	0	0
SPS-8	Study of Environmental Effects in the Absence of Heavy Loads	53	41	77
SPS-9P/ SPS-9A	Validation and Refinements of SuperPave® Asphalt Specifications and Mix Design Process/SuperPave® Asphalt Binder Study	120	30	25
Total:		1591	311	20

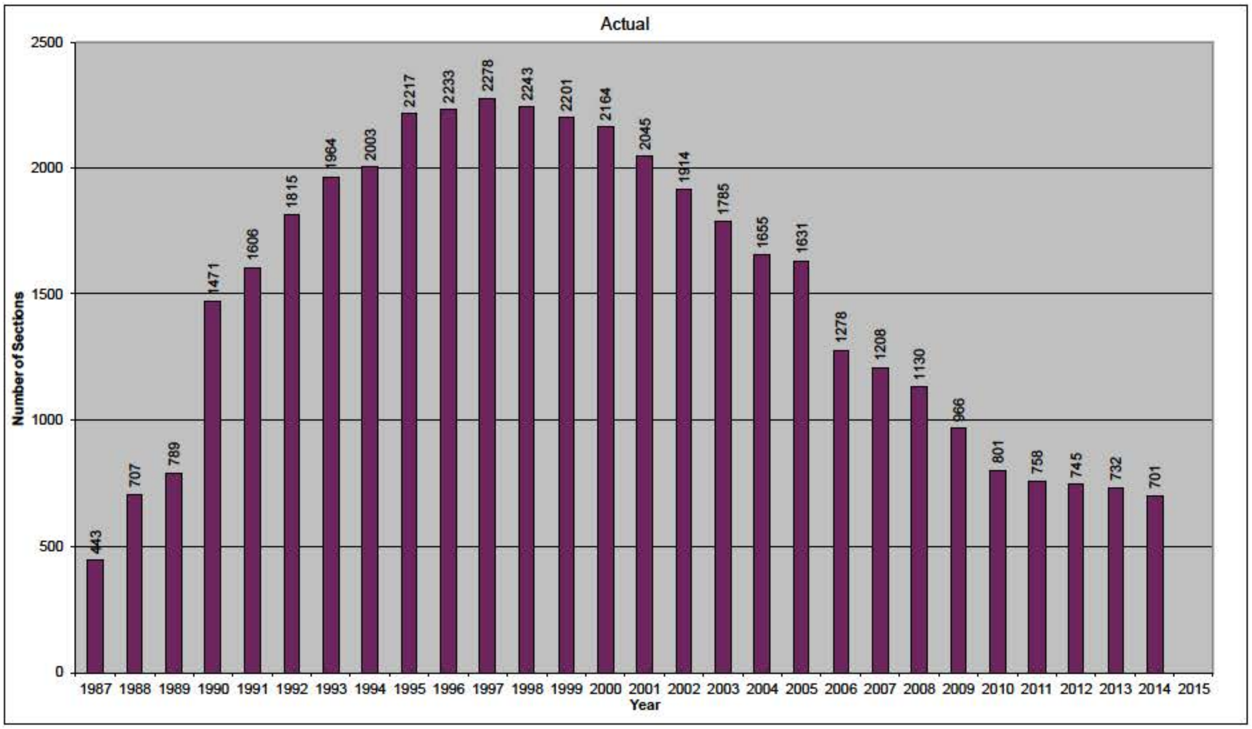


Figure 2. Chart. Variation in number of active test sections over time.

The SPS-3, -4, and -7 experiments were completed. These experiments and the associated 704 test sections were removed from the study. In the case of the SPS-3 and SPS-4, the researchers felt that the goals and objectives of these two experiments had been achieved. In the case of the SPS-7 experiment, the researchers concluded that the 39 test sections in the experiment did not represent a national study, but rather a series of local case studies.

