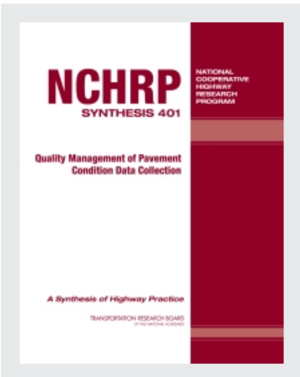

Quality Management of Pavement Condition Data Collection

DETAILS

144 pages | | PAPERBACK
ISBN 978-0-309-14247-2 | DOI 10.17226/14325

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP SYNTHESIS 401

Quality Management of Pavement Condition Data Collection

A Synthesis of Highway Practice

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SUBJECT AREAS
Pavement Design, Management, and Performance

Research Sponsored by the American Association of State Highway and Transportation Officials
in Cooperation with the Federal Highway Administration

TRANSPORTATION RESEARCH BOARD

WASHINGTON, D.C.
2009
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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

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NCHRP SYNTHESIS 401

Project 20-5 (Topic 39-01)
ISSN 0547-5570
ISBN 0-309-14247-2
Library of Congress Control No. 2009936617

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

are available from:

Transportation Research Board
Business Office
500 Fifth Street, NW
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ACKNOWLEDGMENTS

The authors would like to recognize the contributions of Captain Jordan Hudak, Instructor, Department of Civil and Environmental Engineering, United States Air Force Academy, while pursuing graduate studies at Virginia Tech. Mr. Hudak prepared the survey of practice, processed the information, and prepared a report that was used in the synthesis. The contribution of the many highway and transportation agencies that responded to the survey and subsequent requests of information was fundamental for capturing the state of the practice.

Valuable assistance in the preparation of the Synthesis was also provided by the Topic panel, consisting of Thomas J. Kazmierowski, Manager, Materials Engineering and Research Office, Ontario Ministry of Transportation; Ginger McGovern, Division Engineer, Oklahoma Department of Transportation; Michael R. Murphy, Research Fellow, University of Texas; Omar Smadi, Research Scientist, Center for Transportation Research, Iowa State University; Eric S. Thibodeau, Pavement Management Chief, Bureau of Materials and Research, New Hampshire Department of Transportation; Weixian Xiong, Assistant Division Chief, Pavement and Geotechnical Division, Maryland State Highway Administration; Kathryn A. Zimmerman, President, Applied Pavement Technology, Inc.; Aramis Lopez, LTPP Team Leader, Turner–Fairbank Highway Research Center, Federal Highway Administration; Thomas Van, Federal Highway Administration; Stephen F. Maher, Engineer of Design, Technical Activities Division, Transportation Research Board; and Jon Williams, Program Director, IDEA and Synthesis Studies, Technical Activities Division, Transportation Research Board.

This study was managed by Jon Williams, Program Director, IDEA and Synthesis Studies, who worked diligently with the consultants, the Topic panel, and the project 20-5 Committee in the development and review of the report.

FOREWORD

Highway administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to highway administrators and engineers. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire highway community, the American Association of State Highway and Transportation Officials—through the mechanism of the National Cooperative Highway Research Program—authorized the Transportation Research Board to undertake a continuing study. This study, NCHRP Project 20-5, "Synthesis of Information Related to Highway Problems," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute an NCHRP report series, *Synthesis of Highway Practice*.

This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

PREFACE

By Jon Williams
Program Director
Transportation Research Board

Transportation agencies are developing procedures and guidelines for managing the quality of pavement data collected to ensure the data meet the needs of the pavement management process. This study reviews the quality management practices being employed by public highway agencies for automated, semi-automated, and manual pavement data collection and delivery.

Information was gathered through literature review, surveys of U.S. state and Canadian province public agencies and private contractors, and selected interviews.

Gerardo Flintsch of the Virginia Polytechnic Institute and State University and Kevin McGhee of the Virginia Transportation Research Council collected and synthesized the information and wrote the report. The members of the topic panel are acknowledged on the preceding page. This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

CONTENTS

QUALITY MANAGEMENT OF PAVEMENT CONDITION DATA COLLECTION

SUMMARY

This synthesis reviews the quality management practices being employed by public road and highway agencies for automated, semi-automated, and manual pavement condition data collection and delivery using in-house staff and contracted services. Although the review focuses on the collection of distress data at the network level, it also covers smoothness, friction, and structural capacity data collection processes, and some elements of current quality management practices for project-level data collection. The document is a compilation of information from an extensive literature review, a survey of state and provincial practices and data collection service providers, and follow-up communications with a select number of state agencies. The survey was conducted electronically using interactive web-based commercial software. Fifty-five agency responses, covering 46 states and 9 Canadian provinces, were received. A shorter version of the survey was sent to private data collection service providers; six responses from service providers were received.

Many transportation agencies are developing procedures and guidelines for managing the quality of pavement data collection activities to ensure that the data collected meets the need of the pavement management process. Pavement data quality is receiving increased attention because: (1) data quality has a critical effect on the pavement management business decisions, (2) data collection is one of the most costly parts of operating a pavement management system (PMS), and (3) quality management is necessary to ensure that the collected data meets the requirements of the PMS. The review of practice confirms that the type and quality of pavement condition data required for network- and project-level decision making is generally different. Whereas smoothness and distress are collected at the network level by most departments of transportation (DOTs) (98% and 95% of respondents, respectively), deflections and friction are collected mostly at the project level.

The literature suggests that the most efficient way to achieve high-quality pavement condition data collection services is to adopt a comprehensive, systematic quality management approach that includes methods, techniques, tools, and model problem solutions. Although the concepts of quality, quality management, quality control, and quality acceptance have been extensively used in manufacturing industrial processes, these same principles, methods, and tools have not been systematically applied to pavement data collection. This is partially because in these services the "product" is not clearly known and the ground truth or reference value often is difficult to determine.

Over the last decade, there has been an increase in the use of data collection service providers for collecting both network- and project-level pavement condition data. This trend has been fueled by a combination of three factors: (1) an increase in demand for timely quality data to support pavement management decisions; (2) reductions in the public sector staff; and (3) availability of more sophisticated equipment that can collect large quantities of data quickly and efficiently, but that are often expensive and complex to operate. However, although most agencies have evaluated this possibility (81%), they still collect most of their data using in-house staff. Pavement distress and smoothness data are the data types that are most frequently outsourced (by 43% and 38% of the agencies, respectively). The main factor considered for making the decision to outsource the pavement data collection is

cost-effectiveness, followed by limitations of the in-house data collection capabilities, and the amount of data that needs to be collected. More than two-thirds of the agencies that have outsourced at least part of the data collection indicated that data collection outsourcing was a positive step.

Independent of the mechanism used to collect the data, in-house or through a service provider, a complete quality management system includes a clearly documented quality management plan. This plan is the "umbrella" document under which individual quality activities are conducted and it includes a clearly documented quality control plan, detailed quality acceptance procedures, and established guidelines to monitor the entire process, with timelines, milestones, and evaluation criteria. Most plans include activities that are conducted before, during, and after data collection production. Approximately one-third of the DOTs (35%) already have a formal plan and an additional 27% are working on developing such a plan.

The main techniques used for pavement data quality management are: (1) calibration and verification of equipment and/or analysis criteria before the data collection, (2) testing of known control or verification sites before and during data collection, and (3) software routines for checking the reasonableness, consistency, and completeness of the data. Other promising techniques that are not yet as commonly used include the analysis of time-series data, both at the project and network level; independent verification and validation of the pavement condition data by an independent quality auditor; and use of blind site monitoring during the production quality acceptance process. The various techniques are included in the quality control plans, quality acceptance procedures, and/or independent assurance processes.

Quality control includes those activities needed to assess and adjust production processes to obtain the desired level of quality of pavement condition data. These activities are defined in a quality control plan and include checks on the equipment used to collect the data, the personnel responsible for the data collection, and the data collection process itself. The purpose of the quality control plan is to quantify the variability in the process, maintain it within acceptable limits, identify the source of variability that can be controlled, and take the necessary production adjustments to minimize the "controllable" variability. In general, sources of variability for pavement condition data collection can be related to equipment used, operation (including rater/operator training and skills), processing of the data collected, environmental conditions, and shape and condition of the pavement surface.

Approximately two-thirds of state and provincial highway agencies (64%) have a formal data collection quality control plan or require the service provider to develop such a plan. All pavement data collection service providers indicated having a formal data collection quality control plan. The main tools and methods used for quality control are: (1) calibration and verification of equipment and methods before the data collection (used by 94% the agencies), (2) testing of known control segments before data collection (94%) and during data collection (81%), and (3) software routines for checking the reasonableness (57%) and completeness (55%) of the data.

Quality acceptance includes those activities conducted to verify that the collected pavement condition data meet the quality requirements and ensure that the final product is in compliance with the specifications. It applies to the pavement condition data collected by the agency and by service providers. Approximately half of the state and provincial highway agencies (48%) have a formal quality acceptance plan. In the case of data collection contracts, quality acceptance is often also linked to payments.

Important aspects of the quality acceptance plan include the establishment of acceptance criteria (data accuracy and precision, and reliability) and an appropriate sample size necessary to validate that the data meet these criteria. The main tools and methods used for quality acceptance by state and provincial highway agencies are: (1) calibration and verification of equipment/methods before the data collection (used by 80% the agencies); (2) testing of known control segments before data collection (73%); (3) testing of known control or verification segments during data collection (71%); and software routines that check the reasonableness (71%), completeness (61%), and consistency (50%) of the data, and compare the production data with existing time-series data (50%). A small percentage of agencies (21%) currently use blind control sections for quality acceptance. Some agencies are also starting to use geographic information system-based tools to support the quality acceptance process.

Some agencies also incorporate an independent assurance by using a third party to resurvey or reevaluate a sample of the data and compare the results with the production results. Typically, the techniques and approaches used for this independent verification are similar to those applied for the quality acceptance. Although quality engineering practices generally recommend the inclusion of external audits in the quality management plan, only 4% of the agencies surveyed use independent verification for quality control and 12% for quality acceptance.

The implementation of the discussed approaches for quality management is illustrated in four case studies that document the data management practices of state and provincial DOTs. The review included an agency that conducts most of the data collection in-house and three agencies that contract most of the network-level pavement condition data collection with service providers. The first case, the Maryland State Highway Agency, provides an example of an agency that collects data in-house using an automated system. Its' quality control plan includes control site testing and checks to identify abnormalities and verify that all fields are processed and saved. The quality acceptance is conducted by a quality assurance auditor, who checks the data management spreadsheets; verifies that the data are complete, saved, and backed-up; and rechecks a random sample of 10% of the data collected. Time-series comparisons of the percentage of the network in acceptable condition are used to flag potential data quality problems.

The other three cases cover agencies that collect data using service providers. The Virginia DOT case provides an example of an agency that has established a well-documented systematic process for quality management. This process includes an independent validation and verification of a 10% random sample of the pavement deliverables. Among other criteria, the acceptance plan requires that 95% of the data checked fall within plus or minus 10 index points of the data collected by a third-party validation and verification rater. The Oklahoma DOT case illustrates the use of very detailed automatic data quality assurance checks for quality acceptance. Finally, the British Columbia Ministry of Transportation quality management procedures provide an example of the use of blind control sites, which are manually surveyed in advance. These blind sites are situated along various highways in each region.

The review of practice showed that there are some issues that would benefit from further research. For example, it is clear that the type of data collected and the approaches followed to manage the quality of the data collection process vary significantly among agencies. Although there appears to be common agreement that data quality is important for effective pavement management, several agencies still do not have formal quality management plans. The adoption of automated/semi-automated data collection technologies has created challenges for the roadway agencies that verify that the new equipment results are consistent with the historical practices. There are also problems with the consistency of their location referencing systems, especially as the agencies migrate from linear to geodetic methods. Changing business practices, such as the reassessment of the highway PMS or the adoption of mechanistic–empirical pavement analysis and design methodologies, are also influencing the pavement condition data detail and quality requirements.

Topics that were identified for future research include the identification and demonstration of "best quality management practices," investigation of the effect of emerging pavement data collection technologies on the quality of the pavement management decisions, and cost-effectiveness analysis of the implementation of different quality management tools, methods, and programs. These efforts could be used to develop an AASHTO Standard Practice that provides "generic" quality management, control, acceptance, and independent assurance plans that agencies can customize for their specific needs. The development of a workshop or training course on quality management of pavement data collection could also be beneficial.

CHAPTER ONE

INTRODUCTION

A large number of public highway agencies in the United States have adopted pavement management systems (PMS) to cost-effectively manage the pavements on the more than 4 million km (approximately 2.6 million miles) of paved public roads. The collection of network-level pavement condition data, especially pavement distress data, is one of the most costly parts of operating a PMS. This function is also very important because data quality has a critical effect on the business decisions supported by the PMS. If the quality of the pavement condition data is inadequate, the consequent decision making will be compromised. For example, the PMS may recommend inappropriate treatments, or it may not program the roadway sections most in need of preservation. These "wrong" decisions undermine the effectiveness of, and confidence in, the pavement management process. According to AASHTO (*1*), "a properly planned and implemented data collection program will significantly increase credibility, cost-effectiveness, and overall utility of the PMS." To effectively support the pavement management process, the data collection program collects, processes, and records data in a timely fashion, with a level of accuracy and precision adequate for the decision being supported, assuring data consistency and continuity from year to year, and using a consistent location referencing system (*1*).

To ensure that the quality of the data collected meets the needs of the pavement management process, agencies are developing procedures and guidelines for managing the quality of pavement data collection activities. Agencies using service providers for pavement data collection have developed methods for service provider selection, monitoring during the contract period, and data acceptance. Agencies using staff resources for pavement data collection have developed similar quality management activities, which also include training of their staff. Furthermore, many agencies are also coping with changing automation technologies that decrease cost but pose challenges with time-history consistency of the data being collected. Agencies must place special care to ensure that data collected at different times are consistent (e.g., the same pavement characteristics are measured) to obtain reliable pavement condition time-series, monitor the performance of the network, and assess the impact of the pavement management decisions.

OBJECTIVE

The objective of this synthesis is to document quality management practices being employed by public road and highway agencies for automated, semi-automated, and manual pavement condition data collection and delivery. In particular, the synthesis examines: (1) the quality management techniques used in service provider selection, monitoring, and data acceptance by agencies that outsource the data collection; (2) the quality management techniques used for operations by in-house staff; and (3) how these practices affect the quality of the decisions made based on the data collected.

METHODOLOGY

This synthesis includes information from a compilation of sources, including an extensive literature review, an electronic survey of state and provincial practices and data collection contractors, and follow-up communications with a select number of state agencies. The survey was conducted electronically using interactive web-based commercial software. A detailed web-based questionnaire was developed for collecting the information from the state and provincial agencies, and a link to the electronic survey was sent to the Pavement Management contacts in all states and Canadian provinces. This questionnaire was dynamic and questions displayed were dependent on previous responses. On completion, the survey was automatically saved in a database. Fifty-five agency responses, covering 46 states and 9 Canadian provinces, were received. No local agencies were included in the survey. A shorter version of the survey was sent to private data collection service providers; six responses from service providers were received. Copies of the survey forms used are provided in Appendices A and B, and the results for the agencies and service providers are summarized in Appendix C. The analysis of the responses received is included in the relevant sections of the synthesis.

SCOPE AND ORGANIZATION

The study scope, which focused on network-level data, covered the following elements:

- Clear definition of key terms;
- Importance of quality data to pavement management processes and other uses of the data;
- Quality management techniques used for monitoring, and accepting pavement condition data collection activities by in-house staff and data collection service providers;
- Tools available for quality control, quality acceptance, and independent assurance;

- Effect of the size of the network being evaluated on the quality management process;
- How agencies are addressing issues associated with location referencing systems;
- Time-history issues associated with the introduction of new techniques and/or changes in data service provider;
- Gaps in knowledge and needed improvements to current practice; and
- Specific research and development needs.

Although the synthesis focuses on the collection of distress data at the network level, it also covers smoothness, friction, and structural capacity data collection processes and some elements of current quality management practices for project-level data collection.

The synthesis contains six chapters. Chapter one provides the background for the synthesis, including the objectives and scope of work, major definitions relevant to the synthesis, the methodology used for collecting and analyzing the information, some general background on the types of pavement condition data collected, the importance of quality data, and the impact of these data on the quality of the supported pavement management decisions. It also provides a brief description of the organization of the report and how the various components of the research were used to develop the report's conclusions.

Chapter two discusses in detail the type of data collected by highway agencies to determine the pavement's structural and functional condition to support pavement management decisions. Specific issues covered included network- vs. project-level data collection, outsourcings of pavement condition data collection to service providers, location referencing, pavement characteristics evaluated, and network coverage. The chapter also addresses time-history issues associated with introduction of new techniques and/or changes in service providers and additional challenges arising for adoption of new business processes, such as the Highway Performance Monitoring System (HPMS) reassessment and implementation of the Mechanistic-Empirical Pavement Design Guide (MEPDG).

Chapter three presents the main data quality management concepts and principles and summarizes the general policies and guidelines currently being followed by transportation agencies to conduct quality management activities. In particular, the chapter expands on data quality management plans and the distinction between quality control, quality acceptance, and independent assurance. It also covers reference value determination, sources of variability in pavement data collection, and the effect of the size of the network being evaluated on the quality management process.

Chapter four focuses on the specific quality management techniques that are being applied for pavement condition data collection. It discusses the tools and processes being followed for quality control, quality acceptance, and independent verification, and their effect on data rejection. Although the same tools are often used in more than one stage of the quality management process, they are organized in the most common configuration. Quality control tools discussed include personnel training and certification, equipment/method calibration, verification, and certification, data verification procedures, and software data checks. Quality acceptance tools include control and verification test sites, establishing acceptance criteria, sampling, database checks, and time-history comparisons. The chapter also covers some specific issues associated with the acceptance of data collection assembled by contracted service providers.

Chapter five documents the data management practices of four transportation agencies. For each agency reviewed, the chapter discusses the quality management procedures applied before collecting the data, as the data are being collected, during the post-processing of the data, and during the analysis of the data for supporting pavement management decisions and other business processes. Each case study highlights some of the distinct aspects of the agencies' quality management practices.

Finally, chapter six provides a summary of the key findings of the synthesis project, summarizes the state of the practice on quality management of pavement condition data, and highlights examples of good practices. This final chapter also identifies gaps in knowledge and needed improvements to current practice, and notes areas that have specific research and development needs.

BACKGROUND

The Data Warehousing Institute estimates that poor data quality costs American business $600 billion annually (*2*). Transportation agencies are no exception; quality data are essential to support asset (and in particular pavement) management decisions at all organizational levels. However, the level of detail and "quality" of the information required is heavily dependent on the level of decision making being supported. This section provides a brief overview of the types of condition data collected for managing pavements, defines quality and the main quality terms used in pavement data collection, and introduces the main issues associated with the quality of pavement condition data.

Pavement Management

Pavement management is a key asset management business process that allows department of transportation (DOT) personnel to make cost-effective decisions regarding the preservation and renewal of the pavements under their jurisdiction. Pavement management provided the framework for the development of asset management, and pavements account for a large percentage of the total assets managed by a typical DOT (*3*). A PMS is a set of decision-support tools (and methods) that can assist decision makers in finding cost-effective strategies for providing, evaluating, and maintaining pavements in a serviceable condition (*4*). An effective PMS, as with any decision support tool, includes reliable and sufficient data, calibrated analysis models and procedures, and tools that help visualize and quantify the impact of the possible solutions considered. The 2001 AASHTO *Pavement Management Guide* discussed in detail the technologies and processes used for the selection, collection, reporting, management, and analysis of data used in pavement management at the state level (*1*). The data needed in a PMS include inventory information (e.g., pavement structure, geometrics, costs, and environment), road usage (traffic volume and loading), pavement condition (ride quality, surface distresses, friction, and/or structural capacity), and pavement construction, maintenance, and rehabilitation history. In particular, *the quality of the pavement condition data is critical for producing informed decisions.*

Pavement management tools are currently used to support strategic decisions across various asset types within agency-wide asset management systems, network-level project selection and resource allocation decisions, and project-level decisions. Strategic-level tools typically support trade-off analysis across asset classes and agency programs, and high-level impact analysis. Network-level analysis tools support planning and programming decisions for the entire network or system (*5*). Examples include tools to evaluate the condition of the pavement network and predict pavement performance over time; identify appropriate preservation and rehabilitation projects; evaluate the different alternatives and determine the network needs; prioritize or optimize the allocation of resources to generate plans, programs, and budgets; and assess the impact of the funding decisions. Project-level analysis tools are then used to select the final alternatives and design the projects included in the work program. Examples include tools for pavement-type selection, life-cycle cost analysis, pavement analysis, and structural design.

Pavement Management Data Collection

Pavement condition data collection is one of the key components of pavement management. Several NCHRP syntheses have covered this topic; Table 1 summarizes the most recent ones.

The type of data collected in a PMS include smoothness (ride quality), surface distresses (rutting, cracking, faulting, etc.), frictional properties of the surface (tire/pavement friction or skid resistance and, more recently, macrotexture), and structural capacity (deflections). The way in which transportation agencies collect, store, and analyze data has evolved along with advances in technology, such as mobile computing, advanced sensors, imaging technologies, distributed databases, and spatial technologies. These technologies have enabled the data collection and integration procedures necessary to support the comprehensive analyses and evaluation processes needed for asset management (*12*). However, the use of the aforementioned technologies has in some cases led agencies to collect very large amounts of data and create vast databases that have not always been useful or necessary for supporting network-level decision processes.

It is important that the agencies tailor the data collection practices to the use of the data and the level of decisions being supported. Because of excessive data collection requirements, PMS are sometimes seen as too data-intensive and too expensive to sustain. To avoid this situation, three guiding principles are recommended: (1) collect only the data needed; (2) collect data to the lowest level of detail sufficient to make appropriate decisions; and (3) collect data only when they are needed (*13*). To help tailor the data collection practices to the uses of the data, Paterson and Scullion (*14*) introduced the concept of Information Quality Levels (IQL) for road management. This concept helps highway agencies structure road management information into different levels that correlate to the degree of sophistication required for decision making and, thus, the appropriate methods for collecting and processing data. Within the proposed framework, very detailed data (low-level data) can be condensed or aggregated into progressively simpler forms (higher-level data). Bennett and Paterson (*15*) defined five levels as presented in "A Guide to Calibration and Adoption of HDM-4" (see Figure 1). They ranged from very detailed data in an IQL-1 (research and benchmark data for other measurement methods) to a very general IQL-5 (top-level data, such as key performance measures or indicators, which typically might combine key attributes from several pieces of information).

Another relevant and current issue is that the pavement condition data collection technologies are advancing rapidly. *NCHRP Synthesis 334* (*6*) found that essentially all North American highway agencies are collecting pavement condition data through some automated means. Furthermore, the synthesis also found that 33 agencies (out of 56) use service providers (also called vendors or contractors) to collect at least some of the automated data. This creates new challenges for ensuring data consistency over time, as these automated data collection technologies may measure different pavement characteristics than those determined visually. The study also found that significant advances have been made in the area of quality assurance. In particular, the synthesis highlights some good examples from Canadian provinces, especially with sensor-related processes.

Quality Management—General Terminology

Quality is a desired essential or distinctive characteristic, property, or attribute of something (or its degree of excellence). To consistently achieve a quality product or service, it is necessary to adopt appropriate quality management practices. Although the concept of quality management is well developed and has been extensively used in industrial production

TABLE 1
RECENT NCHRP SYNTHESES RELATED TO PAVEMENT CONDITION DATA COLLECTION

No.	Title	Year	Content
334 (*6*)	*Automated Pavement Distress Collection Techniques*	2004	Examines automated collection and processing of pavement condition data techniques typically used in network-level pavement management, contracting issues, quality assurance, costs and benefits of automated techniques, monitoring frequencies and sampling protocols in use, degree of adoption of national standards for data collection, and contrast between the state-of-the-art and the state-of-the-practice.
335 (*3*)	*Pavement Management Applications Using Geographic Information Systems* (GIS)	2004	Examines the use of GIS and other spatial technologies in PMS, and discusses how the technologies have been combined to enhance the highway management process. It discusses data collection and integration, and location referencing systems.
291 (*7*)	*Evaluation of Pavement Friction Characteristics*	2000	Discusses the methods used for evaluating wet pavement friction characteristics of new and restored pavements and reviews models used for measuring and evaluating friction and texture, causes for friction changes over time, and aggregate and mix design to provide adequate friction.
268 (*8*)	*Relationship Between Pavement Surface Texture and Highway Traffic Noise*	1998	Presents a comprehensive synopsis of pavement/tire noise as it relates to roadways. Detailed information is presented on measurement techniques, reported noise emission results for pavement type and texture, effects of pavement wear, surface friction, and maintenance and safety considerations.
203 (*9*)	*Current Practices in Determining Pavement Condition*	1994	Examines practices for the collection, reporting, and application of pavement condition data for their service in PMS, focusing on four primary measures of pavement condition: distress, smoothness, structural capacity, and friction evaluations. It describes the types of equipment used and how the data are used to affect decision making by transportation managers.
167 (*10*)	*Measurements, Specifications, and Achievement of Smoothness for Pavement Construction*	1990	Examines the various devices and specifications that were being used to measure smoothness and ensure that newly constructed pavements will provide a smooth ride.
126 (*11*)	*Equipment for Obtaining Pavement Condition and Traffic Loading Data*	1986	Identified equipment that was associated with the collection of structural capacity, surface distress, friction, smoothness, and traffic loading data. Costs, maintenance requirements, advantages and disadvantages, and new equipment developments are briefly discussed.

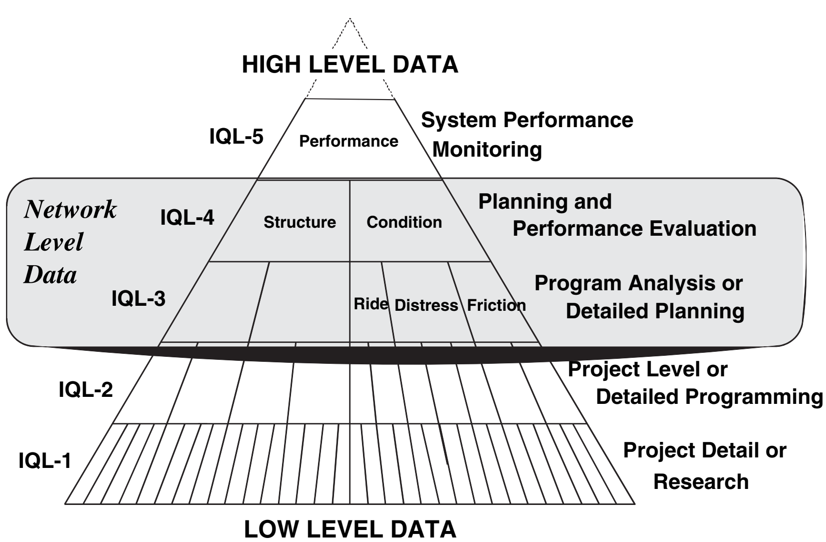

FIGURE 1 Information quality level [after Bennett and Paterson (*15*)].

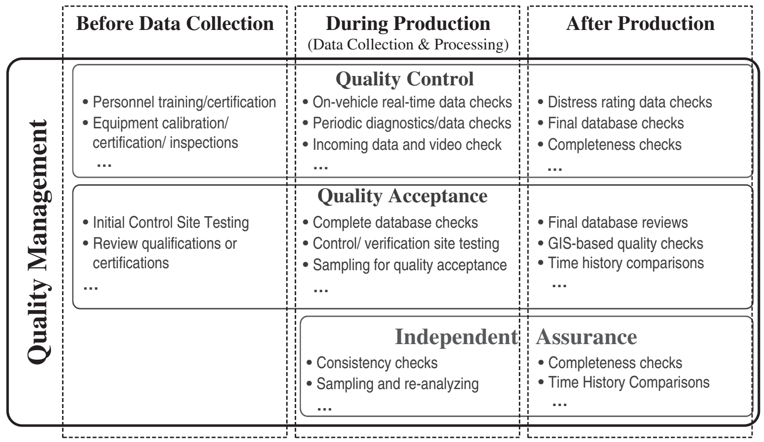

FIGURE 2 Pavement condition data quality management framework.

processes, it has not been systematically applied to pavement data collection. This issue is discussed in detail in the following chapters.

The following definitions were obtained by adapting those found in the quality management field to the pavement data collection activities. Special attention was given to the definitions provided in the *Transportation Research Circular E-C037: Glossary of Highway Quality Assurance Terms* (*16*), which defined standard terminology for highway quality with a focus on construction processes and to the terminology used in *NCHRP Synthesis 334* (*6*).

Quality: "The degree to which a set of inherent characteristics fulfill requirements" (*17*). These requirements could be features and characteristics of a product that are specified in a contract or identified and defined internally by the company or agency based on the customer expectations. The product could be a physical entity (e.g., a calculator) or a service (e.g., auto repair, or, as is the focus of this synthesis, data collection).

Quality Management: The overarching system of policies and procedures that govern the performance of quality control and acceptance activities; that is, the totality of the effort to ensure quality in the pavement condition data.

Quality System: The organizational structure, procedures, processes, and resources needed to implement quality management to meet the quality objectives.

Quality Control: Those actions and considerations necessary to assess and adjust production processes so as to control the level of quality being produced in the end product. It is also called process control. For purposes of this synthesis, quality control activities are those used to control the data collection activities, either by a data collection service provider or a road agency collecting data in-house, so that quality pavement condition data can be obtained.

Quality Acceptance: Those planned and systematic actions necessary to verify that the data meet the quality requirements before it is accepted and used to support pavement management decisions. These actions govern the acceptance of the pavement condition data collected using either a service provider or in-house resources. Quality acceptance is often referred to as quality assurance in the pavement engineering and management field.

Quality Assurance: The part of quality management focusing on increasing the ability to fulfill requirements. It includes all those planned and systematic actions necessary to provide confidence that a product or facility will perform satisfactorily in service. Because this term is often used in practice to refer to quality acceptance activities, to avoid confusion it is not used in the remaining sections of the synthesis.

Independent Assurance: A management tool that requires a third party, not directly responsible for process control or acceptance, to provide an independent assessment of a product or service and/or the reliability of test results obtained from process control and acceptance testing (*16*).

Figure 2 summarizes the terminology used in this synthesis, and provides examples of activities in each data quality management phase. The figure also shows examples of activities typically included in these processes. These and other relevant activities will be introduced in chapter two and discussed in detail in chapters three and four.

CHAPTER TWO

PAVEMENT CONDITION DATA COLLECTION OVERVIEW

This chapter focuses on the types of data collected by highway agencies to determine the pavement structural and functional conditions and support pavement management decisions, how they are collected, and why they are important for pavement management. It combines information from the literature reviewed with results from the survey of state and provincial agencies.

NETWORK- VERSUS PROJECT-LEVEL DATA COLLECTION

Data collection for network-level decision making is generally different from data collection for project-level decision making in purpose, methods, and the actual data collected. Therefore, the quality requirements for the pavement condition data needed are also different. Network-level data collection involves collection of large quantities of pavement condition data, which is often converted to individual condition indices or aggregated into composite condition indices. Owing to the large quantity of required data, collection methods typically involve windshield surveys and automated methods, as these techniques can generally be performed at highway speeds without affecting traffic or posing a hazard to data collection teams. This information is then used to assess the overall condition of the network, determine maintenance and rehabilitation strategies, and develop work programs and budgets for the entire network. This level of information is most appropriate for showing decision makers the highest priority pavement segments and for making multi-year projections with respect to the overall network condition.

Figure 3 summarizes the percentage of states and Canadian provinces that collect each type of pavement condition data at the network and project level; the value indicated above each bar indicates the percentage of agencies collecting the pavement indicators. These results are consistent with the findings reported by McQueen and Timm (*18*). Network-level surface distress and smoothness data are collected by almost all agencies. Only one agency (2%) reported that it is not collecting pavement distress data, and three (5%) reported that they are not collecting smoothness data at the network level. Most agencies define pavement distresses and severities, using approaches similar to the one used in the Long-Term Pavement Performance (LTPP) *Distress Identification Manual for the Long-Term Pavement Performance Program* (*19*). Smoothness data are typically reported using the International Roughness Index (IRI), which is computed as a linear accumulation of the simulated suspension motion normalized by the length of the profile, and is expressed in inches per mile or meters per kilometer (*20*). In addition to the individual condition indicators, a large percentage of the respondents (82%) use an overall pavement condition index, in addition to smoothness and individual distresses. Typically, structural capacity and frictional properties are collected at the project level.

At the project level, more specific data are typically collected in terms of individual distress identification and severity. Friction and structural capacity measurements are more prevalent at this level of data collection as more specific information is needed to determine specific preservation methods and budgeting requirements for individual pavement projects. This level of information is appropriate for use in technical decisions, such as preservation treatment selection decision trees, design of the selected treatment, and project-level cost estimates.

Data collection methods at the project level often include a higher prevalence of walking surveys, in addition to the other methods used for collecting network-level data. Structural capacity evaluation is performed mostly at the project level to support the "design" of the maintenance or rehabilitation projects that have been recommended through network-level analysis. Cost and traffic disruption are the primary reasons cited for agencies not performing structural evaluations at the network level. Friction measurements are also used mostly at the project level.

Approximately half of the agencies (49%) indicted that the data collected are being used to control pavement warranties, performance-based contracts, and/or other types of public–private partnerships. This type of contractual obligation creates additional demands in terms of the quality of the data.

IN-HOUSE VERSUS SERVICE PROVIDER COLLECTED DATA

Over the last decade, there has been an increase in the use of data collection service providers for collecting both network- and project-level pavement condition data. This trend has been fueled by a combination of three factors: (1) an increased demand for timely quality data to support pavement manage-

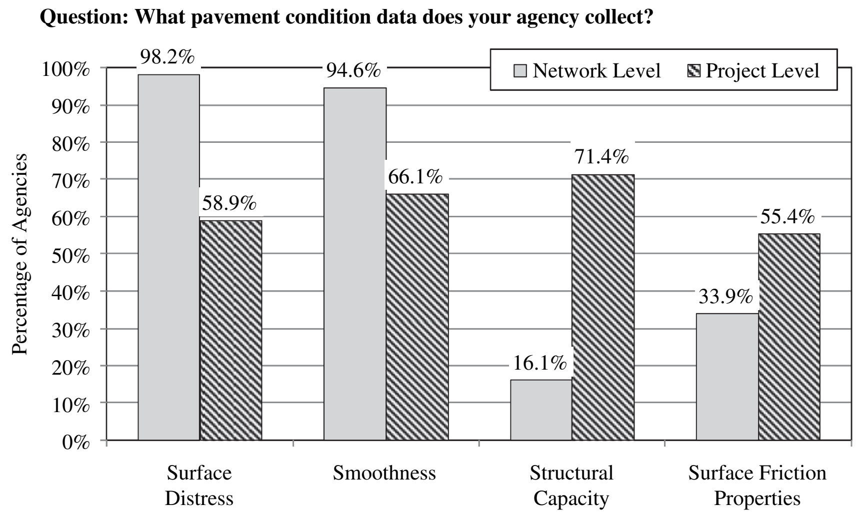

FIGURE 3 Types of pavement condition data collected.

ment decisions, (2) reductions in the public sector staff, and (3) availability of more sophisticated equipment that can collect large quantities of data quickly and efficiently but are often expensive and complex to operate. For these reasons, agencies are increasingly considering the outsourcing of data collection and processing to the private sector. However, although most agencies (81%) have evaluated this possibility, most agencies still collect most of their data using in-house staff. Figure 4 summarizes the percentage of agencies using the various collection modes for each particular pavement condition indicator; it is noted that not all agencies responded to this question.

Forty-eight percent of the respondents to the survey (27 agencies) are currently contracting at least some of their pavement data collection activities. Pavement distress and smoothness data are the data types that are most frequently outsourced (by about one-third of the respondents), although most data collected in those categories are still collected in-house. These results are consistent with the trend recently reported by McGhee (*6*), which indicated that the most commonly contracted data collection services included sensor-measured data condition items (smoothness, rut depth, and joint faulting). In the cases in which the smoothness and/or distress data are collected by a service provider, the service is usually outsourced to a single service provider.

Structural capacity data are collected primarily by in-house staff; however, for agencies that have outsourced structural capacity data collection, the use of multiple service providers is common. Friction data collection showed the lowest rate of outsourcing; only one agency currently contracts these services with a commercial service provider. The survey also showed that the outsourcing practices are not different for the various types of roads. The percentage of the agencies that have outsourced at least part of the data collection for each of the four

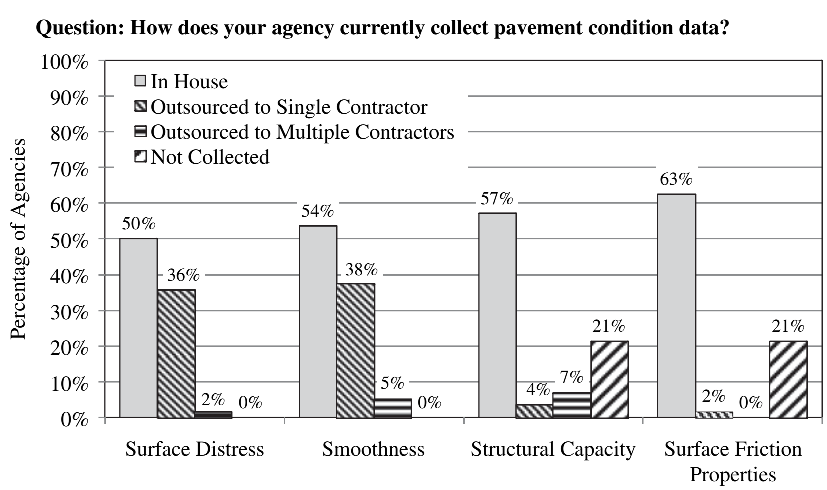

FIGURE 4 In-house versus contracted pavement condition data collection.

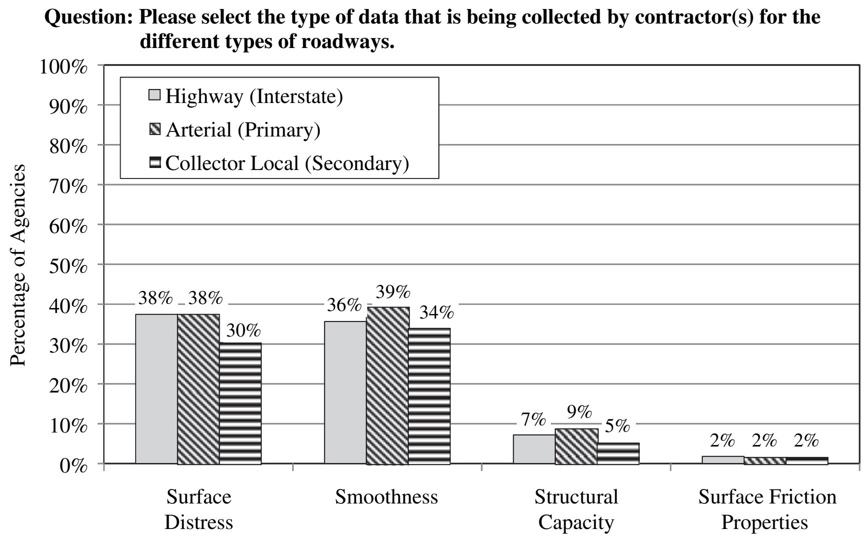

FIGURE 5 Types of data that are being collected by service providers by type of roadway.

pavement condition indicators by administrative classification are presented in Figure 5.

The transition from in-house data collection to the use of data collection service providers has brought new attention to the way the quality of these data is managed. When the agency uses a service provider, the data quality control and acceptance functions are clearly separated because they are conducted by different entities. The quality control is conducted by the service provider and the quality acceptance by the owner agency. Because service providers may use different equipment and methodologies than those traditionally used by the agency, quality checks to ensure consistency throughout the network and over time become a critical component of the quality management process. The distinction between quality control and acceptance is not as clear when the data are collected in-house because both activities are conducted by the highway agency.

Data Collection Outsourcing Rationale

The factors considered by the agencies that responded to the survey for making the decision of whether or not to privatize the pavement condition data collection services are summarized in Figure 6. The main factor cited was cost-effectiveness. Limitations of the in-house data collection capabilities and the amount of data that has to be collected were also frequently cited.

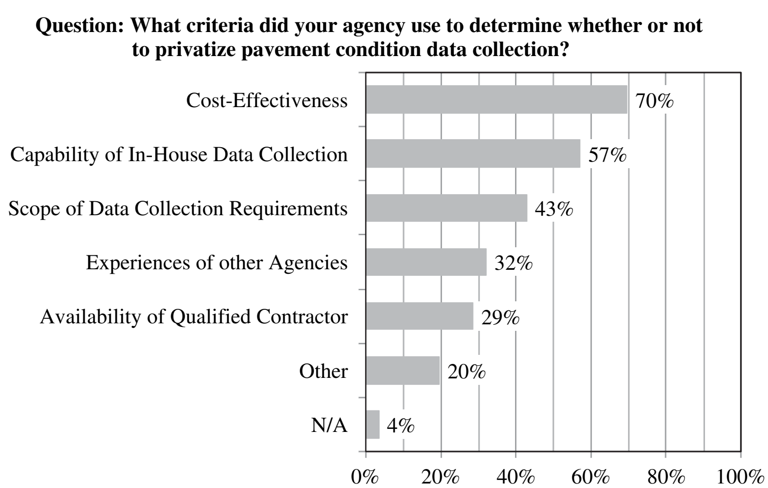

FIGURE 6 Criteria considered to outsource pavement condition data collection.

Several agencies also mentioned quality and timeliness of the data as important factors. However, whereas some agencies gave this reason in support of outsourcing the data collection, others used it to justify their decisions to continue collecting data with in-house resources. This disagreement appears to indicate that there are different degrees of satisfaction with the quality of the contracted services.

Service Provider Selection

The outsourcing of the data collection services typically begins with the issue by the owner agency of a request for proposals (RFP) or terms of reference document. This document outlines the services that are being requested, minimum quality requirements for these services, required service provider qualifications, and selection criteria. The main criteria used for service provider selection include past performance/technical ability (39%), best value (31%), and low bid (12%).

The process often requires a pre-qualification of the potential service providers before the economical offers are considered. For example, some states require service providers to evaluate some control section and meet specific accuracy requirements. The New Mexico DOT has taken a unique approach; the agency has contracted the distress data collection through a professional service agreement with a group of universities within the state.

Contract Characteristics

The contracts are typically let based on a cost per mile (58%), with some having a lump-sum fixed price (31%) and a few agencies citing other contracting modes. One agency reported using a cost per kilometer for network-level evaluations, and a fee for service for project-level surveys. Although no agency reported using performance-based contracts, McGhee (*6*) found that in 2003 most data collection service contracts included a quality assurance provision, approximately half had price adjustment clauses, and a smaller fraction of the contracts included warranty provisions.

The survey conducted for this synthesis revealed that several of the data collection contracts (39%) included clauses that link payment to the quality of the data collected; 32% of the contracts do not include such clauses and 29% of the respondents were not sure about the terms in the contract. The length of the contracting period is highly variable (see Figure 7), ranging from one year to more than three years. Longer contracting periods might lead to more consistency in the data, because the possible change in service providers during the successive bidding may introduce another source of variability.

Although McGhee (*6*) found in 2003 that agencies were contracting only a particular data collection activity (e.g., network-level smoothness measurement), the information

FIGURE 7 Length of the contract period for outsourced pavement data collection services.

reviewed for the preparation of the synthesis appears to indicate that more agencies request that the service providers collect multiple pieces of information. For example, the latest Louisiana Department of Transportation and Development (LADOTD) RFP (*21*) included the following services: preliminary activities (including training of raters and workstation delivery); collection of global positioning system (GPS)-referenced, clear digital pavement (grayscale) and right-of-way (color) images and profile data for each district; distress quantification for all roads tested; and final documentation of the project.

The LADOTD service provider selection criteria included the following factors: firm experience on similar projects (16% of the weight), personnel experience as related to the project (16%), the consultant's understanding of the project requirements as evidenced in the proposed work plan (16%), field trials (16%), and price (36%). The RFP requires that the consultant deliver on a weekly basis the following data: collected right-of-way images, raw data from the consultant's Data Collection Vehicle's electronic sensors (rutting, IRI, faulting, and GPS data), equipment calibrations test results (i.e., distress manifestation index, rut measurement device, video foot print, etc.), and electronic sensor verification results. The acceptance plan called for LADOTD personnel to evaluate the pavement images and condition data summary to look for discrepancies and the right-of-way images for quality assurance. Other examples are presented in the case studies reviewed in chapter five.