For the remaining experiments, as test sections have reached the end of their performance cycle (i.e., owner agency determined it was necessary to rehabilitate or reconstruct pavement), one of two things has happened. The test sections are removed from the study and are no longer monitored by the LTPP Program. Or, when the owner agency is willing to continue monitoring the test sections and the manner in which the owner agency rehabilitates the test sections is consistent with the LTPP GPS-6 or -7 experiments, the test sections are migrated to that experiment and monitoring continues. This migration has strengthened the rehabilitation experiments and provided test sections rehabilitated with SuperPave® mixes that are otherwise used only in the SPS-9 experiment and provides needed performance data for SuperPave® materials. The migration has decreased only modestly the number of active LTPP test sections during the past four years: from 801 active test sections in 2010 to 701 in 2014.

Data Collection, Storage, and Dissemination

In all of the LTPP experiments, implementation of consistent procedures to collect long-term, high-quality data has been given the highest priority. The collected data include climate, traffic volumes and loads, pavement layer types and thicknesses, material properties, and pavement condition (distress, longitudinal and transverse profile, and structural response to loading (i.e., falling weight deflection)).

In addition to routine monitoring of the GPS and SPS experiments previously mentioned, the LTPP Program also has undertaken three intensive data collection efforts to expand the pavement engineering knowledge base and support findings from the original experiments: the Seasonal Monitoring Program (SMP), Dynamic Load Response (DLR), and Traffic Pooled Fund Study (TPFS). More detail on these efforts is provided in the text boxes.

Dissemination of LTPP AIMS Data – Data stored in the LTPP AIMS are not included with the SDR because of the large memory requirements. Point-by-point road profile, Falling Weight Deflectometer (FWD) time-history waveforms, distress map data, and raw traffic data are a few examples. These data have been made available to the public on request through a custom data extraction.

The LTPP information management system (IMS) is the electronic repository for all LTPP data and information. In addition to the data contained in the formal relational databases, the LTPP IMS includes findings from early analysis of LTPP data; raw data sources used to populate the electronic databases; extensive documentation for all aspects of experiment design, data acquisition, quality control, and data dissemination format; and LTPP-related products.

The LTPP IMS is comprised of two major components:

- LTPP Pavement Performance Database (PPDB) – The LTPP PPDB contains comprehensive data documenting and characterizing the structure, service conditions, and performance of the test sections under study. It was developed and operated as an Oracle®-based relational database, and the latest production is implemented in Oracle 10i.
- LTPP Ancillary Information Management System (AIMS) – A central electronic archive of the supporting data (not included in the LTPP PPDB), information, documents, research reports or briefs, and tools collected or developed by the LTPP Program.

Since 1992, public access to the LTPP data has been provided primarily through annual Standard Data Releases (SDRs), which enable users to harness the power of relational databases to manipulate large amounts of data at a reasonable cost and with ease-of-use. Through the SDRs, the database has been made available to the public in Microsoft Access® format on thumb drives or DVDs. The 28th release (SDR 28) was made available to the public in January 2014.

In January 2014, LTPP InfoPave™, a Web interface program for the LTPP IMS, was launched to serve as the primary source of LTPP data and information. LTPP InfoPave™ provides access to the LTPP IMS (both LTPP PPDB and LTPP AIMS) on demand and it also provides tools to maximize user understanding and utilization of the information.

Selected Contributions

The LTPP Program has contributed to advances in pavement engineering practice in many ways. The test methods, guidance, and data processing tools developed to support and ensure consistency in LTPP data collection and testing formed the basis for more widely used standards and tools. Selected examples are listed in Table 3. Analysis of the LTPP data undertaken as part of the research program has yielded a broad array of findings and insights into the factors that influence pavement performance as well as tools to support pavement engineering practice. Some examples are presented in table 4.

Table 3. Selected standards and tools founded on LTPP practices.

Standard or Tool	Application	LTPP Contribution
Weigh-in-Motion.	Collection of reliable traffic loading and classification data.	Developed the procedures and processes.
Highway Performance Monitoring System (HPMS) database requirements for ride, cracking, faulting, and rutting data.	Highway Performance Monitoring System.	LTPP definitions for ride, cracking, faulting, and rutting data provided the basis for these requirements.
ProVal Software.	Review and processing of pavement profile data to monitor and evaluate pavement roughness.	Prototype software developed as part of an LTPP data analysis project.
AASHTO R 32-09 Calibrating the Load Cell and Deflection Sensors for FWDs.	Ensures that FWD data used in pavement structural evaluation are accurate.	Procedures and calibration centers developed in support of LTPP data collection.
Equipment Startup Procedures for Resilient Modulus Testing Equipment.	Ensures uniformity and accuracy of LTPP resilient modulus testing data for bound/unbound materials.	Developed the procedures and processes.
Distress Identification Manual for the Long-Term Pavement Performance Program.	Helps to improve and/or standardize surface distress data collection.	Developed the manual.
Profile monitoring quality procedures and tools.	Used to evaluate profiler equipment, compare performance of various models against actual elevation measurements, and monitor data consistency.	Developed procedures and tools.

Table 4. Selected findings from LTPP data analysis.

Finding	Implications/Benefits	Reference
The 1993 AASHTO Guide for Design of New and Rehabilitated Pavement Structures does not accurately predict pavement performance.	Provided the impetus for pursuing the development of the Mechanistic-Empirical Pavement Design Guide (MEPDG) and AASHTOWare Pavement ME software.	*LTPP Phase I: Validation of Guidelines for k-value Selection and Concrete Pavement Performance Prediction*, 1997, Publication No. FHWA-RD-96-198.
LTPPBind software helps highway agencies select the most suitable and cost-effective SuperPave® asphalt binder performance grade.	LTPPBind was developed based on SHRPBind, but it incorporated LTPP's revised temperature models. The SHRPBind models were found to be conservative, and implementation of LTPPBind resulted in significant cost savings—estimated $50 million per year.	*Long-Term Pavement Performance* Program Highlights Accomplishments and Benefits 1989-2009, 2010, Publication No. FHWA-HRT-10-071.
Skewed joints do not improve the performance of concrete pavements.	By changing its pavement joint design standard to eliminate skewed joints, the Pennsylvania department of transportation (DOT) can reduce the occurrence of joint faulting, which leads to a smoother ride for motorists, reduced construction problems and related costs, reduced maintenance requirements, and fewer maintenance-related disruptions to traffic.	LTPP Findings Pay Off for Pennsylvania: Change in Pavement Joint Design Standard Saves Pennsylvania Money and Reduces Construction Problems, Application Notes, 2000, Publication No. FHWA-RD-00-064.
Slab widening improves structural capacity and single cuts for PCC joints are as effective as double cuts.	Widening slabs from 12 feet (ft.) to 14 ft. provides the structural equivalent of increasing slab thickness by 1 inch (in.) and a single 1/8-in. cut is as effective as Colorado DOT's previous standard 3/8-in. double cut for PCC joints, thereby providing a savings of $0.57 per linear foot of joint.	Implementation of Proven PCC Practices in Colorado, 2006, Report CDOT-DTD-R-2006-9.
Performance of reclaimed asphalt pavement (RAP) and virgin hot-mix asphalt (HMA) mixes used in overlays of flexible pavements is approximately the same.	LTPP performance data revealed that RAP and virgin HMA mixes used in overlays of flexible pavements show about the same performance across a wide range of conditions, which should give agencies confidence in specifying RAP for overlays when economic and other conditions warrant.	Lessons Learned from the Long-Term Pavement Performance Program and Several Recycled Sections in Texas, 2005, Transportation Research E-Circular, Issue No. E-C078).
Improved understanding of the impact of maintenance and rehabilitation treatments.	Engineers can make informed decisions on treatment types based on existing condition of pavement, expected traffic, and climate, which is useful in evaluating the cost effectiveness of alternative strategies, materials, and methods.	Final Report, LTPP Data Analysis: Effectiveness of Maintenance and Rehabilitation Options, 2002, NCHRP 20-50(3&4).
LTPP Performance Forecast Online software developed to provide pavement performance (smoothness and distress) predictions for flexible and rigid pavements.	Software can be used to forecast or estimate performance trends for pavement sections. These estimates are useful in evaluating the MEPDG to determine whether local calibration is needed for validation/implementation process. Predictions are also beneficial in updating pavement family performance curves within pavement management systems, allowing decision makers to optimize investment choices and improve overall pavement network conditions.	Long-Term Pavement Performance (LTPP) Data Analysis Support: National Pooled Fund Study Tpf-5(013): Effects of Multiple Freeze Cycles and Deep Frost Penetration on Pavement Performance and Cost, 2006, Publication No. FHWA-HRT-06-121.