ISSUES ASSOCIATED WITH LOCATION REFERENCING

Location referencing is an important part of pavement management because it allows agencies to manage data spatially and with respect to time. This is important because meaningful analysis generally requires multi-year condition data of the same pavement segments to determine pavement deterioration trends and provide optimum preservation strategies. In addition, accurate referencing also allows overlaying condition indicators and other relevant parameters to identify sections in need of work, select appropriate interventions for those sections, and design the specific treatments. Therefore, the quality of the location referencing data is paramount for efficient pavement management. Quality management practices include checks for the location data. Location referencing problems may affect the pavement condition data quality and the decisions supported by these data. For example, poor location data may make it difficult to overlap different pavement indicators (e.g., roughness and cracking), develop time-series for performance prediction, link condition with traffic, etc.

A *location referencing method* refers to a technique used in the field or in the office to identify the specific location of an asset. Commonly used location referencing methods can be grouped in linear and geodetic (or spatial) reference methods. A *location referencing system* constitutes a set of procedures for determining and retaining a record of specific points in a transportation network. This system includes one or more location referencing method, as well as procedures for storing, maintaining, and retrieving information about points and segments on the network (*22*). State-of-the-art referencing systems can handle more than one referencing method and datum (*22, 23*).

Effective location referencing systems are comprehensive and can be used within and among agencies. This means that objects in the referencing system must be represented as they are in the real world. For example, roads and highway segments can be represented as one- or two-dimensional objects; that is, lines or polygons, and interchanges may be represented in three dimensions. Additionally, because an object's characteristics may change with time, it is necessary to include a standard temporal reference, such as a date of inspection (*24*).

Linear Referencing

The prevalent location referencing used in highway applications is linear referencing. Linear referencing methods consist of procedures for specifying a location as a distance, or offset, along a linear feature (highway network), from a point with known location (*25*). Common linear location referencing methods include route/milepost, link-node, reference point/offset (using a distance measurement instrument or distress manifestation index), and street address.

Spatial Referencing

The use of spatial location referencing based on GPS is becoming more prevalent as the technology becomes more affordable and accurate. The use of GPS to mark the location of distressed areas prevents some of the errors encountered by using milepost methods. Because the location is known in terms of coordinates, the relocation of a milepost or road realignment will not affect the true location of the distressed area. This mitigates the problem of losing historical data when a new segmenting system is implemented and aids with interagency data sharing because coordinates can be converted for use in other referencing schemes. The use of GPS also provides for easier data integration, allowing for the possibility of a more comprehensive and universal location referencing system. The use of spatial/geodetic location referencing facilitates interagency standardization (*26*).

Current Practice

Figure 8 presents the location referencing methods used to support the pavement data collection activities by the agencies that responded to the survey. It is noted that some agencies use more than one method. Most agencies (86%) use mileposts and milepoints. This is a classic example of a linear reference

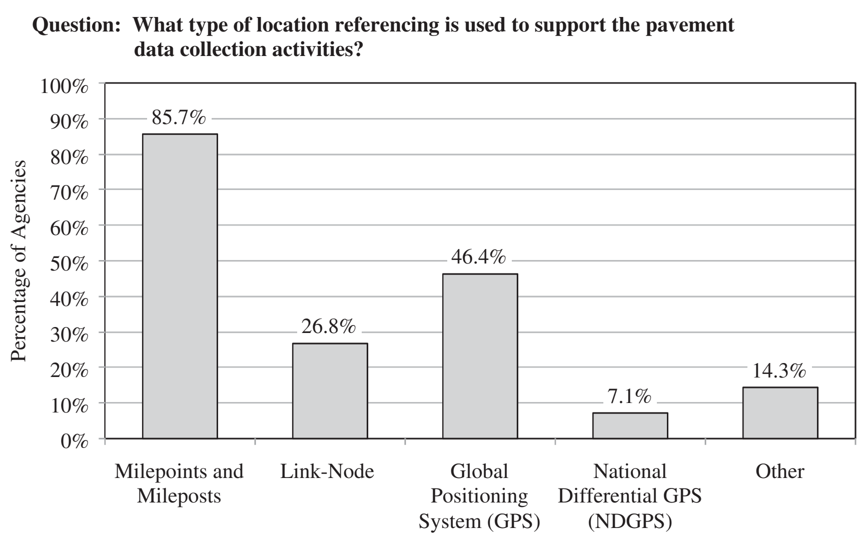

FIGURE 8 Types of location referencing used.

method, which may work well for use within an agency or department, but may not be suitable for sharing the data with other agencies or departments (which may use different referencing methods). The main advantage of this type of referencing is that it facilitates section identification and is familiar to most users and operators. A disadvantage is that markers may move (e.g., as a result of realignments), potentially changing the size and location of individual pavement segments. These changes may cause inconsistencies from year to year.

Whereas many location referencing methods can be used successfully for pavement condition data collection, it is important that they are implemented using smart business practices to ensure the quality of the collected data. More than one-third of the agencies surveyed (38%) reported problems with location referencing, many of which involved ensuring system consistency between departments within the same agency. Other problems listed included those associated with conversion from linear referencing systems to other systems (e.g., spatial coordinates), time-history updates, and inter-departmental standardization.

PAVEMENT CONDITION INDICATORS

Pavement Distresses

The types and number of distresses surveyed varies significantly from agency to agency. This variation is the result of historical practices, use of different materials and pavement designs, and variations in the environmental conditions. Although there have been efforts to standardize the definitions and measuring procedures for the various distresses by ASTM International and AASHTO, the use of national (or international) standards for distress data collection is still not a common practice. Recent steps include the publication of the ASTM Standard E1778, Standard Terminology Related to Pavement Distress. The LTPP *Distress Identification Manual* (*19*) is widely recognized for providing a good reference for project- and research-level distress data collection.

The distresses collected by the various agencies responding to the survey are summarized in Figure 9. Rutting was the only universally collected distress closely followed by transverse cracking and fatigue cracking. Most agencies also collect data on longitudinal cracking and some collect bleeding and flushing. In general, the asphalt pavement distresses most frequently collected (rutting, fatigue, and transverse cracking) are consistent with those used in the hot-mix asphalt mix design and structural design of pavements [e.g., in NCHRP 1-37A MEPDG (*27*)].

After the various types of cracking, the most commonly measured portland cement concrete (PCC) pavement distresses collected are faulting and spalling. This selection reflects the typical concern with the condition of concrete pavement at the joints.

Smoothness

Pavement smoothness is typically considered the pavement condition indicator that best reflects the public's perception of the overall condition of a pavement section. It affects ride quality, operation cost (e.g., fuel consumption, tire wear, and vehicle durability), and vehicle dynamics. Smoothness is computed by measuring the vertical deviations of the road surface along a longitudinal line of travel in the wheel path, which is known as the "profile." The profile is typically determined using laser-based measuring systems (high-speed or light-weight profilers).

These profilers measure the pavement profile directly using lasers to record the distance from the vehicle to the pavement

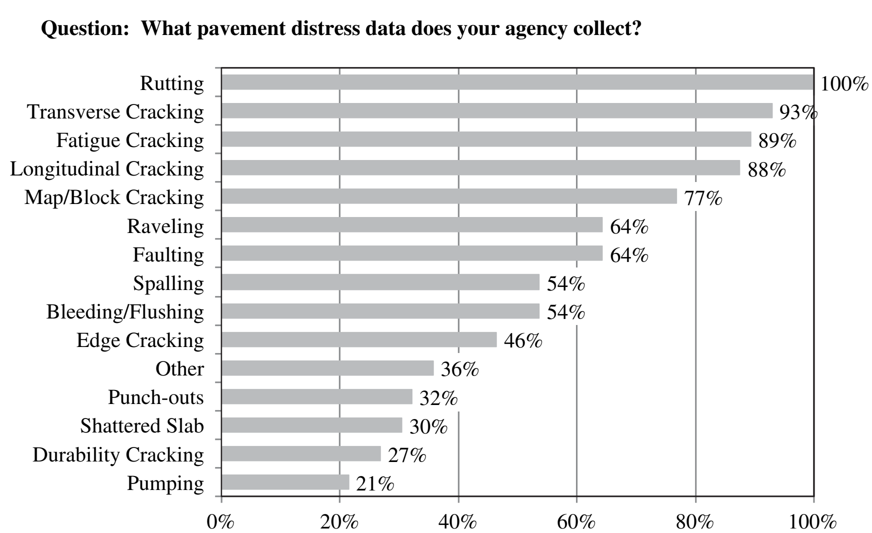

FIGURE 9 Types of distress data collected.

and accelerometers to record the vertical movement of the vehicle. The profile is used in a simulation model to compute the IRI (ASTM E1926, Computing International Roughness Index from Longitudinal Profile Measurements). The IRI is a summary measurement of the profile elevation changes of a roadway that represent the accumulated vertical movement of a "standard" vehicle traveling on the measuring profile (*28*). Although the IRI is fast becoming the standard to directly measure ride quality, there is a lack of standardization among transportation agencies in collecting the data, as is discussed in chapter three.

Surface Friction Properties

Transportation agencies monitor pavement friction because it affects wet-pavement friction and wet-pavement crashes; inadequate friction often leads to higher rates of crashes (*29*). Thus, friction measurements are typically conducted as part of the state's Wet-Accident Reduction Programs on areas with high numbers of crashes (*30*). The friction properties developed at the tire–pavement interface can be measured through contact testing, non-contact testing, or a combination of both. State DOTs typically collect friction using the locked-wheel device, a contact method. Noncontact testing (e.g., using profilers) are starting to be used to determine the pavement macrotexture. The macrotexture measurements are used to determine the change of friction with speed; pavement with high macrotexture presents less reduction of friction with speed and is less probable to contribute to hydroplaning. The International Friction Index (IFI) uses macrotexture properties in conjunction with friction testing to normalize measurement made by different types of equipment (ASTM E1960-98, Standard Practice for Calculating Friction Index of a Pavement Surface). The index is composed of two numbers, the friction value at 60 km/h (*F60*) and the change of friction with speed (s_p).

Structural Evaluation

The structural capacity of a pavement segment is typically obtained by using nondestructive techniques, such as Falling Weight Deflectometer (FWD) and/or destructive testing (i.e., coring and testing of the extracted materials) (*31*). FWD testing is done by dropping a weight on the pavement and measuring the deflection response at different distances from the point of load application. If the layer thicknesses are known, this information can be used to calculate the pavement Structural Number and modulus of the different layers (*31*). These properties can then be used to determine the remaining pavement structural capacity and service life.

Agencies that have started to collect structural capacity data at the network level generally agree that collecting data with a lower sampling rate than the one required at the project level is cost-effective and provides useful information (*32, 33*). Studies in Kansas and Indiana have shown that performing FWD tests at three sites per mile can provide statistically reliable results (*31*).

Deflection measuring devices that collect deflections at traffic speed appear to be more appropriate for network-level use. For example, the Rolling Weight Deflectometer (*34*) and the Danish Traffic Speed Deflectometer (*35*) provide more spatial coverage by measuring deflection at short intervals and averaging results over a longer length to reduce scatter. These technologies bring new opportunities for network-level pavement management; however, they also add additional issues in terms of data quality management. Accurate and repeatable measurements are still difficult to obtain and these technologies are not widely available. Because these devices are not currently being used for production surveys at the state and provincial level, these issues are not included in this synthesis.

TIME-HISTORY DATA COLLECTION ISSUES

One of the major challenges of successfully implementing and maintaining a PMS is ensuring consistency with legacy data when new techniques and technologies are implemented. Compatibility of the pavement condition data collection over time is very important for supporting effective pavement management. Quality time-series of pavement condition data are needed to develop reliable deterioration models, measure the impact of maintenance and rehabilitation treatments, develop multi-year work plans, and optimize the allocation of resources. Therefore, it is important that the new and legacy data are compatible or can be made compatible through an appropriate conversion. This applies to the actual data attributes (e.g., type of crack and length) and to the location referencing. The use of appropriate metadata (i.e., data about the data) can facilitate the transition. The issue of ensuring consistency over time is particularly important at the onset of adopting automated technologies. This typically creates significant challenges in terms of ensuring that the criteria and metadata are properly referenced.

Pavement Condition Data Consistency

The first concern with the adoption of a new data collection technology or with the contracting of a service provider is the verification that the pavement characteristics measured are at least as accurate as the existing data and with agency protocols and requirements. Furthermore, it is also important that the new data can be processed to provide pavement condition indicators that are consistent with the agency's historical data to allow time-history analyses. For example, it is important that automated crack detection systems provide the same ratings as the agency's visual method. Verification tests could be included in the quality management programs to verify this agreement. Several DOTs have used a pre-qualification process, in which they ask potential service providers to conduct measurements on several control sections for which the agency has conducted reference measurements. Another example is the certification process that has been proposed for profilers (*36*). Verification of the consistency of the data is also important when changing service providers or when the service providers (or the agency itself) use more than one pavement data collection piece of equipment or technology.

Location Referencing Consistency

The second key issue with the implementation of a new system or data collection approach is the adoption of a common location referencing method (*37*), or that appropriate and accurate conversion procedures are provided. Non-standardized location reference methods can pose significant obstacles when new methods of collecting data or new methods of using data are introduced. A universal location referencing method based on the spatial and temporal characteristics of the data collected can reduce problems with year-to-year variations and time-history updates. Agency enforcement of data referencing can prevent many time-history update problems (*37*). Generally speaking, spatial and temporal referencing of raw data is one of the most effective methods of ensuring historical continuity and preventing the loss of historical data.

NETWORK COVERAGE AND SAMPLING

Another important issue that affects the quality of the pavement condition data is the network spatial and temporal coverage. Network coverage and sample size are generally controlled by the type of data desired and their intended use. Pavement condition data quantity expectations generally vary according to: (1) the type of information required by the agency (and its intended use), (2) how often a particular piece of data is used, (3) the expense and/or difficulty in obtaining that data, and (4) changing federal requirements. The perceived rate at which the pavement condition changes and the volume of data necessary to provide useful information influences how often, if at all, different types of pavement data are collected. Thus, all these factors influence the frequency of evaluations and sampling procedures. Automated condition data collection is generally considered ideal for collecting network-level data because it allows for the efficient collection of large quantities of data, and with the proper calibration and quality management, data consistency can be assured (*38*).

Temporal Coverage

According to the survey, most agencies collect smoothness data for their highways at least once every three years, with many collecting data every year. Given that the HPMS program managed by the FHWA formerly required the submission of smoothness data on a sample of the network biennially (*39*), it is not surprising that smoothness data are collected frequently. The reassessment of the HPMS now requires annual smoothness submission for the National Highway System.

Most agencies also collect surface distress data at least once every three years, with many collecting such data every year. Even agencies that still use windshield surveys reported data collection frequencies of three years or less, resulting in a high degree of temporal network coverage.

Friction data are generally collected once every two to three years, with a low percentage of agencies collecting data every year. For network-level friction data collection, a roadway is typically divided into segments, usually 0.5 to 1.0 mile in length, and a friction value is measured over the segment. For example, Indiana collects annual friction testing on Interstate highways and once every three years on other roadways (*29*).

Structural capacity data are collected with the lowest frequency. Network-level structural condition data for an Interstate highway can be assessed by taking as few as three FWD readings per mile, once every five years, resulting in 20% network coverage per year. Studies in Indiana suggest that these measurements, along with ground penetrating radar (GPR) evaluation, can provide reliable information with respect to the remaining structural capacity of a pavement system (*40*). A significant number of respondents were unfamiliar with their agency's structural capacity data collection practices, suggesting that the collection of this pavement condition indicator is conducted by an office other than the one in charge of pavement management.

Lanes Evaluated

Another important issue related to data quality is the number of lanes evaluated. Most agencies (73%) reported collecting data for one lane only along multi-lane roads, whereas only a few reported collecting data along multiple lanes of the same roadway. Studies in Indiana have shown that in terms of pavement smoothness, the difference between the driving lanes and passing lanes is statistically insignificant (*29*). However, this type of agreement would not be expected in cases where separate lanes may receive different preservation treatments. When only one lane of a multi-lane road is being evaluated, care is to be taken so that the same lanes are consistently evaluated to be able to establish historical trends for developing performance models. Many agencies have recognized this and have standardized which lanes are used for collecting data; for example, many agencies collect data on the primary direction on two-lane roads and on the outside lane in both directions on four-lane roads.

NEW DEMANDS IMPOSED BY CHANGING BUSINESS PRACTICES

Changes in business practices, such as the HPMS reassessment and the adoption by AASHTO of the MEPDG, are expected to affect quality management practices. The type of data collected and their degree of detail will likely change, influencing the quality management practices used for their collection.

Impact of the Highway Pavement Management System Reassessment

The HPMS is a key national transportation data program that provides highway inventory, condition, performance, and operating characteristics data to national, state, and regional customers. The system is used at the national level for apportionment, performance measures, highway statistics, and conditions reporting. HPMS stores data on pavement condition and other items such as road classification and travel by vehicle type. Because all state DOTs are required to report their data, HPMS data requirements have a significant impact on their data collection practices.

The HPMS has historically only required ride quality data on a biennial cycle to characterize the condition of the pavements. Pavement metadata to describe the processes used for collecting and reporting some of the pavement data items have been optional. States report the average of both right- and left-wheel path quarter-car IRI as a Mean Roughness Index. However, the system has recently been evaluated to respond to current and future business needs, capitalize on changing technology, and address resource constraints and institutional changes. The reassessment has resulted in new procedures that increase annually the frequency of IRI data collection throughout the National Highway System and requires the collection of additional pavement condition and structure data. These new requirements would be expected to change the quality management practices states follow to collect the required data.

The specific additional pavement condition data items required include rutting and faulting (collected using a profiler at same time as IRI), IRI year, fatigue, and transverse cracking (regardless of severity). Other pavement-related data include last construction or reconstruction year, last overlay data and thickness, layer thicknesses, base type, and subgrade soil type. In addition, the reassessment has made metadata required, reduced the IRI metadata, and added additional metadata for rutting, faulting, and cracking. The required pavement metadata has been published in the *HPMS Reassessment 2010+* (*41*).

Impact of the Mechanistic–Empirical Pavement Design Guide Implementation

Many highway agencies are adopting mechanistic–empirical procedures, because this approach in general provides an improved methodology for pavement analysis and design with respect to the traditional purely empirical approaches. In particular, AASHTO has recently adopted the MEPDG proposed by NCHRP Topic 1-37A (*27*). Mechanistic–empirical procedures use pavement models based on the mechanics of materials to predict pavement responses (deflections, strains, and stresses) and empirically based transfer functions to estimate distress initiation and development based on these responses. The distresses predicted are then used to estimate the evolution of ride quality, in terms of IRI. Implementation of these procedures is expected to improve the efficiency of pavement designs, provide better capability for the prediction of pavement lifetime preservation needs, and help assess the effect of new materials and pavement technologies and systems. In the long term these changes are expected to result in longer-lasting pavements that provide smoother, safer, and more comfortable rides, thus improving the level of service provided to the roadway users (*42*).

The implementation of mechanistic–empirical pavement analysis and design methodologies is expected to affect pavement management practices and, in particular, pavement condition data collection. The validation and calibration of the mechanistic–empirical models depends on accurate performance data from in-service pavement sections. Although information currently available in some PMS can be used to develop initial calibration factors, an accurate long-term calibration will require significant changes in the information that is stored in the PMS databases. The level of detail and quality of the information currently included in most PMS does not appear to be enough to support the validation and calibration of mechanistic–empirical pavement analysis and performance prediction models. A recent study conducted to determine the best way to calibrate the proposed MEPDG pavement condition prediction models using PMS data identified several limitations (*43*). For example, in most cases the materials, construction, and maintenance data available within a DOT are not currently tied to pavement management activities. This makes it difficult to link performance data to materials and construction data. Furthermore, not all relevant data are recorded (e.g., in-place thickness is often missing) and the network-level pavement deterioration and performance data often do not have the required level of detail. Therefore, the use of mechanistic–empirical performance models, especially at the network level, will likely require the collection of significantly more data, such as material characterization test results, environmental conditions, as-constructed layer thicknesses and properties, and more detailed condition evaluations.

SUMMARY

This chapter covered the types of data collected by highway agencies to determine the pavement structural and functional conditions and support pavement management decisions, and how they are collected. The review of practice indicates that the type and quality of data required for network- and project-level decision making is generally different. Although smoothness and distress are collected at the network level by most DOTs, deflections and friction are collected mostly at the project level.

Factors that impact the quality management procedures, and that require additional attention include the following:

- *Pavement data collection outsourcing*—brings new challenges to ensure that the data collected are consistent with the agency protocols and requirements. This is particularly true for those agencies switching from in-house manual to contracted automated or semi-automated data collection.

- *Quality of the location referencing data* is paramount for efficient pavement management, allowing, for example, the collection of time-series of data for developing performance curves, overlapping different pavement indicators (e.g., roughness and cracking) to determine optimum preservation treatments, and linking condition with traffic and other road characteristics.
- *Historical data consistency*—especially when adopting new technologies or measurement techniques.
- *Network spatial and temporal coverage*—expectations for quality and quantity of pavement condition data generally vary according to the type of information required by the agency (and its intended use), how often a particular piece of data is used, and the difficulty in obtaining that particular data.
- *New demands imposed by changing business practices*—the HPMS reassessment and the adoption by AASHTO of the MEPDG for example are expected to affect quality management practices. The type of data collected and their degree of detail will change, influencing the quality management practices used for their collection.

CHAPTER THREE

DATA QUALITY MANAGEMENT CONCEPTS

A complete pavement condition data collection quality management program provides a comprehensive, systematic approach to data collection and processing. This chapter presents the main data quality management concepts and principles as they apply to pavement condition data collection; the main sources of variability in pavement condition data collection; and the general policies, principles, and guidelines currently being followed by transportation agencies to conduct quality management activities.

The concept of quality is reasonably simple to understand; however, the methods, tools, attitudes, and values involved in providing high-quality products and services are not. Approaches to achieve quality, such as Total Quality Management (TQM), are often difficult to understand and operationalize because they are not simply toolkits, methods, or management theories, but rather part of an encompassing quality approach (*44*). Furthermore, the concept is particularly complex to apply to services such as pavement data collection, because the approach was developed for, and has had its greatest successes in, manufacturing industries where the "product" is a clearly defined physical entity. Managing the quality of pavement condition data is particularly challenging because not only the product is not clearly known, but also the ground truth or reference value is often difficult to determine (*45*). It is important that the quality principles and practices used in the manufacturing industries be adapted to match pavement data collection services.

The most efficient way to achieve high-quality services is to adopt a comprehensive quality management approach that includes methods, techniques, tools, and model problem solutions. The development of a quality management system requires, as any management system, the interaction of three fundamental components: processes, people, and technology. If any of these components is lacking, it is unlikely that the system will be successful (*46*). Furthermore, adopting a comprehensive quality approach is typically hard to justify with a simple cost-benefit analysis. The costs and benefits of a quality "approach" are clear only after the quality processes have been tested and the organization can exploit the benefits from the improved quality. The overall quality approach would include the following elements (*47*):

1. Identification and documentation of the procedures that cover all key business processes (control of documents);
2. Monitoring processes to ensure these procedures are effective (including audits);
3. Adequate record keeping (control of records);
4. Continuous checking output for defects (control of nonconforming product/service), with appropriate corrective actions;
5. Periodic reviews of individual processes, preventive actions, and the quality system itself to verify its effectiveness (often including both internal and external audits); and
6. Fostering continuous improvement.

PAVEMENT CONDITION DATA COLLECTION QUALITY MANAGEMENT SYSTEM

Independently of the mechanism used to collect the data, in-house or through a service provider, a complete pavement condition data quality management system would include a clearly documented quality management plan, detailed quality acceptance procedures, and established guidelines to monitor the entire process (as summarized in Figure 2). It is important that the quality management plan include the activities to be conducted, as well as clear timelines, milestones, and evaluation criteria. For the quality management system to properly work, everything from effective data collection procedures and training to efficient data processing and quality control/quality acceptance reviews needs to be performed in a timely manner.

For example, previous studies have suggested that the steps in the quality management process of distress data collection include the following activities [adapted from Morian et al. (*45*)]:

- Distress definition;
- Rater training (and equipment calibration);
- Systematic data collection process management;
- Systematic data handing and processing;
- Timely, effective quality control system;
- Timely, effective quality acceptance check system;
- Timely identification and implementation of corrective actions;
- Timely report development; and
- Delivery of results to the owner agency.

BACKGROUND ON QUALITY MANAGEMENT CONCEPTS AND PROCESSES

The subjects of quality, quality management systems, quality management, quality control, and quality acceptance have been the focus of a series of documents developed by the

International Standards Organization (ISO) known as the ISO 9000 series, or "family," of standards (*48*). These standards offer quality management guidance and identify the elements necessary to direct and control an organization with regard to quality. The standards lay out the requirements for an organization (company, public agency, etc.) to deliver products and services that consistently meet customer expectations and for an organization to be "certified." The Deming cycle, plan-do-check-act, is one of the models that can be used to achieve higher levels of quality.

One of the main concepts that have influenced the development of the aforementioned standards is that of TQM. Total Quality is a process by which an organization strives to provide customers with products and services that satisfy its needs. The TQM philosophy seeks to integrate all organizational functions (design, engineering, production, etc.) to focus on meeting customer needs and organizational objectives. The key principles of TQM include management commitment (plan-do-check-act), employee empowerment, fact-based decision making, continuous improvement, and customer focus (*49*).

Another business management approach that is closely related with quality is Six Sigma. This management philosophy, originally developed by Motorola, emphasizes setting extremely high-quality objectives, collecting data, and analyzing results to a fine degree as a way to reduce defects in products and services. The name comes from the Greek letter sigma, which is used to denote variation from a standard (e.g., standard deviation). The philosophy behind Six Sigma is that if you measure how many defects are in a process, you can determine ways to systematically eliminate them and get as close to perfection as possible (*50*).

IMPORTANCE OF QUALITY DATA TO SUPPORT PAVEMENT MANAGEMENT

"Good" data are very important in providing effective pavement management. In particular, adequate quality and quantity of pavement condition data are a very important component in a PMS. For example, accurate and temporally consistent data are critical to develop models to predict smoothness and crack progression (*38*). These models are necessary for developing effective multi-year preservation plans and work programs. Even when performing network-level analysis, errors in the data can have a significant effect on the recommended treatments and budgetary requirements. Systematic errors are considered especially critical at the network level, where a large volume of data is collected and errors can be compounded (*51*). Less critical are the random errors, because it is expected that they will offset each other if enough data are collected.

Adequate quality management can help eliminate systematic errors and minimize random errors. For example, in Virginia, the introduction of a third party to provide independent validation and verification has been especially useful. A third-party contractor was asked to manually check 10% of the data collected and analyzed through automated methods. This process provided a high-level check of the deliverable tables to verify data completeness and data reasonableness, as well as a direct pavement distress comparison between the service provider automated ratings and manual ratings from experienced pavement raters. The process also helped identify several systematic errors (e.g., erroneous classification of a particular distress type). The correction of these errors resulted in an 83% reduction in the pavements requiring rehabilitation, and a 22% increase in pavements requiring no maintenance. The overall effect of these changes was a decrease of $18 million in the pavement maintenance recommendation for the Interstate Highway System (*51*).

QUALITY MANAGEMENT PLANS

A Quality Management Plan documents how the agency will plan, implement, and assess the effectiveness of its pavement data collection quality control and quality acceptance operations. It describes the quality policies and procedures; areas of application; and roles, responsibilities, and authorities. The Quality Management Plan is a program-specific document that describes the general practices of the program. It may be viewed as the "umbrella" document under which individual quality activities are conducted.

Figure 10 summarizes the state of the practice with respect to the use of formal data collection quality management plans among state DOTs and Canadian provinces. Approximately one-third of the agencies (35%) already have a formal plan and an additional 27% are working on developing such a plan. It is interesting to note, however, that a large percentage of the agencies still do not have a formal approach for ensuring the quality of the data and 11% of the respondents did not know if a quality management plan existed.

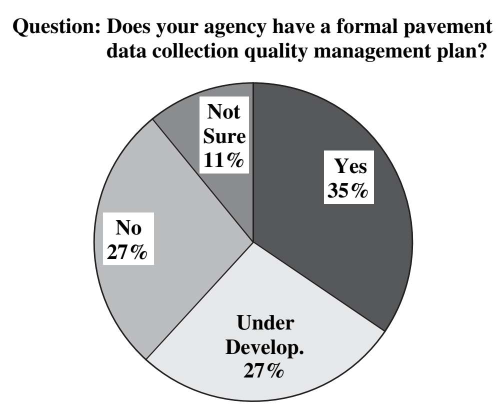

FIGURE 10 Use of data collection quality management plans.

DATA MANAGEMENT ACTIVITIES

For data quality management practices to be effective and efficient, quality management methods needs to be employed throughout the entire data collection process. Figure 11 summarizes the types of activities used for quality control and acceptance by the agencies that responded to the survey. It can be observed that several of the tools and methods used for quality control and acceptance are basically the same. This is probably one of the reasons why the two processes are often confused. However, the objective of the activities, the way they are conducted, and the personnel responsible for it are typically different in the two quality management phases as discussed in chapter one.

The main techniques used by state and provincial DOTs for pavement data quality management are calibration of equipment and/or analysis criteria before the data collection, testing of "control" segments before and during data collection, and software routines for checking the reasonableness and completeness of the data. Similarly, 100% of the pavement data collection service providers indicated that they use equipment and/or analysis criteria before the data collection, and software routines for checking the reasonableness and completeness of the data, and most (86%) reported that they use testing of "control" segments before and during data collection. These tools are briefly introduced in the following sections and are discussed in detail in chapter four.

Personnel Training and Certification: Continuous training is very important to ensure that the personnel operating the equipment or conducting the visual surveys are properly trained. That the classification of the distresses is somewhat subjective makes training even more critical for the distress surveys. Some agencies require a formal "certification" of the pavement distress raters and equipment operators to verify that they have the required knowledge and skills.

Equipment and Method Calibration, Certification, and Verification is to be conducted before the initiation of the data collection activities and periodically thereafter to verify that equipment is functioning according to expectations and that the collection and analysis methods are being followed.

Data Verification Procedures by Testing of Control or Verification Sites are used for both quality control and acceptance before and during production. Typical verification techniques include periodic retesting of control or verification pavement segments, oversampling or cross-measurements, and reanalyzing or resurveying a sample of the sections measured by an independent evaluator. The locations of sections can be known or unknown (blind) to the data collection crews.

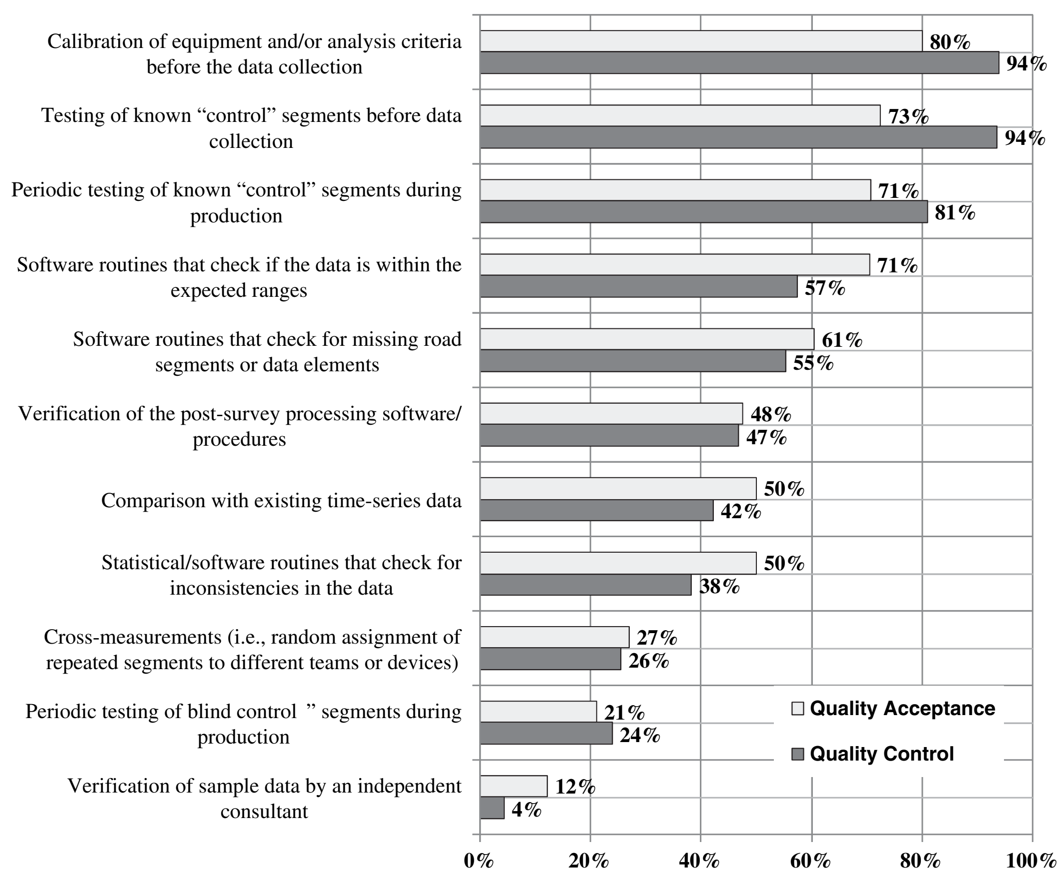

FIGURE 11 Percentage of state and provincial agencies using each quality control and acceptance activity.

Software Data Checks are used during production for quality control, when the data are submitted for quality acceptance, and when the data have been entered into the pavement management database. Typical checks include network-level checks for ratings that are out of expected ranges, checks for detecting missing segments or data elements, and statistical analyzes to check for data inconsistencies.

Other Tools: In addition to the test described earlier, some agencies also conduct other tests, such as time-history comparisons, geographic information system (GIS)-based analysis, and verification of sample data by independent third parties.

As previously discussed, the tools described can be included in the quality control plans, quality acceptance procedures, and/or independent verification processes. For example, the equipment calibration is a key component of the quality control process, but the verification of this calibration is typically also included as part of the quality acceptance plans. Similarly, control or verification test sites are used by most agencies for both quality control and acceptance.

QUALITY CONTROL

Quality control includes actions and considerations necessary to assess and adjust production processes to obtain the desired level of quality of pavement condition data. These activities include checks on the equipment used to collect the data, the personnel responsible for the data collection, and the data collection process itself. When data are being collected using automatic data collection equipment, quality control may include equipment maintenance, testing, and calibration. Training and supervision of the survey crews is critical when data are collected using manual/visual surveys. Examples of quality control activities also include data verification checks using control or verification sections, on-vehicle real-time data checks, periodic diagnostics/data checks, submitted data and video checks, distress rating data checks, and database checks.

Before data collection, equipment is to be properly calibrated, procedures clearly defined and documented, and personnel trained. During data collection, it is important that pavement condition data be continuously monitored by a variety of possible methods to ensure equipment calibration and data accuracy and consistency during the collection effort. This monitoring allows for errors to be detected and corrected before submission of large batches of unsatisfactory data. After data collection is complete, the data may then be validated before acceptance.

QUALITY ACCEPTANCE

Quality acceptance activities are those that govern the acceptance of the pavement condition data; this is often referred to as quality assurance in the pavement data collection terminology. However, this latter term is not used in this synthesis because quality assurance in the quality management literature encompasses all the activities focusing on increasing the ability to fulfill requirements for the product of service being produced. The definition used in pavement engineering is closer to the definition provided by the National Quality Institute, which defines quality assurance as "actions taken by the buyer or user of the data to ensure that the final product is in compliance with the agreements, provisions, or specifications."

Quality acceptance tools are used for testing both the pavement condition data that are collected by the agency and those that are collected by a service provider. These tests validate that the data meet the establish requirements before they are used to support pavement management decisions. Examples of commonly used quality activities include control/verification site testing, complete database checks (e.g., to check for ratings outside of an expected range), sampling and retesting for quality acceptance, GIS-based quality checks, and time-history comparisons.

Software programs used for quality management usually search for data that are missing, misidentified, incorrect with respect to segment size, improperly formatted, and/or outside of expected ranges. These programs ensure data completeness and functionality. For example, the state of Oklahoma uses a Microsoft Access-based program with Visual Basic modifications to perform such tasks (*52*). Use of such programs not only ensures completeness, but standardization as well, reducing problems with time-history updates and allowing for better analysis of raw data into higher-level data such as composite indices.

INDEPENDENT ASSURANCE

Quality engineering practices typically recommend the inclusion of at least some degree of external audit in the quality management plan; this is called independent assurance. The purpose of the independent assurance testing is to validate the data for the user agency. Data checks by quality acceptance personnel are intended to ensure the accuracy of the data. Such checks typically involve making sure that distresses are properly identified and severity is properly evaluated. The check can be done by the data collection personnel, by someone else internal to the organization, or by an external third party. For example, a procedure to verify the quality of the pavement data collection during production is the use of a sample of a "control" section that is resurveyed or reanalyzed by an independent evaluator and the results compared with the production ratings. The reference measurements on these sections are determined using the best available practical technique for that particular pavement condition indicator. The survey showed that only 4% of the agencies use independent verification for quality control and 12% for quality acceptance.

REFERENCE VALUES/GROUND TRUTH

The determination of the correct value for pavement condition data is a particularly challenging task that has received significant attention. This reference value or "ground truth" is typically determined using the "most appropriate" methodology available, which is done by using trained and experienced raters for pavement surface distress and a calibrated or certified piece of equipment for sensor-based measurements. Because the most appropriate methodology is sometimes difficult to determine, some agencies prefer to use the term reference value instead of ground truth. Ongoing studies may provide additional insights on this issue. For example, the Strategic Highway Research Project 2 (SHRP 2), *S03: Roadway Measurement System Evaluation,* is developing, organizing, and conducting a roadway measurement accuracy evaluation of mobile road and pavement inventory services collected at highway speeds (*53*). The recent *National Workshop on Highway Asset Inventory and Data Collection* (*54*) compared automatic systems for inventorying roadway geometry and roadside element data.

For surface distress, the control sections are typically evaluated using visual surveys or by independently analyzing the images captured by pavement evaluation equipment. Rutting and faulting are typically determined using a straight edge and rut wedge or a static inclinometer, and faulting using a straight edge and a ruler or the Georgia Faultmeter. Statistical methods are typically used in conjunction with control site testing to establish acceptable ranges for various data collection techniques. The ground truth smoothness is currently determined based on the profile measured using rod and level, the static inclinometer, or "walking" profilers; however, research is underway to find a more appropriate reference profiler (*55*).

To compare friction measurements obtained with different types of friction equipment, the Permanent International Association of Road Congresses (PIARC) has devised the IFI (*56*). ASTM currently uses the Dynamic Friction Tester (DFTester) and Circular Track Meter (CTMeter) as the reference devices for the IFI. The index is composed of two numbers, the friction value at 60 km/h (*F60*) and the change of friction with speed (s_p) (*57*).

SOURCES OF VARIABILITY IN PAVEMENT CONDITION DATA COLLECTION

One of the purposes of the quality control, and to some degree quality acceptance, processes is to reduce the variability in the pavement condition measurements. Thus, it is important to understand the various sources of variability before designing pavement control and acceptance programs. Because there is inherent variability in the pavement condition data that are collected, it is important that agencies understand the magnitude and sources of variability in the data being collected to be able to compare results and establish target control and acceptance level for quality management. For example, Stoffels et al. (*58*) proposed a process to identify acceptable ranges for comparing results from two independent sources using standard variability control concepts with pavement data collection.

In general, sources of variability for pavement condition data collection can be related to the equipment used, equipment operation (including rater/operator training and skills), processing of the data collected, environmental conditions, and shape and condition of the pavement surface. All of these potential sources have to be considered and, if possible, controlled because they will affect the quality of the data collected. Although the potential sources of variability are many, this section summarizes the primary sources that can be controlled during the data collection process. Calibration and/or validation before, during, and after data collection are necessary to ensure accuracy, given the possible variations between different devices and operators, as discussed in chapter four.

Surface Distress

Sources of variability for manual and automated methods of data collection are similar and generally involve distress identification and classification, as well as assigning distress severity levels. McGhee (*6*) classified the automated distress data in distresses collected with sensors (e.g., smoothness, rutting, and faulting) and distresses obtained from processing of pavement images (e.g., cracking). Because some of the sources of variability for sensor-based (rutting) and image-based (cracking) distresses are in general different, they are presented in two separate sections. Typically, both manual and automated crack detection methods display a noticeable bias toward detecting higher-severity distresses, while missing lower-severity distresses. This is usually the result of higher-severity distresses being more readily identifiable than medium- or lower-severity distresses (*18*).

Cracking

Cracking is measured from a moving vehicle or "walking" the section. The evaluations from the moving vehicle can be done manually ("windshield" evaluation) or automatically by processing images of the pavement collected by a pavement distress data collection vehicle. The processing of the images is done manually in semi-automated data collection and automatically by the processing software in the fully automated process. Sources of variability for automated, semi-automated, and manual distress include (*59*):

- Type of equipment/data collection method
  - Image quality—for automated and semi-automated surveys.
    - △ Type of technology used; for example, analog images, digital images, laser-based images.
    - △ Resolution of the imaging equipment (detection of smaller cracks require higher resolution equipment).
    - △ Field of view (distresses may be missed if they do not cover entire lane).
    - △ Quality of the color contrast of the pavement image (color contrast between the crack and the

surrounding pavement is an important factor when distress software programs are evaluating the severity of the distress).
  - △ Lighting method.
- – Rater's vision—in case of windshield surveys.
- Raters/equipment operator training—The experience and understanding of rating protocols is paramount to reduce the variability of the collected data.
- Processing software—The algorithm used to detect and quantify the various types of cracks is critical in the case of automated surveys. For example, one common problem with an automatic cracking detection algorithm is the classification of the pavement shoulder joint as a longitudinal crack.
- Measurement environment—The conditions under which the distress surveys are conducted will affect the detection of the cracks. For example, cracks are typically more visible soon after rain because they may be filled with water. The severity of the extent detected under such circumstances may be different.

Rutting

Most agencies are currently measuring rut depth (transverse profile) with some type of automatic data collection equipment, including rut bars with multiple sensors or continuous measurement systems. In general, the sources of variation include the following:

- Type of equipment
  - Type of sensors—Common sensors include point laser, ultrasonic, and continuous scanning lasers. "Point" lasers are currently the most commonly used sensors. Continuous scanning lasers can cover a total width of up to 13 ft with a resolution of 1,280 points. These sensors are very accurate; however, the user needs to input the width of the lane to allow the software to exclude curbs or edge drop-off. Ultrasonic sensors are still used in some systems, but they can be affected by temperature and moisture.
  - Rut bar width (and lane coverage)—Even with a large number of sensors, most older (and still used) rut bars will only cover a certain width of the lane. Furthermore, even the extendible rut bars will almost never be fully extended for safety reasons. Typically, the rut bar is only extended to 10 ft. Some rut bars have the two most lateral sensors angled out to increase the width of coverage.
  - Number of sensors—The number of sensors can range from 3 to 37, to continuous, with continuous systems becoming more common.
  - Distance measuring system.
- Equipment operation
  - Wheel path wander affects noncontinuous measurement because it affects the data points collected.
  - Edge drop-off and/or narrow lanes—The far right sensor may pick up a drop-off or grass on the right shoulder, which will affect the measurements.
  - Equipment driver and/or operator—The experience, training, and driving skills of the data collection personnel will affect the measurements and thus the quality of the data collected.
- Rut depth calculation method is to be controlled to ensure consistency from year to year or from service provider to service provider because there are different algorithms for processing the transverse profile and calculating rut depth. The main methods currently in use are the stringline or "wire" method [AASHTO PP-38-00 Standard Practice for Determining Maximum Rut Depth in Asphalt Pavements (2005)] and the straight edge. The stringline method allows an imaginary line to bend at the hump between the wheel paths if the hump is higher than the outside and centerline of the road. The straight edge method projects a straight line across from the inside to the outside of the lane and results in lower rut depth calculations than the stringline method.
- Measurement environment
  - Temperature, wind, humidity, and surface moisture affect the various types of sensor differently and can add to the variability of measurements.
  - Presence of pavement contaminants, such as sand, gravel, etc.
  - Lighting conditions affect optical sensors.
- Surface texture—High-textured surfaces, such as open-graded friction courses and chip seals, can affect the sensor readings

It is generally accepted that rut bars with a greater number of sensors (or transversal measurements points in the continuous systems) yield more accurate and consistent measurements. When changing from the older style rut bar to a new scanning laser, the Oklahoma DOT (ODOT) found that the rut calculations were usually deeper but closer to manual measurements. Older rut bars could under-report rut depth because of a lack of full-lane-width coverage.