The LTPP Program has also contributed to research undertaken by other organizations. Several of the more important contributions are identified in table 5.

The LTPP IMS is arguably the most important contribution of the program. It is the only source of long-term, inservice pavement performance data that offers nationwide coverage, high-quality data collected in a consistent manner, and the "critical mass" of test sections required to support well-founded conclusions. As such, the LTPP IMS provides a strong foundation for deriving the information needed to manage pavement performance effectively.

Table 5. LTPP contributions to other work of national importance.

Sponsor	Product/Application of LTPP Data	LTPP Contribution	Implications
National Cooperative Highway Research Program/AASHTO.	Mechanistic-Empirical Pavement Design Guide (MEPDG)/AASTHOWare Pavement ME Design software.	Test methods on which the MEPDG relies and data that made development and national calibration possible.	Estimated cost savings of $1 billion per year due to more reliable performance prediction.
Second Strategic Highway Research Program (SHRP2).	Guide to Using Existing Pavement in Place and Achieving Long Life.	Data used to identify appropriate strategies.	Washington State DOT saved $20 million by applying the SHRP2 tool on just two pavement projects.
Federal Highway Administration.	FHWA Pavement Health Track (PHT) analysis tool.	Default dataset to fill holes in HPMS and State datasets.	Provides agencies with a tool to forecast pavement investment needs.
Federal Highway Administration.	Highway Economics Requirements System (HERS).	LTPP data were used to fill in gaps in the HPMS dataset and were also used to calibrate the HERS pavement deterioration models.	Provides calibrated models, which are used to develop the biannual report to Congress on the status of the Nation's highways.

LTPP Contributions to Pavement Performance Needs—Today and Tomorrow

Understanding pavement performance and reliable performance prediction are fundamental to effective management of pavement assets. LTPP has made significant contributions to improvements in performance prediction and to the understanding of how and why pavements behave as they do, but many questions remain.

Since 1999, national analysis of LTPP data has been guided by the Strategic Plan for LTPP Data Analysis initially developed by the

TRB Expert Task Group for LTPP Data Analysis; it is now updated and maintained by FHWA with support from the TRB LTPP Committee and supporting Expert Task Groups. The plan lays out a long-term strategy for data analysis and answers questions that are important to effective management of highway pavement assets. To date, 76 of 220 identified projects have been completed through FHWA, National Cooperative Highway Research Program (NCHRP), or pooled fund projects.

While the plan does not identify all of the potential applications of LTPP data, the pursuit of the projects it identifies will make significant inroads on the questions that must be answered to achieve more effective pavement management.

While many of the identified projects can be fully accomplished with data already collected and available in the LTPP database, other projects would benefit from or require that data collection on the applicable LTPP test sections be continued through the end of the performance cycle (i.e., until the test sections are in need of rehabilitation or reconstruction). The currently identified analysis projects that would benefit from, if not require, additional data collection for various experiments (in priority order) include the following:

- GPS-3, SPS-1, SPS-5, SPS-8, and especially SPS-2 experiments – combined they represent 377, or 52 percent, of the active LTPP test sections and individually they represent 25 percent or more (84 percent in the case of the SPS-2) of the overall number of sections within each experiment.
- GPS-6, GPS-7, and SPS-9 experiments – combined they represent 258, or 35 percent, of the active LTPP test sections and individually they represent 28 percent or more of the overall number of sections within each experiment.
- GPS-1, GPS-2, and SPS-6 experiments –combined they represent 38, or 5 percent, of the active LTPP test sections and individually they represent 10 percent or more of the overall number of sections within each experiment.
- GPS-4, GPS-5, and GPS-9 experiments – combined they represent 59, or 8 percent, of the active LTPP test sections and individually they represent 33 percent or more of the overall number of sections within each experiment.