Smoothness

Given the large variety of devices commercially available, smoothness measurements of the same pavement segment can show significant variation from device to device (effecting reproducibility). However, measurements by the same device are generally repeatable. The main factors that affect variability of smoothness measurements include the following (*60*):

- Type of profiler—The various profilers commercially available use different technologies, sensors, and signal processing techniques.
  - Height sensor—Most current profilers use a laser sensor; however, some agencies still operate profilers with ultrasonic or infrared sensors. Important sensor

characteristics include sampling rate, resolution, footprint, and range.
  - Sensor footprint—Although traditional laser profilers use point lasers, agencies are starting to require sensors that have a wide footprint.
  - Accelerometer—The type (range) and location of the accelerometers may affect the measured profile and processed indices.
  - Distance measurement system.
  - Number of sensors, sensor location, and spacing—when multiple sensors are used.
- Profiler operation—the manner in which the profiler is driven.
  - Profiler driver and operator—experience, training, and driving skills.
  - Lateral position—Wheel path wander is a big source of variation; thus, operators are trained to stay in the center of the lane.
  - Longitudinal positioning/triggering.
  - Measurement speed—Although it has been hypothesized that measurement speed has an influence on the measured smoothness (*61*), some of the latest research indicates that most profilers produce measurements that are stable with respect to the measuring speed (*55*).
  - Lane measured—Although most agencies measure only the outermost lane, others are starting to measure the profile on all lanes.
  - Tire inflation pressure affects longitudinal distance measurements.
  - Calibration of the various components of the equipment.
- Profile data interpretation and processing
  - Filters—Most profilers use filters to eliminate unwanted high and low frequencies in the measured profile; although some allow the user to select the filters, others do not.
  - Profiler computation algorithm—The algorithm used to combine the output from the key component sensors and determine the profile.
  - IRI calculation algorithm and procedure—for example, some profiler manufacturers automatically apply nonstandard filters to the profile. Other manufacturers and states may choose to average the profiles from the left and right wheel paths before applying the IRI algorithm, thus generating a half-car roughness index instead of an IRI from a single wheel path or an average of two wheel paths of IRI.
  - Integration interval—The length of the segment over which the smoothness is reported is important because the profile elevation data are aggregated. A relatively large sum of elevation values can indicate a pavement that is moderately rough over the entire segment or very rough over a small section of the entire segment. Measurements over smaller segments tend to yield more useful results because short, rough areas are detected and might be unnoticed if the segments were larger.
  - Wheel path measured—Although some agencies report one of the wheel paths, others compute the average of both wheel paths. This is significant because measurements from the outer (right) wheel path are generally rougher than those in the inner wheel path (*20*).
  - Bridges—There is lack of agreement on how to deal with bridges included within the considered road segment. These bridges are often localized areas of high roughness. Some agencies include bridges as part of the road segment because this better reflects the actual user's perception for the overall road segments. Other agencies do not include bridges to avoid artificially high estimates of the pavement IRI in the segments.
- Measurement environment
  - Temperature, wind, humidity, and surface moisture affect the various types of sensor differently and can add to the variability of measurements.
  - The presence of pavement contaminants, such as sand, gravel, etc.
  - Lighting conditions affect optical sensors.
- Surface shape—The condition and texture of the surface affect the accuracy and repeatability of profilers.
  - Surface distresses have a major influence on transversal variations of the profile.
  - Daily and seasonal profile variations are caused by curling of PCC slabs, moisture changes in the subgrade, freeze and thaw cycles, etc. Differences as high as 0.4 m/km have been observed in some sites.
  - Road geometrics—Cross slope, curves, hill, and grades can affect the output of accelerometers, which are key components of inertial profilers.

Surface Friction Properties

Typical sources of variation in friction measurements include the following.

- Equipment used—Most state DOTs use the locked-wheel skid trailer (ASTM E274) for high-speed friction measurements (*62*). The system includes a truck with a water tank and a trailer system that can lock one of the wheels for measuring the friction coefficient between tire and wet pavement. The wet pavement friction (or skid) number is reported as 100 times the coefficient of friction (*63*). Some of the equipment has incorporated laser-based systems to determine the surface macrotexture and use it to estimate the gradient of friction with speed.
- Operation
  - Type of tire—Some states (e.g., Virginia) use smooth tires and others (e.g., Florida) still use ribbed tires.
  - Testing speed—Some states have equations for calculating the friction number from skid testing at other speeds, but those correlations have been only locally verified (*61*).

- Equipment calibration—Calibration is usually performed once at the beginning of the data collection season (or every two years), with verification testing taken at control segments during data production.
- Measurement environment—Annual variations in pavement friction have been detected; therefore, annual testing of the network is recommended (*61*). Temperature has been shown to be one of the contributing factors (*64*). Some states use seasonal (typically monthly) correction factors for the measured friction.

Structural Evaluation

Sources of variability on FWD measurements include the following:

- Equipment used—Different FWDs use slightly different configurations and sensing technologies. In addition, available devices use a variable number of sensors.
- Equipment operation/testing protocol
  - Load—Most agencies use 9,000 lb, whereas some add additional tests at variable load levels to assess the nonlinearity of some of the materials.
  - Sensor spacing—Several devices and testing protocols use different sensor spacing; however, the LTPP data collection guidelines have helped standardize them.
  - Sitting errors—Some protocols call for one or two initial drops to improve the contact between the plate and the pavement and the repeatability of the measurements.
  - Equipment calibration is important to correct systematic errors in the sensor measurements and there are regional sites that have been established for this purpose, as discussed in chapter four.
  - Testing spatial frequency—Although closely spaced tests are preferred for accurately assessing the structural capacity of the pavements, this reduces productivity and increases cost.
  - Lane tested—Testing in Indiana showed that structural capacity in one direction of an Interstate highway was nearly identical to the capacity in the opposing direction. However, non-interstate roads showed more variability and more variable results can be expected in highways where opposite lanes were constructed at different times and/or with different structural materials and designs.
- Measurement environment—Environmental factors have substantial influence on the pavement response and thus on the measured deflections
  - Temperature affects the stiffness of the asphalt-based materials. Deflection adjustment factors have been developed at the national (LTPP) and state level to account for temperature variations.
  - Moisture—The presence of water affects the bearing capacity of soils and unbounded pavement materials.
- Interpretation of the results
  - Type of analysis conducted—the information collected can be used for assessing the overall structural capacity of the pavement (e.g., computing a surface modulus of an effective Structural Number or determining the moduli of the various pavement layers using backcalculation).
  - Software used—the backcalculation software used typically affects the resulting layer properties.

Ground Penetrating Radar

Some agencies have used GPR to determine layer thickness data. This device operates by using electromagnetic waves to identify and locate interfaces between layers within the pavement, which in turn allows for determination of layer thicknesses. For GPR to distinguish layer separations, the pavement layers must have different dielectric properties. Additionally, higher frequency waves yield better resolution, whereas lower frequencies allow for further penetration into the pavement, resulting in upper layer profiles being more accurate than those of lower layers (*40*). Testing has shown that GPR provides accurate layer thicknesses if calibrated with just a few cores, and the GPR measurements can be used to influence future coring requirements (*65*).

EFFECTS OF NETWORK SIZE ON QUALITY MANAGEMENT

The size of the network appears to have an effect on the quality management procedures. For example, it takes considerably more effort to conduct quality assurance checks for large networks than for smaller ones. Because large agencies have to review large amounts of data they appear to be more motivated to develop formal quality management plans. Figure 12 shows that large agencies (e.g., with more than 25,000 lane-miles) were noticeably more likely to have a formalized quality management plan, or have one under development, than were the small agencies. This is logical given that agencies with larger networks would receive higher quantities of data, and the occurrence of systematic errors could result in large quantities of poor data. Larger networks are also more costly to maintain on an annual basis, making development of new and improved quality management methods more cost-effective.

Network size also appears to play a minor role in the condition data quality management process. Agencies with larger networks (e.g., more than 25,000 lane-miles) under their management collected data less frequently than agencies with fewer than 5,000 lane-miles. This trend held not only for highways, but arterials, collector, and local roads as well. The same was true for smoothness data collection; agencies with larger networks generally collected data less often than those with smaller networks. This is illustrated in Figure 13, which summarizes the average (considering the various functional categories) data collection frequency

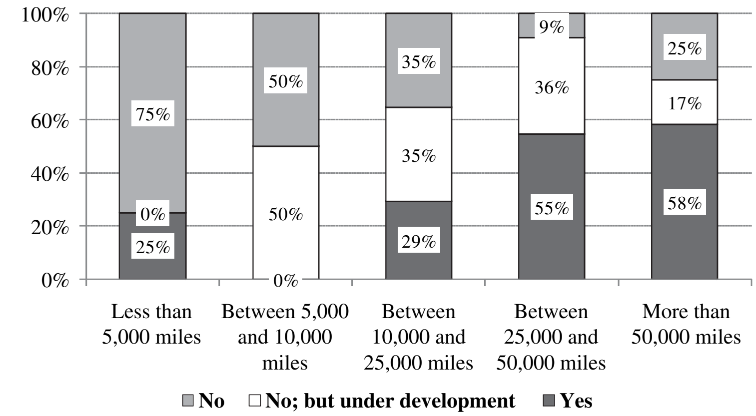

FIGURE 12 Percentage of agencies having a quality management plan as a function of network size.

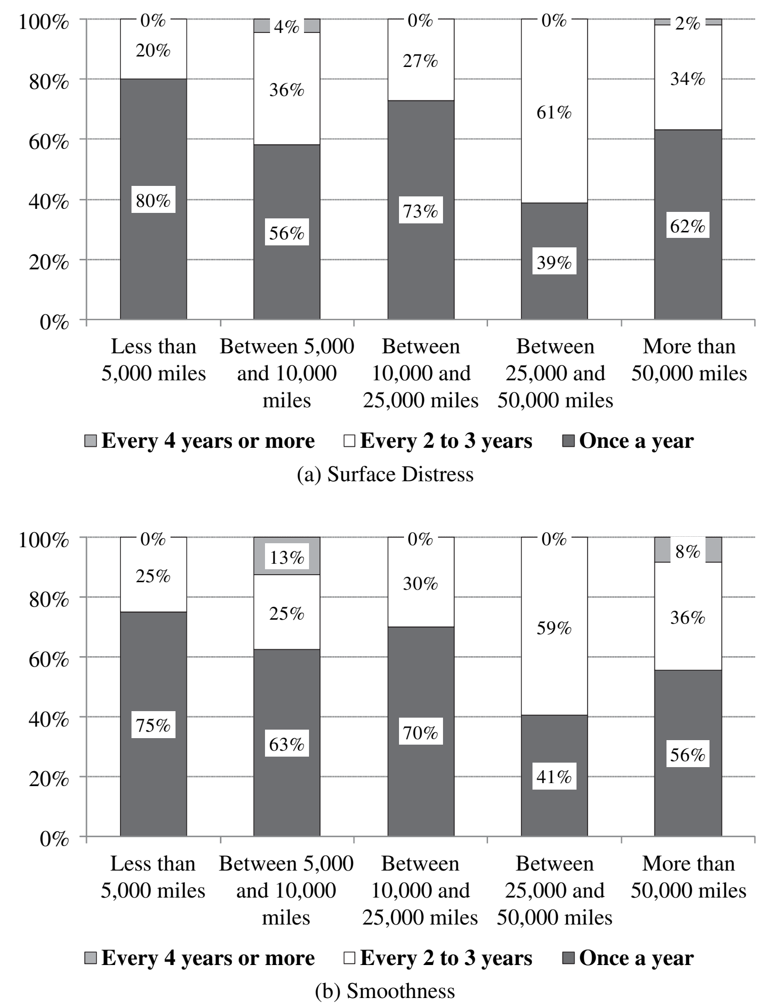

FIGURE 13 Temporal data collection frequency for (a) surface distress and (b) smoothness as a percent of agencies collecting the pavement condition indicator.

as a percentage of agencies collecting surface distress and smoothness.

SUMMARY

"Good" pavement condition data are very important in providing effective pavement management. Pavement condition data collection quality management is necessary to ensuring that the collected data meet the requirements of the pavement management system. This chapter presented the main data quality management concepts and principles as they apply to pavement condition data collection.

Effective data collection quality management programs provide a comprehensive, systematic approach to data collection and processing. It is important that a complete pavement condition data quality management system include a clearly documented quality control plan, detailed quality acceptance procedures, and established guidelines to monitor the entire process, with timelines, milestones, and evaluation criteria. The Quality Management Plan is the "umbrella" document under which individual quality activities are conducted. Approximately one-third of the DOTs (35%) already have a formal plan and an additional 27% are in the process of developing such a plan.

The main techniques used for pavement data quality management are calibration of equipment and/or analysis criteria before the data collection, testing of "control" segments before and during data collection, and software routines for checking the reasonableness and completeness of the data. These tools can be included in the quality control plans, quality acceptance procedures, or for independent assurance.

Quality control includes those activities necessary to assess and adjust production processes to obtain the desired level of quality of pavement condition data. Included are checks on the equipment used to collect the data, the personnel responsible for the data collection, and the data collection process itself conducted before, during, and after the data collection.

Quality acceptance includes those activities conducted to verify that the collected pavement condition data meet the quality requirements. Quality acceptance tools are used for testing both the pavement condition data that are collected by the agency and those that are collected by a service provider. Common methods include testing of controls or verification sites, use of software to check for errors such as incorrect asset data or ratings outside of an expected range, and checking a certain percentage of data by quality assurance personnel.

The independent assurance testing aims at validating the data for the user agency. For example, a procedure to verify the quality of the pavement data collection during production is the use of a sample or "control" section that is resurveyed or reanalyzed by an independent evaluator and the results compared with the production ratings.

In general, sources of variability for pavement condition data collection can be related to equipment used, operation (including rater/operator training and skills), processing of the data collected, environmental conditions, and shape and condition of the pavement surface. All these potential sources have to be controlled (or at least accounted for) because they will affect the quality of the data collected.

CHAPTER FOUR

QUALITY MANAGEMENT PRACTICES

This chapter focuses on the specific quality management principles and techniques currently being followed by transportation agencies for pavement condition data collection. It discusses the various approaches and tools used for quality control, quality acceptance, and independent assurance.

The creation and implementation of a comprehensive data collection quality management program is a very important step to ensure that quality data are collected. However, as reported in the previous sections, a significant percentage of highway agencies (approximately half) still do not have such procedures in place. With respect to how these plans are developed, the survey showed that most agencies prepare their own quality acceptance plans, whereas the quality control plans are developed either by the agency, the data collection service provider, or as a collaborative effort. Only one agency reported having used a third-party contractor for developing the pavement data collection quality management plan.

The following sections discuss the main techniques and procedures used for quality control, acceptance, and independent assurance. As discussed in chapter three, the distinction between quality control and acceptance activities depends on how the activities are incorporated into the management plan, rather than the activities themselves. Many of the tools used for quality control and quality assurance are the same. To avoid duplication, this chapter discussed the various activities and tools organized in the most common configuration.

QUALITY CONTROL

Common quality control activities include personnel training and certification, equipment calibration, certification and verification, production quality data verification, and on-vehicle and office data checks. These are covered in detail in the following sections after a brief discussion on pavement condition data variability and quality control planning for controlling this variability.

Quality Control and Variability

The purpose of quality control is to quantify the variability in the process, maintain it within acceptable limits, identify the source of variability that can be controlled, and take the necessary production adjustments to minimize the "controllable" variability. It is also important that the quality control process detect problems soon, before large quantities of data have to be re-collected. The sources of variability for the various pavement condition indicators were discussed in detail in chapter three.

Contents of a Quality Control Plan

Based on the examples reviewed, it becomes apparent that a comprehensive quality control plan typically includes the following elements:

- Clear delineation of the responsibilities;
- Documented (and available) manuals and procedures;
- Training of survey personnel;
- Equipment calibration, certification, and inspection procedures;
- Equipment and/or process quality verification procedures (e.g., testing of control sections) before starting and during production testing; and
- Checks for data reasonableness, consistency, and completeness.

The survey revealed that a large percentage of the respondents (64%) have a formal data collection quality control plan or require the data collection service providers to develop such a plan (Figure 14). It is noted that some of the agencies that checked the "other" option indicated they have procedures for only some of the pavement condition indicators or that such a plan was under development.

Approximately half of the data collection quality control plans were developed by the service provider collecting the data. Although it was not asked specifically, it is hypothesized that this corresponds to all or most of the services being contracted. It is also interesting to note that a shorter survey sent to pavement data collection service providers showed that all the service providers have a formal data collection quality control plan; however, none of them provided a copy and several indicated that the plan was project-specific or proprietary. This last result is an indication of the importance data collection companies place on the quality control procedures.

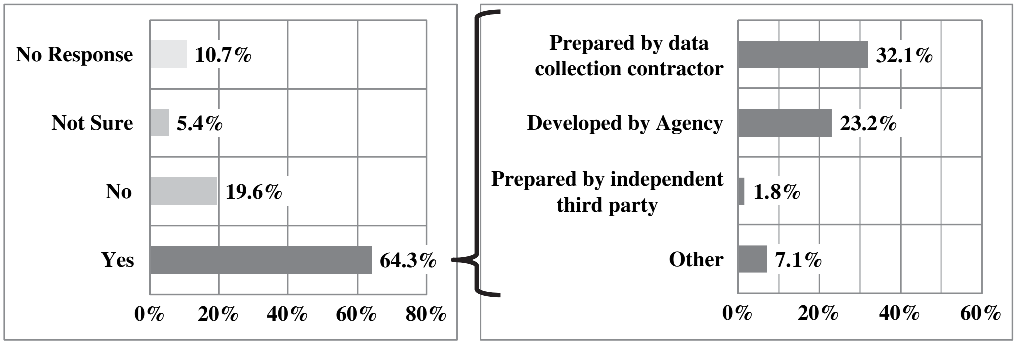

FIGURE 14 Percentage of highway agencies having a formal quality control plan.

From the available quality management tools and methods, the most common methods/tools used for quality control are the following (in order of decreasing frequency, the percentage of agencies citing each method/tool is provided within brackets):

1. Calibration of equipment and/or analysis criteria before the data collection [94%],
2. Testing of known control segments before data collection [94%],
3. Periodic testing of known control segments during production [81%],
4. Software routines that check if the data are within the expected ranges [57%], and
5. Software routines that check for missing road segments or data elements [55%].

All the data collection service providers responded that they use calibration of equipment and/or analysis criteria before the data collection, and software routines that check if the data are within the expected ranges for missing road segments or data elements, and for inconsistencies in the data. At least half of the service providers also indicated using the other techniques.

An illustrative example of a pavement data collection quality control plan is presented in Figure 15. The figure presents examples of the activities that are typically conducted before, during, and after the production process, rather than a comprehensive list of all available tools and processes.

For example, the Maryland State Highway Administration (MDSHA) is one of the agencies that reported having a formal quality control process for its in-house pavement data collection activities. The agency developed a detailed quality management program when transitioning from windshield distress data collection to an automated system to measure smoothness, rutting, and cracking (*66*). In the case of the automated crack detection, the quality control plan includes (1) review of completeness, (2) review of section-level data, and (3) review of data management. The first step simply verifies that all fields are processed. The section-level review is conducted by examining approximately 50% of the sections. The operator also verifies that the data have been saved and inputs a subjective evaluation of the crack detection process (good, fair, and poor). Further details on this approach are provided in a case study presented in chapter five.

Personnel Training and Certification

It is very important that the personnel operating the equipment or conducting the visual surveys are continuously trained. This is particularly critical given the current environment in the transportation profession, where the work force is highly mobile, and technicians and engineers change positions and employers quite frequently. Training is even more important for the distress surveys because the classification of the distresses is somehow subjective.

Personnel Training

Personnel training is necessary for obtaining repeatable and reproducible pavement condition data. It affects manual, semi-automated, and automated practices. Adequate training helps improve the consistency and accuracy of visual surveys and proper operation of the equipment using automated or semi-automated procedures.

According to the survey of practice, pavement evaluation personnel are trained mostly through on-the-job training from experienced staff and in-house training programs. The pavement condition data collection is primarily composed of experienced technicians (69% have more than 6 years and 26% more than 10 years of experience). They hold associate degrees (44%) or high-school diplomas (39%), with only a small percentage having bachelor's and graduate degrees. The pavement data collection staff for the pavement data collection service providers appears to be a little less experienced (57% have more than 6 years and 14% more than 10 years) and have a

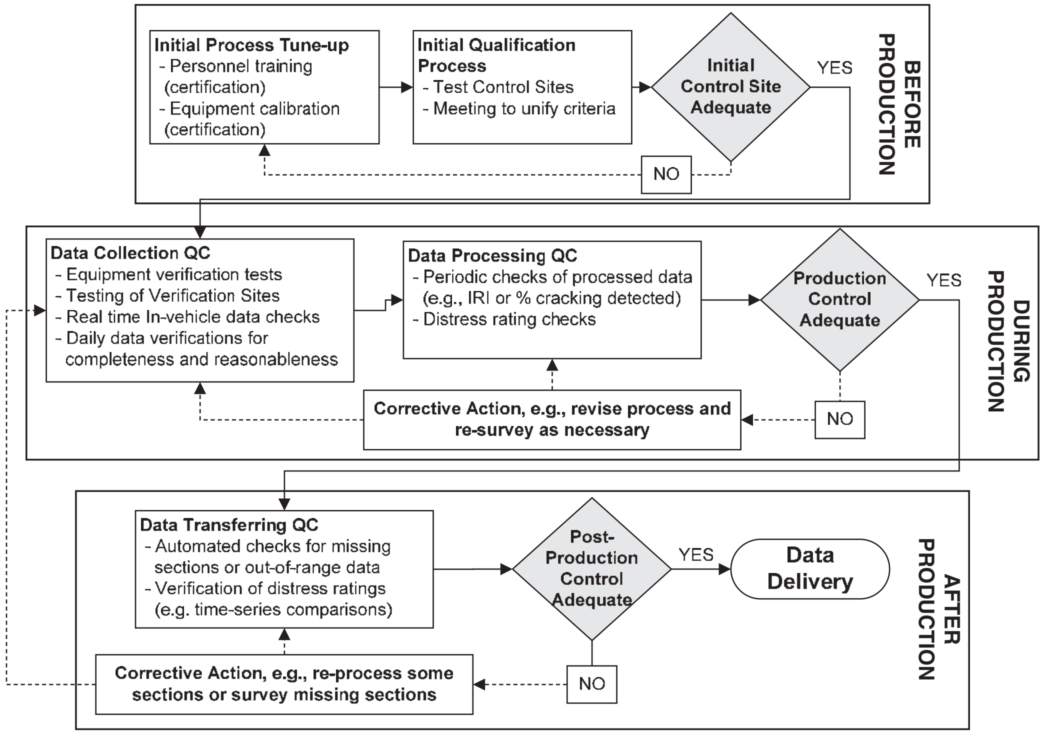

FIGURE 15 Example of quality control plan.

higher average level of education, with 43% having graduate degrees (MS/PhD). It can be noted that the sample of pavement data collection service providers that responded to the survey was much smaller than the number of highway agencies. Only one service provider requires certification for the pavement evaluation staff.