Benefits that will be derived from continued data collection and the more relevant experiments to achieve these include: (1) improved ability to develop definitive results, based on complete performance histories, concerning the impact of design features on long-term pavement performance (SPS-1 and SPS-2); (2) improved ability to assess the effects of loading and environment on pavement life (SPS-8); (3) improved design, construction, and maintenance procedures for asphalt concrete overlays, which will result in longer and more economical renewed pavement life (GPS-6, GPS-7, SPS-5, SPS-6, and SPS-9); (4) performance data required to develop, verify, and calibrate designs for long-life, high-performance pavements and to manage and maintain those new pavements (GPS-1, GPS-2, GPS-3, GPS-4, GPS-5, and GPS-9).

While LTPP is well positioned to provide a wealth of information concerning the performance of the pavements and materials commonly used over the past 20 years, it cannot, by itself, provide information on the long-term performance of emerging technologies. In recent years, for example, growing use of warm-mix asphalt (WMA) technology has been accompanied by questions concerning the long-term performance implications of its use. To address these questions, work began in 2013 on development of a new field experiment, SPS-10, to collect research-grade performance data on WMA pavements. SPS-10 builds on the findings of two recently completed NCHRP projects: 09-47 "Engineering Properties, Emissions, and Field Performance of Warm Mix Asphalt Technologies; and 09-47A "Properties and Performance of Warm Mix Asphalt Technologies ." The purpose of the SPS-10 experiment is to provide short- and long-term data on the performance of WMA relative to traditional HMA to answer the simple question, "Is there any significant difference?" The experimental matrix and research plan, test section nomination guidelines, LTPP inventory data collection guidelines, maintenance and rehabilitation data collection guidelines, and materials sampling and testing requirements have been developed. Test section recruitment has begun, with the goal of constructing at least one pilot SPS-10 project in 2014.

Similarly, the growing importance of pavement preservation and evolution in pavement preservation practices in recent years have brought about a need for better understanding of the long-term performance implications of different pavement preservation treatments. A request for proposal to develop a pavement preservation experiment was issued earlier in the year and a contractor to develop the experiment was recently selected. Other topics that have been suggested for possible exploration through LTPP experiments include cold-in-place recycling, high-RAP, recycled asphalt shingles (RAS), ground tire rubber (GTR) technologies, lime-cements, ternary cements/mixes, and precast systems.

What are the Options for Moving Forward?

While there are substantial benefits to be gained from continued investment in LTPP, the program cannot address all of the important highway engineering issues that need to be addressed through FHWA's research and development programs, and is therefore in competition with other research for scarce resources. For this reason, several potential funding scenarios, and the payoff associated with each, are discussed below. Figures 3 and 4 show the proposed fully funded scenario. Having a budget that is twice the current program budget would be highly desirable but unrealistic. Alternatively, having a budget that is half the current one would have significant negative impacts.

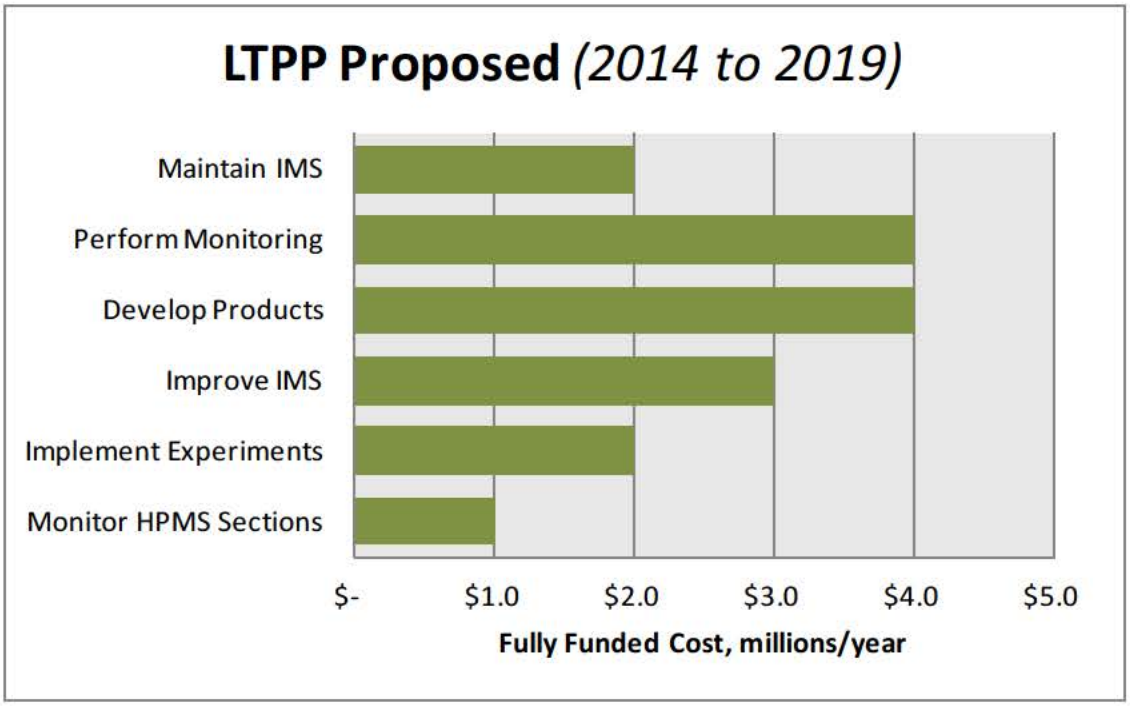


Figure 3. Chart. Breakdown of estimated LTPP annual program for 2014 to 2019.

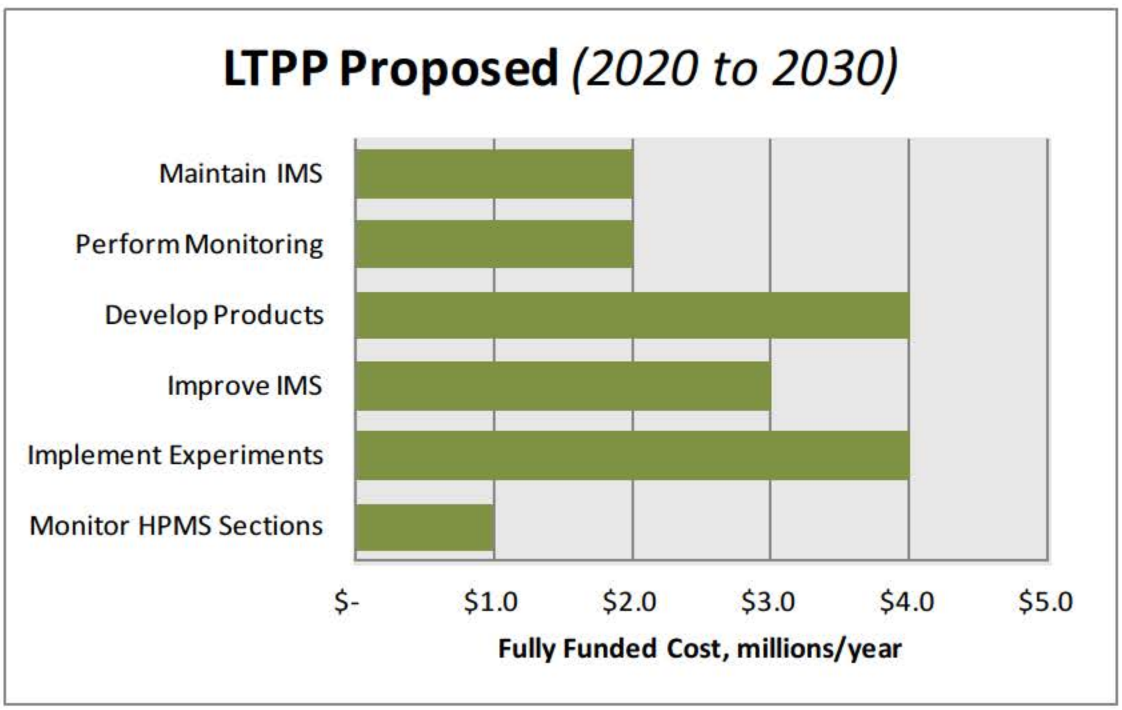


Figure 4. Chart. Breakdown of estimated LTPP annual program for 2020 to 2030.