Personnel Certification Practices

Only a small percentage of highway agencies (15%) currently require “certification” of the pavement distress raters for the agency, service provider, or both. However, most agencies indicated that they only use experienced personnel to rate pavements and that they undergo extensive training before collecting data. The accreditation workshops developed by LTPP provide a good example of a certification practice. These workshops were intended for experienced technicians who had completed high school, had experience with data collection, had received formal training on the *Distress Identification Manual,* and had experience in assisting an accredited rater in distress data collection or data interpretation for both asphalt and concrete pavement. The accreditation includes a written test and a two-part film-interpretation examination. The results are compared with reference values provided by experienced raters. To remain accredited, it is important that a rater regularly perform a minimum number of interpretations per year (*67, 68*).

Ponniah et al. (*69*) present another example of a rater certification program. The paper presents the results of one of the workshops organized by the Ontario Ministry of Transportation every two years to certify pavement raters. As part of the workshop, the raters from five regions evaluated a circuit of nine sections and the results were statistically analyzed. Reference values for each section were obtained by a panel of four experts. The analysis compared the accuracy and precision of the raters, established province-wide, within-region, and between-region variability, investigated the effect of reducing the number of severity and density levels, and identified the distress types particularly hard to evaluate. The investigation showed that there were significant differences among raters, but no regional bias. The study also found that reducing the number of severity and density levels would help to reduce the variability in the pavement condition index.

Equipment and Method Calibration, Certification, and Verification

The verification that the equipment is functioning according to expectations and that the collection and analysis methods are being followed is key for ensuring the quality of the collected data. This is typically done before the initiation of the data collection activities and periodically after that. Equipment or process verification and validation is typically assessed by determining their repeatability and reproducibility (*16*). Repeatability is the variation in measurements taken by a single piece of equipment on the same road segment(s) and under the same conditions over a short period of time. It is generally evaluated based on the standard deviation of repeated values from different measurements. Repeatability measures the ability of the equipment/technology/raters to produce the same values on repeated measurements. Reproducibility is the ability of a technology or equipment to accurately reproduce or replicate measurements. The reproducibility of pavement condition measurements is typically measured as the standard deviation of measurements taken with different equipment or using different technologies. It is a measure of how well two different devices/methods/raters are able to measure the same pavement condition value on the same road segment(s).

Equipment Calibration

Equipment calibration is critical for the collection of accurate pavement data, especially for sensor-based measurements. Calibration is a systematic process to validate the data collection methodology and/or equipment by comparing the measurements with a standard reference value or ground truth that is considered correct. Adjustment to the equipment or technique may be required to match the "correct" measurement.

The LTPP pioneered the development of detailed and well-documented calibration procedures for pavement condition measurement equipment. For example, the LTPP defined a clear distress rating methodology and established rigorous calibration procedures for the high-quality photographic images used for distress identification and quantification (*67*). Equipment calibration and harmonization of the measurements is the subject of several current national and international research efforts. The basic principles are discussed later in this section. Additional sources of information about equipment calibration and verification can be found in the literature references provided.

Distress For pavement distress, calibration is usually done by evaluating control sites where the pavement condition is closely monitored by a group of experts (*70*). These experts determine the condition of the control site, usually through careful evaluation and consensus ratings before equipment calibration, or in the case of manual data collection, personnel training. The expert ratings are considered the reference ratings of the control site. Statistical confidence intervals are often calculated to determine the requirements for equipment and personnel criteria calibration (*18*). For example, a 95% confidence interval with respect to the reference rating has been used for evaluating distress data collection equipment (*71*). Calibration of rutting measurements is typically conducted at the profiler calibration centers, such as the one at the Texas Transportation Institute (*72*).

The Iowa DOT uses eight control sites (four asphalt concrete and four PCC sections) for the initial verification of the data collection equipment and methodology. The service provider tests these sections before starting the production data collection. The sections have a variety of distress conditions and serve as a sample of the state and local roads in the state. The reference distress measurements are determined by experienced staff and the DOT equipment is used to collect ride and rutting information. The service provider measures the site three times and the data are compared with the benchmark data collected by the Iowa DOT. The final data delivery requirements are set based on this comparison. The control sites are also measured monthly by the service provider during production or whenever there is a change in equipment or subsystems on that same equipment (*73*).

Smoothness Proper calibration of smoothness equipment requires an accurate and repeatable reference measurement. Early approaches to determine this reference value included the use of rod and level to determine the actual road profile. Another common method for determining the reference value is to perform a continuous, close-looped test in accordance with ASTM E950 using a static inclinometer. Slow-speed profile measuring devices, often called "walking" profilers, have also been developed. Standard methods for evaluating profiler accuracy are provided in ASTM E950 Measuring the Longitudinal Profile of Traveled Surfaces with an Accelerometer Established Inertial Profiling Reference and AASHTO PP49 (*74*). These methods are generally considered appropriate for network-level pavement data collection (see Table 2); however, recent research has suggested that the method used in ASTM E950 does not ensure that two calibrated profilers can measure the same value of IRI within an acceptable tolerance for construction quality control (a project-level function) (*75*).

TABLE 2
TOLERANCES FOR THE VARIOUS TYPES OF PROFILERS ACCORDING TO ASTM E950

Class	Longitudinal Sample (LS) (mm)	Vertical Measurement Resolution (VR) (mm)	Precision Requirement (SD, mm)	Bias Requirement (mm)
Class 1	$LS \leq 25$	$VR \leq 0.1$	0.38	1.25
Class 2	$25 < LS \leq 150$	$0.1 < VR \leq 0.2$	0.76	2.50
Class 3	$150 < LS \leq 300$	$0.2 < VR \leq 0.5$	2.5	6.25
Class 4	$LS > 300$	$VR > 0.5$	—	—

Source: ASTM E950, Measuring the Longitudinal Profile of Traveled Surfaces with an Accelerometer Established Inertial Profiling Reference.

Additional information on calibration of longitudinal and transverse profiles can be obtained from the Transportation Pooled Fund Project 5(063), *Improving the Quality of Profiler Measurement* (*55*); University of Michigan Road Roughness Home Page (*76*), PIARC evenness harmonization studies (*56*), and the Road Profiler User Group meetings and equipment comparison studies (*77*). The aforementioned pooled fund (*55*) objectives are to assist states with the implementation of AASHTO provisional standards; establish a level of integrity to the measurements; deliver sample procurement specifications, maintenance guidelines, and profile analysis software; establish criteria for verification centers and assist with the development of these centers; develop and deploy a traceable verification process; and provide technical review of related software. This research program is currently working on selecting equipment and technologies for measuring the reference profile (ground truth) and devising a practical approach for profiler calibration and certification, which probably will involve the establishment of regional certification centers.

Structural Capacity For structural capacity (FWD) equipment, this phase typically includes sending the equipment for calibration and/or certification to a regional calibration center. These centers are operated by the equipment manufacturers and/or independent agencies; typically, university research and engineering centers. Regional FWD calibration centers were first established in four states (Colorado, Texas, Minnesota, and Pennsylvania) for supporting the LTPP data collection. The hardware and software in these centers have recently been updated through a pooled-fund study (*78, 79*). A new protocol for testing the load cell and deflection sensors has been prepared; this protocol determines gain factors or dynamic calibration factors that are entered into the FWD software as multipliers (*79*). It is important that the mass and drop height (load) levels produce loads within ±10% of three pre-selected target loads and that the sensor gain factors agree within a standard deviation of 0.003. The protocol also includes a procedure for conducting field-based relative calibration using a stand provided by the FWD manufacturer.

The Transportation Pooled Fund Project 5(039) *FWD Calibration Center and Operational Improvements* (*78,79*) and the *LTPP Manual for Falling Weight Deflectometer Measurements* (*80*) provide additional information on FWD calibration.

Friction Properties Friction measuring equipment is also sent for calibration and/or certification at regional calibration centers. The regional calibration sites for the locked-wheel testers include the East Coast use of the Field Test and Evaluation Center for Eastern States in East Liberty, Ohio (*81*) and the Central and Western Field Test Center in College Station, Texas (*82*). The principal features of the friction calibration centers include water calibration and evaluation, force measurement calibration, and dynamic correlation.

Additional information on calibration and harmonization of friction properties measurements can be found in the PIARC experiments to compare and harmonize texture and skid resistance measurements (*83*), the Transportation Pooled Fund Project 5(141) *Pavement Surface Properties Consortium* (*84*), and the *AASHTO Guide for Pavement Friction* (*57*).

Equipment and Method Certification

There is an increasing trend toward establishing formal certification procedures for the pavement condition data collection equipment and methods. These procedures typically require the use of a “certification center” that verifies the correct functioning of the various components of the equipment and the training and skills of the operators and provides an official certificate of compliance with a specific standard. Certification typically implies that the equipment and/or operator have successfully passed formal verification testing. The granted certificate attests that the measurements meet some minimum accuracy and precision requirements.

Examples include the Texas DOT inertial profiler operator and equipment certification program (*72*) and the LTPP distress rater accreditation program (*67,68*). In the Texas DOT procedure, the profiler operators are required to pass written and practical tests to be certified to receive an operator identification card that specifies the type or brand of inertial profiler they are certified to operate. The equipment certification includes the collection of profile data on two test sections in accordance with Test Method Tex-1001-S (*85*) in 3 hours. The results are evaluated for repeatability and accuracy and a profiler must meet all of the requirements to pass certification and receive a decal that is placed on the profiler as evidence of certification.

Equipment and Method Verification

Verification tests are periodic checks that control the accuracy of pavement condition data collection by examining the data and/or comparing it with known reference measurements. It is important that the data collection process is verified both before and during the data collection process. This is necessary to ensure that the actual pavement condition measurements meet the quality requirements and are adequate for supporting the decision processes that will be using the data. In addition, this process could verify that the measurements are consistent with the historical records to ensure year-to-year consistency.

Data Verification Procedures

During the data collection process, a variety of methods are available for ensuring the continued collection of satisfactory quality data. The purpose of verifying collected data in real time or near real time is to avoid production of large quantities of unsatisfactory data. This benefits both the data collection teams and pavement managers by allowing quick detection and correction of errors and minimizing the delays and costs associated with poor data quality collection. For this reason, it is recommended that the data be verified frequently during production. For pavement distress data collection, the verification of the distress ratings can be done for individual distress quantities, individual distress indices, multiple distress indices, or overall condition indices.

Quality management techniques that can be used to verify the data collection process include periodic retesting of "control" pavement segments, oversampling, and reanalyzing or resurveying a sample of the sections measured by an independent evaluator. If the verification process identifies deficiencies, the equipment will be checked and possibly recalibrated if automated or semi-automated procedures are used, or the raters' criteria will be normalized so that all rating work remains within the acceptable limits of variation. This may include additional rater training (*45*). All of the substandard data need to be reevaluated and the corrective actions be recorded and documented to support long-term quality improvement goals.

Testing of Control Sections

The testing of control pavement segments is used to determine: (1) the accuracy of the procedure if the results are compared with those obtained against reference measurements determined using the best available practical technique for that particular pavement condition indicator; or (2) its repeatability and reproducibility if the results are compared with results obtained with the same equipment or method. The locations of these segments can be known or "blind" for data collection teams. Typically, the testing of known control sections is used for quality control and testing of blind controls for quality acceptance. In both blind and known segment testing a second team of raters reevaluates a segment of pavement for comparison testing. If the data collection team's ratings are outside the established reevaluation team's confidence interval, the equipment and/or procedure is rechecked and the data collected since the last satisfactory evaluation is either closely examined for accuracy or rejected entirely (*86*).

Oversampling

Another method of data verification during data collection is oversampling. In this procedure the data collection team samples the same segment(s) multiple times. This is similar to verification of blind or known pavement segments, because data from the retest are used for comparison purposes (*87*). However, this method of verification is generally considered less rigorous than verification testing by another team of raters, because if the source of error is systematic it most likely will not be detected by retesting undertaken by the same data collection team and equipment. This method of quality management is considered effective for assessing random errors because it is unlikely that the same random error will occur multiple times over the same pavement segment. If more than one evaluation team or type of equipment is available, cross-measurements by different teams or equipment could be used to overcome this limitation.

Sampling and Independent Reanalyzing or Resurveying

Another data verification method consists of reanalyzing or resurveying a sample of the sections measured by an independent evaluator. The analysis of the sampled data is typically different depending on the level of pavement management considered.

Network-Level Data Checks These checks often include statistical testing of the differences between the mean values (of the parameter being evaluated) for the quality control or acceptance samples and the production surveys for the same sections. The analyses typically include paired *t*-tests to assess the potential bias of the collected data and provides an indication of whether the pavement condition is consistently under- or overestimated as a result of the automated data collection process. The differences between individual measurements from the verification sample and the production field survey are computed for each sampling unit and the mean difference is tested against the null value using a pre-selected level of confidence (typically 95%). A two-sided *t*-test is used to determine if there is a significant difference. If there is a significant difference, then a one-sided *t*-test can be used to estimate how far off the mean difference was by evaluating the achievable tolerance levels (*12*).

Project-Level Data Checks If the collected data are to be used for making project-level decisions, the mean comparison may not be applicable because some individual differences can exceed the acceptable range at the project level owing to limitations and the production data collection and processing technology (*88*). Statistical tests based on individual measurement rating may be more appropriate in these cases. These tests involve selecting a sample from a dataset, rating each individual observation within this sample using established pass–fail criteria for minimum acceptable quality, and concluding whether the whole dataset satisfies criteria for minimum acceptable quality based on the number of "failed" observations in the sample (*88*).

Comparison of Manual and Automated Distress Surveys

There have been several studies to verify AASHTO provisional protocol PP-44-01, which offers interesting approaches for comparing the results of different pavement condition collection methods; for example, manual versus automated surveys. These analyses provide good examples of tools and methods that can be used to compare the production and control measurements.

Groeger et al. (*89*) used the cumulative cracking length to compare two automated cracking detection procedures for a network, including approximately 2,000 data points. The results of the automated process were then compared with the average of three experienced evaluators that classified the section using a five-level condition scale (very good, good, fair, poor, and very poor). The data were evaluated as a function of the percentage of points that fall within one, two, and three deviations in the five-level scale. For example, if a pavement was classified as poor by one method and very poor by another, the deviation is one. The study found that the automated procedure produced good results for longitudinal and transverse cracks, with 94% of the data falling within one deviation of the visual assessment.

Raman et al. (*90*) used statistical analysis to compare the severity and extent of the transverse crack by various procedures. The researchers used analysis of variance in the cases where data were normally distributed and nonparametric test (Kruskar–Wallis) in the remaining cases. Statistical comparison of sample and full-section image data showed that a 5% sampling rate was enough to evaluate transverse cracks with the precision desired for network-level pavement management in Kansas.

Wang et al. (*91*) compared the use of an automated cracking survey system with manual evaluations in Arkansas using the provisional AASHTO protocol. The evaluators reviewed and analyzed 5% of the images for each comparison section. The study found some differences between the manual and automated process, especially for Level 1 and 3 cracks; however, it also suggested that these discrepancies may be the result of the low repeatability of the manual surveys.

The Ontario Ministry of Transportation compared automated and semi-automated pavement distress collection techniques from three service providers with in-house manual surveys (*92*). The study included sections with surface-treated, hot-mix asphalt, composite, and PCC pavement structures. An overall pavement condition index, the distress manifestation index, was used for the comparisons. The investigation concluded that, in general, automated results are comparable with manual surveys. However, the authors emphasized the need of supplementing the automated collection with manual surveys, especially for project-level analysis, because some of the pavement distresses were difficult to identify with the automated methods.

Determination of Sample Size

One important element of the quality control process is the determination of how big a sample must be to have an acceptable degree of confidence that the sample is representative of the entire process and sufficient to verify the required accuracy in the measurements. For pavement data collection, the percentage of data that is checked in the quality control process typically ranges between 2% and 10%. However, it may be noted that the sample size is also dependent on the scope of the quality control task in hand. For example, computer-based checks can be applied to all the data, whereas cross-testing of control sections in general is often limited to a small sample of the network. The pavement data collection service providers surveyed indicated that they typically review 2% to 5% of the data (29%), 6% to 10% (29%), or more than 10% (42%) as part of their regular quality control practices.

The selection of the number of segments to verify for quality control (and/or quality acceptance) purposes is often set at a "rational" number based on previous experience. However, there are a series of statistical techniques that allow the calculation of the required sample size based on the desired accuracy and degree of risk that the agency is willing to take. Procedures similar to the one developed by the National Parks Service (*88*) and that are discussed in the quality acceptance section can be used for determining the most appropriate quality control sample.

Software Data Checks

Many agencies use software routines that check the data for inconsistencies for both quality control and acceptance, although these checks are slightly more prevalent for quality acceptance than for quality control. There is some variation in verification methods used for quality control: 55% of the agencies surveyed perform checks for detecting missing segments or data elements, 57% check for ratings that are out of expected ranges, and 38% use statistical analysis to check for data inconsistencies.

The checks may include on-vehicle data checks, data and video checks when the data are received in the office, condition rating data checks, and/or final database checks after it has been entered into the relevant pavement/asset management databases. On-vehicle data checks are conducted in real time as the data are being collected and/or periodically (e.g., at the end of the day). Real-time checks typically include visual displays of certain data that alert crews if anything is malfunctioning and/or data that are out of range. Periodic diagnostics/data checks are typically scheduled at fixed intervals during breaks of the data collection to verify the correct functioning of the equipment. These diagnosis checks are important to avoid collecting large amount of deficient data. Final database checks are conducted to verify that data have been formatted properly and all the different data have been entered in the final database. These later checks include tests for completeness and format, time-history comparisons, plots on GIS, etc.

The use of software to check for data inconsistencies can provide a noticeable improvement with respect to the accuracy of the data, identify areas for data collection improvements, and standardize data formats. These improvements might allow for better data analysis and time-history updates.

QUALITY ACCEPTANCE

Quality acceptance activities include all procedures used for acceptance testing of both the pavement condition data that are collected by the agency and those that are collected by a service provider. These tests validate that the data meet the established requirements before they are used to support pavement management decisions. Quality management techniques commonly used for this purpose include testing of control and verification sites, sampling and re-rating, complete database checks, GIS-based quality acceptance checks, and time-history comparisons.

Quality Acceptance Plan

Figure 16 summarizes the percentage of agencies that indicated that they have a formal pavement condition data quality acceptance plan. Two additional agencies indicated that they are working on developing such a plan.

Quality acceptance processes typically require that a sample or all of the data are checked to determine if some of the data may need to be corrected or resurveyed. Although listed by some of the agencies as quality acceptance activities, it is the opinion of the authors that the first two (calibration and testing of control sections before data collection) are more correctly classified as quality control activities. The quality acceptance procedure, however, could verify that these procedures were conducted as specified and that the required tolerances were met. In addition, the procedures typically include testing of known or blind control sections, automatic check on all the data, detailed checks on a sample of the collected data comparisons with data from previous data collection campaigns. In the case of data collection contracts, quality acceptance is often also linked to payments.

The most common methods/tools used for quality acceptance are the following (in order of decreasing frequency; the percentage of agencies citing each method/tool is provided within brackets):

1. Calibration of equipment and/or analysis criteria before the data collection [80%],
2. Testing of known control segments before data collection [73%],
3. Periodic testing of known control segments during production [71%],
4. Software routines that check if the data are within the expected ranges [71%],
5. Software routines that check for missing road segments or data elements [61%],
6. Statistical/software routines that check for inconsistencies in the data [50%], and
7. Comparison with existing time-series data [50%].

The percentages of the data that are typically reviewed by the agencies are shown in Figure 17. It may be noted that the survey did not differentiate between general checks for completeness and reasonableness and detailed checks for accuracy, repeatability, and reproducibility.

An example of a detailed quality acceptance plan is presented elsewhere (*93*). The New Mexico DOT checks the quality of the pavement condition data collected by a service providers (universities) for consistency, completeness, and reasonableness. The agency checks that all values fall within acceptable data ranges and that the distress types and severities are reasonable. The agency also randomly selects sites and conducts data checks on both blind and known locations. These checks include comparing results with previous years' data to identify locations where large changes occurred. If there had been areas where large changes occurred, the data have to be checked for reasonableness and consistency (*93*).

Similar procedures are followed by agencies that collect data in-house. MDSHA uses quality acceptance checks to val-

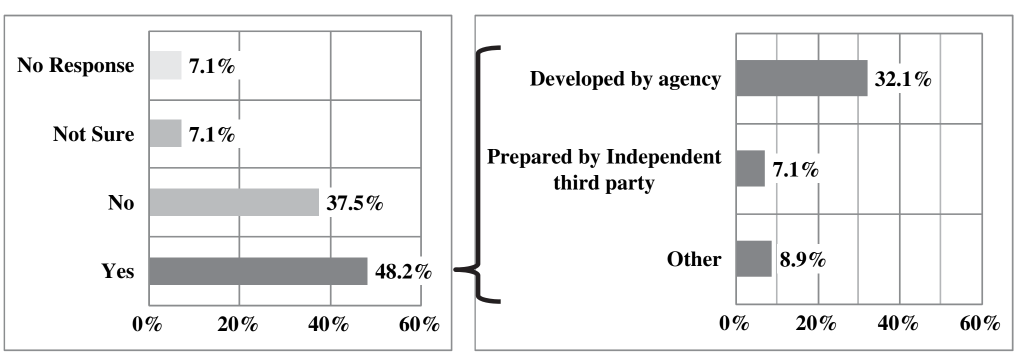

FIGURE 16 Percentage of highway agencies having a formal quality acceptance plan.