The following options for moving forward with the LTPP Program into 2030 have been formulated:

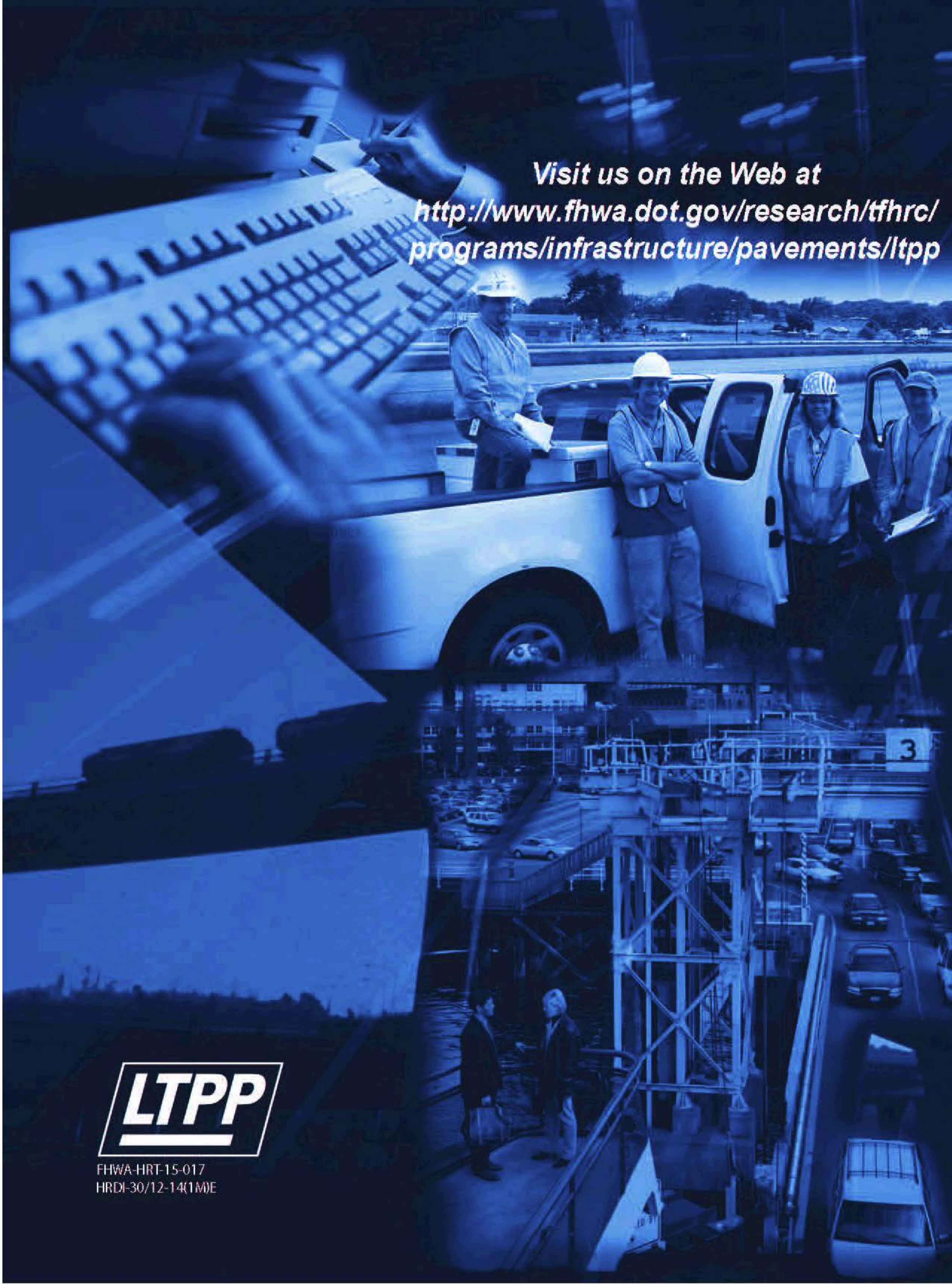
- ***Maintain the LTPP IMS as it exists today with the minimum investment needed to provide security and access to the data***. The LTPP IMS is an important national asset, which has the capability to support advances in pavement engineering for decades into the future. For this to happen, however, LTPP IMS data and information must be secured and access to the data and information must be provided. Accordingly, consistent with the recommendations provided by the TRB LTPP Committee and others over the past decade, this option is considered the program's highest priority and the absolute minimum, responsible investment option. This is estimated to cost approximately $1 million to $2 million per year in today's dollars.
- ***Continue monitoring of existing LTPP test sections***. To realize the full potential of the investment made in the remaining active test sections, monitoring must be continued until the end of their performance cycle. This option is considered the second-highest program priority. Doing so will maximize the ability to draw well-founded and meaningful conclusions about pavement performance, and especially the performance of pavements rehabilitated with SuperPave® mixes. It is estimated that this monitoring will cost $2 million to $4 million per year through 2020 and $1 million to $2 million per year through 2030.
- ***Perform LTPP data analysis and develop products***. Historically, data collection and storage activities have traditionally been given a higher priority than data analysis and product development due to the extremely high opportunity cost of not collecting time-sensitive data. After 25 years of monitoring, however, the program has reached a mature stage. Information in the LTPP IMS has reached a critical mass, and stakeholders cannot afford to wait for the insights the data can provide. Accordingly, data analysis and product development are seen as the program's third highest priority. It is estimated that $1 million to $4 million per year could be productively invested in data analysis and product development activities.
- ***Improve and enhance LTPP IMS interface and functionality***. As with any such system, there are a myriad of improvements and enhancements that can be made to the LTPP IMS. As noted earlier, it represents the most comprehensive assembly of pavement-performance data and information ever created. By virtue of its size and the evolutionary nature of its development, it is highly complex and challenging to navigate. The LTPP InfoPave™ goes a long way to addressing this issue, but there remains room for improvement. Ultimately, the goal is to have an LTPP IMS that contains complete, high-quality, higher-order datasets (e.g., back-calculated layer moduli from deflections and not the deflections) ready for analysis along with the supporting lower-level data (e.g., the deflection data and deflection-time histories at an even lower level) that can easily be accessed by future LTPP data users. By accomplishing this and other

proposed improvements and enhancements, the more widespread application of the database can be achieved, thereby increasing the return on investment. This option is considered the fourth priority and it is estimated to cost around $2 million to $3 million per year.

- ***Implement new LTPP experiments***. New materials and technologies will continue to evolve with time and understanding the performance and impact of these materials and technologies on performance will require long-term monitoring under a wide range of conditions. At the national level, there is no other program capable of carrying out the uniform, high-quality data collection, processing, and storage activities required for supporting pavement performance understanding. Implementation of the WMA experiment has commenced this year. Planning activities associated with the formulation of the pavement preservation experiment have recently commenced, and similar planning activities could follow for other topics. This option is considered the fifth most important to the program. The estimated cost associated with the implementation of new LTPP experiments is $1 million to $2 million per year through 2020 and $2 million to $4 million per year through 2030.
- ***Monitor control HPMS test sections.*** Recent FHWA studies have shown that there is great variability in the pavement- performance data submitted to FHWA as part of the HPMS. Since LTPP has created the most uniform field pavement data collection unit within FHWA, adding collection of performance data at selected HPMS sample sections to serve as control points would be beneficial in FHWA's ability to assess the health of the national highway system on a uniform basis. This option is considered the program's sixth priority and it is estimated that the cost of monitoring HPMS sample sections is a half to one million dollars per year through 2030.

It is estimated that these activities will cost $7.5 million to $16 million per year and they will be ongoing, to various degrees and in various forms, for the foreseeable future.

The above discussion on options for moving forward are contemplated solely within the context of pavements. Clearly, another option that merits serious consideration is the potential for the eventual integration of the LTPP Program with the Long-Term Bridge Performance (LTBP) Program into a Long-Term Infrastructure Program (LTIP) to address the need for greater understanding of the performance of not only pavements and bridges, but other assets as well.



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