Question: If you have a pavement data collection quality assurance plan, what percentage of the data collected do you typically review in this plan?

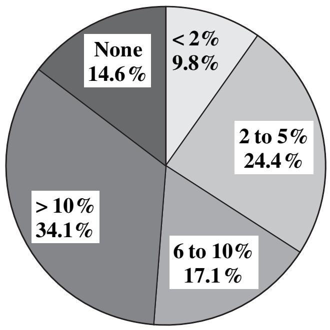

FIGURE 17 Percentage of data reviewed for quality assurance.

idate that the quality control process was conducted properly. The quality acceptance is done by a quality assurance auditor, who is not the operator. This quality auditor checks the data management spreadsheet to verify that the data are complete, verifies that all data have been saved and backed-up, and re-checks a random sample of 10% of the data collected (*66*).

Control and Verification Site Testing

Approximately three-fourths of the agencies use known or blind control sites as part of the quality acceptance procedure. Blind sites are often used for distress rating comparisons. Although the terms control and verification sites are often used interchangeably, there is a practical difference:

- Control sites are those in which the reference measurements have been determined and can be used to determine both accuracy and repeatability of data. The control sites are measured using the reference procedure; for example, manual visual survey for distress data.
- Verification sites are used to determine continued repeatability and/or reproducibility. They are measured periodically by the same equipment/crew or by different devices/crews. The first case is typically called over-sampling and allows determining the repeatability. The second is referred as cross-testing and determines the reproducibility.

The percentage of data collected that has to be corrected/resurveyed as a result of deficiencies identified by the quality acceptance process is very similar for in-house and contracted data collection. Approximately two-thirds of the respondents (64% for in-house and 67% for contracted) indicated that their staff or the service providers need to correct less than 2% of the data collected. Most of the others (30% for in-house and 33% for contracted) reported having to correct between 2% and 5% of the data.

Establishing Acceptance Criteria

A key aspect of the quality acceptance procedure is the definition of what constitutes "acceptable" data. Agencies need to define the criteria to determine how much variation is allowable between the reference value (or ground truth) and actual data measurement. The criteria are usually different for the various pavement condition indicators (e.g., smoothness and distress data), and include limits for accuracy and repeatability. It is important that the criteria reflect the actual capabilities of the available technology and that the service provider and agency agree on the acceptance criteria. For example, the tolerance for IRI might be ±5%. Table 3 presents, as an example, the criteria originally defined for the Pennsylvania DOT for quality acceptance. Additional examples of tolerances used by DOTs are compared in Table 4.

TABLE 3
INITIAL PAVEMENT CONDITION ACCEPTANCE CRITERIA FOR THE PENNSYLVANIA DOT

Reported Value	Initial Criteria	Percent Within Limits (PWL)	Recommended Action if Criteria Not Met
IRI	±25%	95%	Reject deliverable
Individual Distress Severity Combination	±30%	90%	Feedback on potential bias or drift in ratings. Retrain on definitions.
Total Fatigue Cracking	±20%	90%	Reject deliverable
Total Non-Fatigue Cracking	±20%	90%	Reject deliverable
Total Joint Spalling	±20%	90%	Reject deliverable
Transverse Cracking, Jointed Plain Concrete	±20%	90%	Reject deliverable
Location Reference—Segment/Offset	Correct Segment	All	Return deliverable for correction
Location Reference—Segment Begin	±10 ft	95%	Return deliverable for correction and systems check
Panoramic Images	Legible signs	80%	Report problem. Reject subsequent deliverables.

Source: Ganesan et al. (*94*).

TABLE 4
EXAMPLE OF TOLERANCE FOR VARIOUS PAVEMENT INDICATORS

Condition Indicator	Virginia		British Columbia	
	Range	Criteria	Accuracy	Repeatability
Smoothness (IRI)			10% of Class I	0.1 m/km
Rut Depth			±3 mm	±3 mm
Pavement Condition Index (surface distress)	±10	95%	±1 PDI [scale 1 to 10]	±1 SD of PDI for five runs

PDI = Pavement Distress Index; SD = standard deviation.

Sampling for Quality Acceptance Testing

Another important aspect is the determination of how large of a sample is needed for determining and verifying the accuracy and repeatability of the data collection procedure. For example, for automated or semi-automated distress data collection it is common to extract a sample of the collected pictures and review the ratings for accuracy. A 5% sample is common for this purpose; however, statistical approaches can be used to determine the required sample size. Larger samples may be required for research-quality data; for example, the LTPP distress data collection protocol requires that 10% of each lot is checked for distress mismatches, questionable severity levels, or errors in the test section or survey date.

Selezneva et al. (*88*) presents a series of promising sampling approaches that have been evaluated for quality assurance of the data collected for the National Park Service PMS. The data are surveyed by a service provider that collects pavement and right-of-way images, rutting, smoothness, road horizontal and vertical alignment, and GPS coordinates. Surface-cracking data are determined from the images using an automated crack detection system that detects the type, severity, and amount of cracking within a 0.01-mile section. The data are then aggregated in indexes for individual surface distresses, a composite distress index [the surface condition rating (SCR) and an overall pavement condition rating (PCR)].

The quality control and acceptance checks required for field data collection are documented in the *Road Inventory Program—National Park Service Quality Assurance Manual* (*95*). The checks include equipment checks, diagnostics of data collection and processing hardware and software, and a verification survey of a sample of selected parks by a review panel. Collected distress data are subject to a two-step data quality control and acceptance process in which the service provider first applies a series of internal quality control checks and the FHWA then conducts quality acceptance checks. The quality acceptance checks verify that the collected data are rated in accordance with the approved methodology for distress identification and distress severity ratings by manually rating selected pavement distress images provided by the service provider's automated crack detection system. The size of the sample requiring these later checks is determined using the following procedures.

Sample Size Determination for Assessing Network-Level Accuracy

This section discusses available tools to determine how large a sample is needed to verify that the accuracy of the measurements is within a specified range (e.g., ±10%) with a certain degree of confidence. Statistical testing of the mean differences is typically conducted using two- and one-sided *t*-tests. The size of the sample required for conducting meaningful comparisons is a function of the following statistical parameters:

1. Test significance (alpha) used as threshold for statistical significance (e.g., an alpha of 0.05 is typically selected to achieve a 95% level of confidence);
2. Desired precision or maximum acceptable difference;
3. Variability in the population, determined as the standard deviations of the computed differences (unknown at the time of analysis); and
4. Test power, or probability of correctly rejecting the null hypothesis (no difference between surveys) when it is false, which is typically computed by using a parameter beta defined as a probability of not detecting a difference when the difference exists (e.g., to achieve test power of 90%, beta would be limited to 10%).

The sample size is selected by balancing accuracy and cost. Although a larger sample allows for identifying a finer mean difference as statistically significant, the cost and effort of obtaining the sample and processing and analyzing the data may offset the benefit of the added precision of the results. A pilot application of the methodology for one park showed that a tolerance level of five SCR points would require 103 to 112 sample sections, which was considered relatively high because of the high cost for the field survey. If the tolerance level for the difference in mean SCR values between manual and automated surveys is relaxed to 10 SCR points, it would require 26 to 28 sample units, which was considered more reasonable (*88*). This type of precision of ±10% points of a 100 point index is also used by other agencies.

Sample Size Determination for Conformity Testing

To compare a sample of individual measurements against the reference and determine what percentage of the data collected fail to meet the quality acceptance criteria (e.g., ±20%), Selezneva et al. (*88*) recommend the use of the lot acceptance sampling plan methodology. The decisions about acceptance of production data are based on counting the number of unacceptable quality observations in a random sample of observations from a set.

To determine the required sample size for a known targeted maximum number of unacceptable observations in the sample, the analyst defines the following statistical parameters:

1. Acceptable quality level or the percentage of automatically collected data points that are expected to differ from the reference value assessment as a result of limitations of production technology;
2. Lot tolerance percent defective (LTPD) or percentage of automatically collected data points differing from the reference value assessment of the same data points that would make a dataset unacceptable by the specifications;
3. Type I Error (service provider's risk) or probability of rejecting a dataset that has a defect level equal to the acceptable quality level; and
4. Type II Error (client's risk) or probability of accepting a dataset with a defect level equal to the lot tolerance percent defective.

For large datasets, where the sample size is less than 10% of the total number of observations, n_0, that must pass the acceptance criteria without a single unacceptable observation can be computed using Eq. (1), and the number n that must pass the criteria with no more than one unacceptable observation using Eq. (2):

$$n_0 = \frac{\ln(1-C)}{\ln(R)} \tag{1}$$

$$(R)^n + n(1-R)(R)^{n-1} = 1-C \tag{2}$$

where

R = reliability of the data production procedures expressed as a fraction; the percentage of the observations not passing the pass–fail criteria because of limitations of the production methodology is equal to $100*(1-R)$; and

C = confidence level expressed as a fraction (for a 95% level of confidence, $C = 0.95$).

Other Statistical Analyses

The Cohen's weighted Kappa Statistic has also been proposed as a measure of agreement between raters, which evaluates the probability of agreement beyond chance. This method allows for the use of weights between disagreements, so that less important disagreements have less of an effect than more important disagreements and more weight can be given to those distresses that have the most effect on PMS decisions. For example, inconsistencies among distress severities are weighted less than disagreements among distress identification. This type of analysis has been shown to be more effective in identifying data inconsistencies than traditional methods, but assignment of weights and benchmarks needs to be carefully done (*86*).

Complete Database Checks

Typical quality acceptance procedures also include automatic checks on all the collected data to determine (1) if the data are within the expected ranges, (2) if there are any missing road segments or data elements, and/or (3) conduct simple statistical analysis and/or check to find possible inconsistencies in the data. This can be done as the data are being submitted (e.g., weekly) or after the entire product has been submitted. It is recommended that at least some of these checks be conducted frequently to identify possible issues as soon as possible and avoid collecting large quantities of bad data.

These checks are similar to the ones discussed for quality control but are conducted as a second check by the owner agency in the case of contracted data collection or by an independent quality acceptance auditor (internal or external) in the case of in-house data collection. Examples include checks to verify essential "general" information included in the condition database, sensor checks to flag out-of-range values for different indicators, and distress checks to verify that the distresses identified match the surface type (e.g., fatigue cracking on asphalt pavements).

An example of a well-developed set of software checks has been presented by Wolters et al. (*52*). This publication describes an application developed for Oklahoma DOT for checking the pavement data quality. The program conducts four types of checks: preliminary, sensor, distress, and special. All of the data checks can be organized into reports to identify inconsistencies and areas where data collection protocol may need to be modified (*52*).

The Iowa DOT quality acceptance process includes checks to verify that the measurements are between the expected minimum and maximum values, and to identify segments with missing roughness, rutting, or distress data, and sections in which all distress values are zero on continuous segments. The quality acceptance procedures also compare pavement condition index values from year to year. To improve communications with the service providers and reduce the amount of rejected data, some of these steps have also been incorporated into the service provider's quality control process (*73*).

Use of Geographic Information Systems in Pavement Condition Data Quality Management

One particular technique that is gaining acceptance is the use of GIS-based checks for quality acceptance. The visualization and spatial analysis tools available in GIS can be very useful for detecting missing sections, inconsistencies in the location of some sections, and unexpected changes in pavement condition. ODOT, for example, has recently begun using GIS for complementing the agency's quality acceptance procedures. Zhang and Smadi (*73*) present another example of the use of GIS to support the data collection quality management.

Time-History Comparisons

Approximately half of the responding agencies conduct comparisons of the pavement data collection with existing time-series data to identify unexpected changes in the condition that may be an indication of data collection problems. Larson et al. (*96*) presents some interesting approaches for comparing time-history pavement condition data. MDSHA also conducts a comparison of the current percentage of pavement sections in acceptable condition with those obtained over the past 5 years to highlight potential data collection problems; this approach is discussed in detail in chapter five.

The Florida DOT requires that the Ride Rating (100-point scale) be within plus or minus eight points of the previous year's survey. It is important that the data collection crew rerun the section if a rating falls outside this range. The second run must not vary by more than plus or minus one ride rating point from the first run. If the second measurement differs by more than plus or minus one rating point, then additional runs are required (*97*).

The LTPP distress data quality control protocols require that the rater analyze the images, compare them with the closest available survey (before or after) in a side-by-side plot, and resolve any differences before the distress maps are shipped to the quality acceptance contractor. The contractor checks 10% of each lot, and the data undergoes a higher-order quality acceptance, which includes time-series comparison and information management checks. The time-series checks plot the distress versus time with a 3-standard deviation error band (computed based on an average coefficient of variation obtained from variability studies), preservation treatments, and linear trend lines. A software tool, called Distress Viewer and Analysis has been developed by LTPP to assist in this process. The comparisons allow for identifying missed maintenance treatments or errors in the distresses identified (*67*).

Quality Acceptance of Contracted Data Collection

This section covers some quality assurance issues that are applicable only to agencies that have outsourced the data collection services. An important point is the use of the quality control data as part of the quality assurance process. For example, an agency may chose to use the service provider quality control data on the control segments for quality assurance purposes, and only validate a fraction of these data during the quality acceptance checks. According to the survey (Figure 18), only approximately one-third (30%) of the agencies that contract the data collection services use the service provider's quality control results as part of the quality assurance process. A significant number responded that they were not using these data (43%) or were not sure (27%).

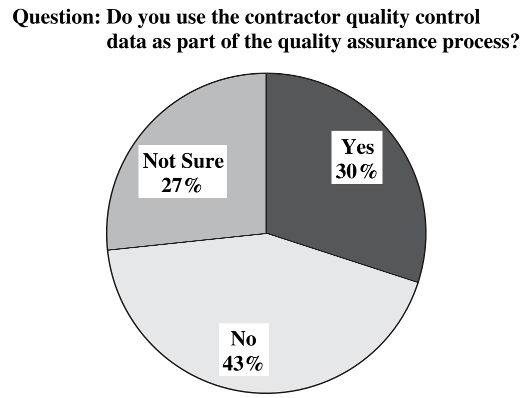

FIGURE 18 Percentage of respondents that use service provider quality control data for quality acceptance.

More than two-thirds (69%) of the agencies that have outsourced at least part of the data collection indicated that it was a positive step, with only one (3%) responding that it was not (Figure 19). The remaining agencies (28%) were not sure. Furthermore, 89% of the agencies are satisfied with the performance of the data collection service provider(s) most recently used or currently being used. However, this satisfaction is not universal; two agencies responded that they were not satisfied with the performance of their service providers.

INDEPENDENT VERIFICATION

It is surprising that only a very small number of agencies use third-party verification of data as a quality management tool; 4% for quality control and 12% for quality assurance. In the case of the Virginia DOT (VDOT), the use of an independent consultant to review the data led to a substantial reduction

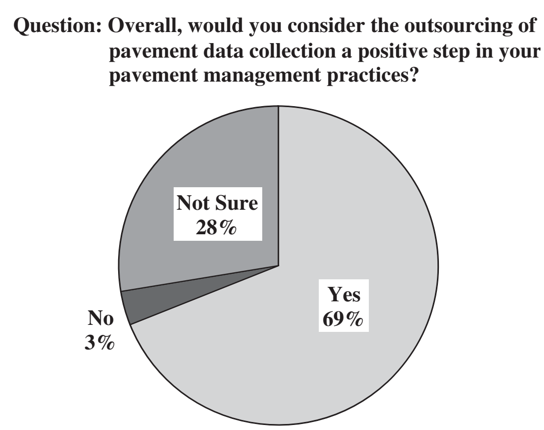

FIGURE 19 Degree of satisfaction with the outsourcing of pavement data collection.

in the number of pavement segments identified as requiring treatment and a large reduction in the estimated budgetary requirements (*51*). Although this is only a single case, it indicates that third-party verification of data may be a cost-effective quality management tool. The techniques and approaches used for the verification are typically very similar to those applied for the quality acceptance. A sample (e.g., 5% to 10%) of the data is typically subjected to the independent verification.

DATA REJECTION

In general, the amount of data that has to be corrected because of errors detected during the quality assurance process is relatively small. More than half of the agencies (52%) reported that less than 2% of the data need to be corrected or resubmitted by the service provider, and 39% reported having to correct 2% to 5% and only 8% (two agencies) reported having to reevaluate or correct 6% or more. This result is consistent with the responses indicated that, in general, outsourcing of the data collection with appropriate quality acceptance procedures has been beneficial for pavement management practices.

Although there does not appear to be a clear connection between network size and amount of rejected data, states with larger networks generally reported a data rejection rate of less than 2%, whereas agencies with smaller networks showed more variation. Nearly all agencies reported a data rejection rate of less than 5%. Agencies with a formalized quality management plan appear to reject less data. This is expected because a formalized quality management plan would clarify data acceptance procedures to all parties and data collection teams would most likely follow the quality control procedures and would not submit data that would not meet the known standards.

SUMMARY

This chapter covered the main quality control, quality acceptance, and independent assurance principles and techniques currently being followed by transportation agencies for pavement condition data collection. As discussed in the previous chapter, the distinction between quality control and acceptance activities depends on how the activities are incorporated into the management plan, rather than the activities themselves.

The purpose of the quality control plan is to quantify the variability in the process, maintain it within acceptable limits, identify the source of variability that can be controlled, and take the necessary production adjustments to minimize the "controllable" variability. A large percentage of the respondents (64%) have a formal data collection quality control plan or require the service provider to develop such a plan. A comprehensive quality control plan typically includes clear delineation of the responsibilities, documented manuals and procedures, personnel training, equipment and/or process calibration, certification and inspection, verification procedures before starting and during production testing (e.g., using control sites), and checks for data reasonableness, consistency, and completeness.

Quality acceptance activities include all procedures used for acceptance testing of both the pavement condition data that are collected by the agency and those that are collected by a service provider. These tests validate that the data meet the established requirements before they are used to support pavement management decisions. Approximately half of the agencies that responded to this question have a formal pavement condition data quality acceptance plan. Quality management techniques commonly used for this purpose include testing of control and verification sites, sampling and re-rating, complete database checks, GIS-based quality acceptance checks, and time-history comparisons. Important aspects for the testing of control and verification sites include establishing the acceptance criteria and the size of the sample required.

In some cases, agencies also use an independent verification by a third party to resurvey or reevaluate a sample of the data. The techniques and approaches used for the independent verification are typically similar to those applied for the quality acceptance.

CHAPTER FIVE

CASE STUDIES

This chapter documents the data management practices of a select group of transportation agencies. The case studies include an agency that conducts most of the data collection in-house and three agencies that contract most of the network-level pavement condition data collection with data collection service providers and use different quality acceptance approaches.

MARYLAND

MDSHA uses an in-house automated system to measure smoothness, rutting, and cracking, in addition to other data such as right-of-way images, longitudinal and transverse slopes, and GPS coordinates (*66*). The network-level data collection process includes: (1) data management, (2) pre-processing, (3) processing, (4) quality control, (5) quality acceptance (denoted as quality assurance), (6) classification and rating, and (7) data reduction. The quality control and acceptance procedures for the automated crack detection are discussed by Groeger et al. (*66*).

Quality Control

As discussed in chapter four, the quality control plan includes checks to verify that all fields are processed, reviews of section-level data in a search for abnormalities, and checks to verify that all the data have been saved. The reviewer then inputs a subjective evaluation of the crack detection process (good, fair, or poor).

Section-Level Review

The section-level review is conducted by looking at the total quantity of cracking by station and searching for abnormalities; for example, a road segment with many spikes. The operator reviews the segments with abnormalities by manually superimposing the cracks detected with the actual pictures. At the time the plan was published, this process was applied to approximately 50% of the pictures and the goal was to recognize 80% of the cracks. The operator also looks at the last rehabilitation date and verifies that the amount of cracking is consistent with the age of the surface; for example, a pavement recently rehabilitated would have little cracking.

Subjective Rating

In the last step, the operator verifies that the data have been saved and inputs a subjective evaluation of the crack detection process, following a set of recommendations summarized in Table 5. For example, if more than 90% of the stations reviewed pass the crack detection criteria and all the data were saved in the hard drive and the network, the batch is given a "good" rating.

Repeatability and Accuracy Examination

MDSHA has also implemented a quality control program to monitor data repeatability and the accuracy of test equipment using a test loop. The experiences of Virginia and other states have been incorporated into the program. The test loop is measured 20 times at the beginning of each data collection season, then run once every three weeks during the season. To analyze data accuracy of a particular test-loop run, the moving average of all the previous runs, including the initial 10-run results, is considered as the reference value for that particular test. This test is also compared with the previous one to check data repeatability.

Quality Acceptance

Quality acceptance is done by a quality assurance auditor, who is not the equipment operator. This process verifies that the data collection and quality control processes have been conducted properly. The independent auditor checks the data management spreadsheet, verifies that the data are complete, verifies that the data have been saved and backed-up, and re-checks a random sample of 10% of the data files collected implementing the same procedure used for quality control. This sample includes any files that have comments that are out of the ordinary. If there is one discrepancy in a file, it is noted on the data management form. If more than two discrepancies are detected, 50% of the file is reviewed to determine if there is a systematic error. If more than 10% of the quality acceptance samples have discrepancies, consideration is given to repeating the crack detection process (*66*). All data are backed-up on the server on a daily basis and copied to tapes once a week.

TABLE 5
EXAMPLE OF QUALITY CONTROL RATING MATRIX USED BY MDSHA

QC Procedure	Good	Fair	Poor
Stations Processed			<100%
Criterion 1: Detected > 80% of Cracking	>90% Stations	70%–90% Stations	<70% Stations
Data Saved to Hard Drive	Yes		No
Data Saved to Network	Yes		No

Source: Groeger et al. (*66*).

Classification and Rating

After the data have been processed for crack detection, quality control, and quality acceptance, the next step in the process is to classify and rate cracks using an automated process. Cracks are classified as longitudinal and transverse, their locations in the pavement (outside wheel path, inside wheel path, center, left edge, or right edge) are determined, and the severity is rated as low, medium, or high using the AASHTO cracking protocol definition and the crack width determined by the system.

Data Reduction

The cracking data are reduced to a condition rating of 0 to 100 and assigned a condition state of very good, good, fair, mediocre, or poor using a software program known as the MDSHA Automated Distress Analysis Tool. This tool also performs the final quality check through a suite of logic, range, and trend checks on the data and generates a progress report to document the pace of data collection and data processing. If the checks detect any problems, the file is flagged and a note is output to an error log. If the file passes all the checks, data are converted into U.S. units and reformatted to match PMS specifications, and the pavement condition index (PCI) is calculated.

Time-Series Comparisons

MDSHA also monitors network-level time-series data with the help of a software tool developed and implemented in 2004. This quality acceptance tool checks reasonableness of the data trend. The tool is routinely used to test each data submission and includes two steps: data trend monitoring and data quality investigation.

Data Trend Monitoring MDSHA uses the percentage of the network in acceptable condition—called acceptable rate—to monitor the network-level pavement condition. A software program summarizes the acceptable rates in terms of IRI, rutting, cracking, and friction individually by route, county, district, or statewide. A table is prepared for each of the pavement condition indicators along with the values obtained for the last five years. As an example, Table 6 shows 2 years of the 5-year comparison for IRI for a sample of routes. For each year, columns 1 through 5 indicate the percentage of pavements in each condition state and the last column the percentage of road in acceptable condition (states 1 through 3).

TABLE 6
IRI TREND MONITORING BY ROUTE

Route	2007						2006					
	1	2	3	4	5	Acc. Rate	1	2	3	4	5	Acc. Rate
IS68E	41.04	36.57	18.16	3.23	1	95.77	30.6	37.81	25.87	4.23	1.49	94.28
IS68W	33.83	41.79	20.65	3.48	0.25	96.27	24.38	43.78	27.11	2.99	1.74	95.27
MD35N	0	33.33	58.33	4.17	4.17	91.67	0	33.33	58.33	8.33	0	91.67
MD35S	0	33.33	58.33	4.17	4.17	91.67	0	41.67	50	4.17	4.17	91.67
MD36N	12.97	40.61	29.35	7.85	9.22	82.94	9.62	39.52	34.02	9.28	7.56	83.16
MD36S	12.24	42.52	28.91	7.48	8.84	83.67	11.6	41.98	32.08	7.85	6.48	85.67
MD47N	**0**	**11.76**	**58.82**	**23.53**	**5.88**	**70.59**	**0**	**17.65**	**58.82**	**23.53**	**0**	**76.47**
MD47S	0	5.88	76.47	17.65	0	82.35	0	11.76	70.59	17.65	0	82.35
MD49E	**0**	**9.09**	**72.73**	**9.09**	**9.09**	**81.82**	**0**	**10**	**80**	**10**	**0**	**90**
MD49W	0	10	90	0	0	100	0	10	90	0	0	100

Source: W. Xiong, personal communication, 2008.
Note: Columns 1–5: the percentage of pavements in each condition; last column percentage of road in acceptable condition. In bold, routes where pavement condition indicators differ more than 2% from previous year.
Acc. = acceptable.

Similar summaries are prepared by the county, district, and for the entire state. If the acceptable rate for any of the pavement condition indicators differs more than 2% (routes MD47N and MD49E in the example) from the previous year, the record is highlighted for further investigation.

Data Quality Investigation A data quality investigation is required for those sections in which the trend analysis indicates a potential data quality problem. This investigation aims to identify the reason for the suspicious rate change, determine if there was a problem, and, if there is one, find a solution to fix it or to prevent it from happening again. Historic treatment information, test and equipment event records, pavement images, and weather conditions during testing are collected and analyzed to determine which factors may have contributed to the suspicious condition variation. If test operation or equipment condition is identified as a concern, a notice is sent to the data collection staff requesting that the data be re-collected or suggesting modifications to the data collection procedures.

Data Collection Equipment Comparison

After replacing its automated data collection equipment, MDSHA conducted a data comparison study to evaluate the consistency of the data collected between the old and new devices. The two systems were used to collect data on a 250-mile loop. The smoothness (IRI), cracking, and rutting values for a sample of one hundred 0.1-mile segments were compared. The comparison showed that the two systems produced similar IRI data, but statistically different rutting and cracking measurements. Cracking data were collected from pavement images using a proprietary automated cracking detection software tool.

To resolve the cracking data consistency problem, MDSHA initiated a study to compare the results of the two systems with reference ratings determined visually from the same pictures collected with the data collection systems for the same 100 segments. This ground truth determination is critical for hardware and software calibration to improve data accuracy.

VIRGINIA

VDOT has used different pavement distress data collection methodologies over the past 15 years. These changes have resulted in a continuous improvement process through which the department has gained significant experience and developed sophisticated quality control and assurance procedures. VDOT collects data over 0.1-mile- (161-m)-long management units.

Background

Larson et al. (*96*) presents some interesting approaches for comparing time-history pavement condition data. Figure 20 shows the comparison for the overall PCI and IRI for 1996 and 1997 after removing all sections that received preservation treatments. The PCI plot pointed out a deficiency in the rating procedure used in 1997, which overestimated the PCI for the pavements in poor condition. The IRI plot also suggests a problem, because the smoothness was lower in 1997 than in 1996; this was attributed to the switch from ultrasonic sensors to laser sensors.

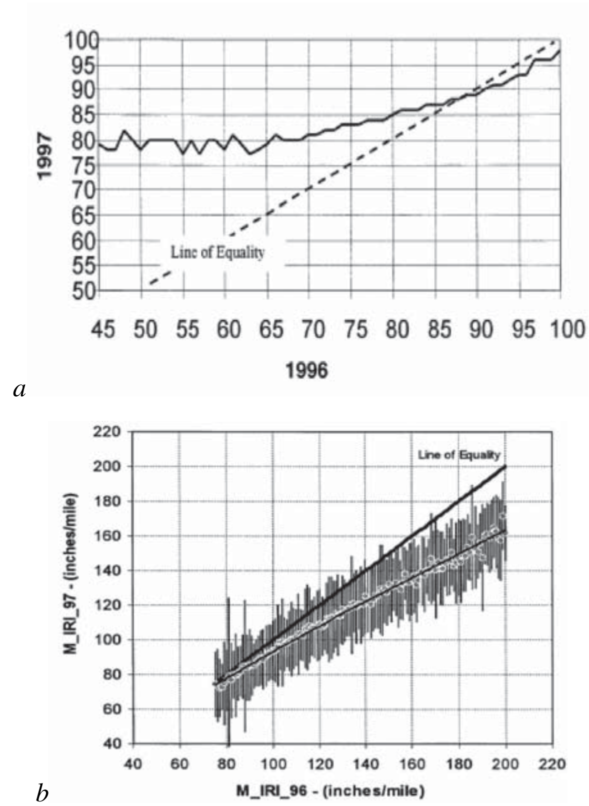

FIGURE 20 VDOT yearly pavement condition comparisons (*96*): (*a*) Pavement Condition Index; (*b*) Smoothness (IRI, in./mi).

The network-level comparison prompted a review of the pavement data collection approach, which helped enhance data quality requirements in successive years and establish formal quality assurance/quality control processes. Most significantly, VDOT defined the following vision statement for data collection "to collect pavement condition data with sufficient detail and accuracy to model deterioration and perform multiyear planning with the PMS. Data variability for each data element must be smaller than the year-to-year change in that element."

The study also prompted the agency to require the calibration of smoothness measuring equipment against a reference device and its verification against VDOT equipment, and pilot testing of a sub-network during the data collection contract inception phase. It also provided the data that was used to develop precision (±12%) and bias (±5%) criteria for the PCI.

Current Data Collection Practice

In 2005, after a formal solicitation process, VDOT contracted with a service provider to collect, process, and deliver network-level pavement condition data (*51*). The equipment specified included digital pavement imaging to a resolution of at least 2 mm, laser measurements of longitudinal and transverse profiles, and automated or semi-automated distress quantification. The potential service providers were required to provide documentation of their quality control plans for all aspects of the project, ranging from equipment calibration through data delivery. The selected service provider had an established quality control plan, but added an outside third party to provide an independent verification and validation of the data before delivery to VDOT for this project. The service provider-supplied quality process flow diagram (Figure 21) outlined the flow of data collection, data processing, quality control, independent validation and verification, and data acceptance processes.

Initial Calibration

The calibration of the service provider's longitudinal profile, transverse profile, and pavement distress measurement processes was done using 13 known-location control sections. The control sites varied in length, smoothness, and distress conditions. Data collected by VDOT were used as reference values. The sites were used to establish the service provider's precision and bias, which in turn were compared with the ones required in the RFP.

For calibration of the pavement distress measurements, the service provider used an automated crack detection rating process and semi-automated ratings of the additional distresses. The reference distress surveys were conducted by VDOT staff and the independent third party using the equipment collected images. This effort also served to train all distress raters, unify criteria, and made the necessary adjustments to the process. Comparisons were made based on the overall pavement condition index; the allowable difference was ±10 points.

Independent Verification and Validation

The verification and validation of the pavement distress data by an independent quality auditor was performed after the service provider had completed all in-house quality control reviews and believed the data were ready for submittal to VDOT. Acceptance criteria require that 95% of the data checked fall within plus or minus 10 index points of the third-party data. The third party evaluated a 10% random sample of the pavement deliverables. This process

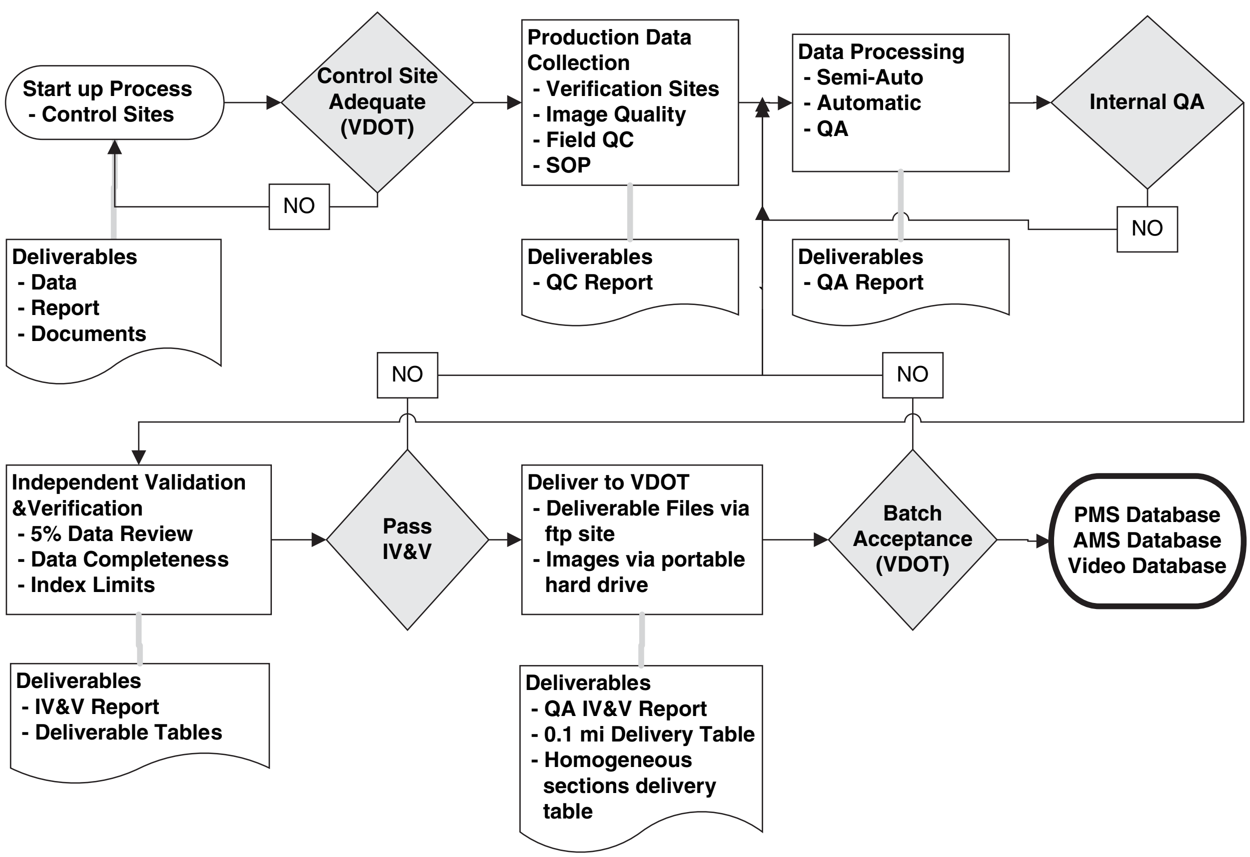

FIGURE 21 VDOT quality process flow diagram [after Shekharan et al. (*51*)].

provided a high-level check of the deliverable tables to verify data completeness and data reasonableness, as well as a direct pavement distress comparison between automated/semi-automated ratings and manual ratings from experienced pavement raters.

The verification and validation also helped identify random and systematic errors. Because several systematic errors (e.g., erroneous classification of a particular distress type) were identified, the service provider had to adjust the process and reanalyze specific types of sections. For example, the process identified problems with the rating of patches in the jointed reinforced concrete pavement sections and in the classification of cracks in asphalt pavements. These problems required adjustments in the data analysis criteria. The effect of these adjustments had a very significant effect on the classification of the pavements in the various condition categories, the number of deficient pavements, and the subsequent estimated budget needs, as was discussed previously in the synthesis.

In the latest completely audited available survey (corresponding to 2006), using a sample of 5% of each deliverable, the independent verification found that the percentage of the distress data meeting the tolerance requirements varied between 93% and 98% for the various deliverables. The independent quality auditor also compared the repeatability of each vehicle used by the service provider, and reproducibility between the two service provider's devices and VDOT's profiler and performed a high-level data review for reasonableness and completeness (*98*).

OKLAHOMA

As the Oklahoma (ODOT) started implementing a PMS, quality pavement condition data were identified as a key component. The agency recognized the importance of checking the quality of data before they are used for important management decisions and has implemented detailed quality control and acceptance processes.

Pavement Data Collection

ODOT established a 4-year contract with a data collection service provider to collect network-level sensor, geometric, and distress data by automated data collection techniques. The data are processed using a combination of automated and semi-automated techniques. Data on roughly half of the network are collected each year of the contract. The contract includes sensor data (IRI, rutting, faulting, and macrotexture), distress ratings (type and severity) based on visual analysis of pavement video, and geometric data (longitudinal slope, crossfall, horizontal curve radii, and GPS coordinates). Data are collected over the entire length of each section (i.e., sampling is not used) and reported in 0.01-mile (161-m) increments (*52*).

Quality Control

The quality control plan was developed by the data collection service provider and includes quality control checks at all stages of the data collection, processing, reduction, and delivery processes. Some of the quality control steps included control and verification site testing, inter-rater consistency testing, and numerous checks of data quality and completeness.

Quality Acceptance

ODOT initially instituted additional quality acceptance checks, which are applied to the data submitted by the contactor and include the following:

- **Control site testing** to help identify factors that could affect the accuracy and repeatability of sensor data measurements and evaluate the quality of the collected video.
- **Checks of distress ratings** on batches of submitted data using a modified version of the service provider's distress rating software. Because these distress rating checks proved to be very time-consuming and labor-intensive, ODOT contracted the review of the distress ratings for the third year of collection to a consultant.
- **Additional data quality assurance checks** of every data element in the pavement condition database.

After 3 years of consistently instituting more checks, the agency developed an automated procedure to rapidly and efficiently check the data delivered by the service provider. Figure 22 presents the main screen for the Visual Basic quality acceptance tool developed within the Access database.

The software tool automates the following four groups of checks:

- **Preliminary checks** verify a variety of essential "general" information included in the condition database. This step checks the district number, type of data entered in each field (e.g., integer versus characters), general section identification data, GPS values, pavement type, events (bridges, etc.), geometric values, and missing data, among others.
- **Sensor checks** for all sensor-related data elements (i.e., those data elements collected using lasers or sensors to determine properties of the pavement section) look for duplicate records in adjacent sections, date, number of sensors used for rutting, and out-of-range values for IRI, rutting, faulting, and macrotexture.
- **Distress checks** verify the specific distress for a given surface type to confirm that they are in accordance with ODOT distress rating protocols and within the expected values not only on an individual basis but also when considering various distresses in combination with one another.
- **Special checks** include more specific elements such as maximum asphalt concrete patch length, number of

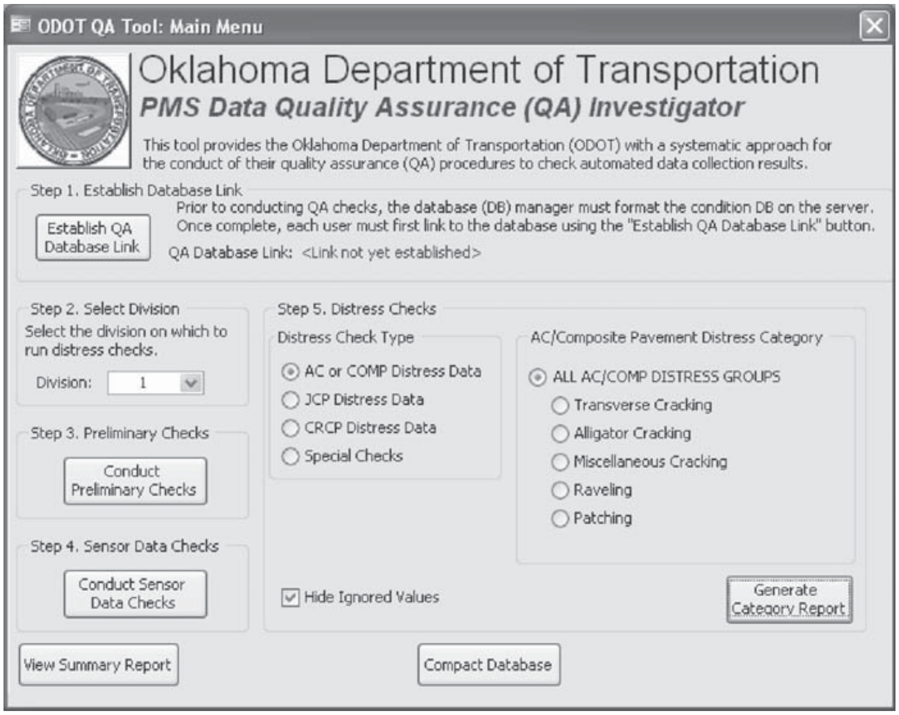

FIGURE 22 Main menu for the ODOT pavement data quality assurance software (*52*).

railroad crossings and bridges, and nonmatching distress types (e.g., an asphalt concrete distress assigned to a concrete pavement).

ODOT has found that these checks provide a wealth of information that has been helpful for evaluating the data provided by the data collection service provider. The software also provides a useful interface for accessing and changing the data in the database.

Use of Geographic Information System in Quality Acceptance Checks

ODOT has recently begun using GIS for complementing the agency's quality acceptance procedures. The visualization and spatial analysis tools available in GIS can be very useful for detecting missing sections, inconsistencies in the location of some sections, and unexpected changes in pavement condition.

BRITISH COLUMBIA

The British Columbia Ministry of Transportation's (BCMoT) *Pavement Surface Condition Rating Manual* (*99*) originally released in 1994 and updated in 2002 includes a detailed quality assurance section. The *Manual's* rating methodology was designed to be applicable to both automated and manual surveys so that it can be used for network- and project-level analysis. The surveys and data post-processing are guided by quality management procedures to ensure that the data are collected accurately and repeatedly from year to year.

Data Collection Practices

At the network level, the survey includes surface distress, rutting, and smoothness (in addition to crack sealing, patching rating, and right-of-way pictures), which the Ministry believes provides sufficiently accurate and consistent information for network-level analyses. The surveys are conducted by service providers using automated road testing vehicles.

The project-level surveys consist of manual surface distress surveys conducted during the detailed evaluations that are carried out for candidate rehabilitation projects. In addition to distress surveys, this evaluation can include geotechnical investigations, strength testing, coring, and laboratory testing. The distresses are evaluated every 20 m and plotted on a map.

The quality acceptance procedures consist of three levels of testing: (1) initial tests completed by the service provider before the surveys, (2) blind site monitoring during the production surveys, and (3) final assessment of the submitted data files.

Initial Quality Acceptance Tests

The initial tests verify the service providers' application of the BCMoT rating system and the operation of the smoothness and transverse profile instrumentation. The service provider is required to pass all checks before starting production data collection. The agency selects four 500-m-long test sites that exhibit a variety of distress types, range in pavement deterioration, surface types, and operating speed. The sites are surveyed manually at 50-m intervals to determine the reference values (Figure 23). The rut depth is determined taking manual transverse profile measurements in each wheel path at 10-m intervals using a 2-m straight edge. The longitudinal profile and IRI in each wheel path is obtained using a Digital Profilite 300, which is a Class 1 profiler.

Following the reference value determination, the service provider and BCMoT personnel conduct an on-site review where they compare the semi-automated survey results with the results of the manual survey. They walk over the site comparing the results to resolve ambiguities and, if necessary, adjust the rating procedures and/or revise the manual ratings.

The service provider's ability to accurately and repeatedly rate pavement distress is assessed by completing a series of five runs over each site, generating ratings at 50-m intervals, and comparing the results for each run with the manual survey. The distress comparisons are based on (1) a combined Pavement Distress Index (PDI) to assess accuracy and repeatability, and (2) severity and density rating totals for each distress type present over the entire site to highlight possible discrepancies. The accuracy criteria are ±1 PDI (a 10-point scale index) value of the manual survey, and the repeatability criteria ±1 standard deviation of the PDI values for five runs. Landers at al. (*86*) reported that the range of PDI errors was 0.0 to 0.6 between 1999 and 2001, and the standard deviation (from 5 runs) was 0.2 for all the initial test sites.

The service provider's smoothness and rut depth measurements are also compared for the 50-m segments for each wheel path and for the 500 m test site. The IRI criteria establishes that the measurements must be within 10% of the Class I profile survey for each wheel path (accuracy) using 100- and 500-m integration intervals, and have a maximum repeatability of 0.1 m/km standard deviation for five runs. The rut depth measurements must have an accuracy of ±3 mm of manual survey, and a repeatability of ±3 mm standard deviation for five runs.

Production Survey Quality Acceptance

During production surveys, quality acceptance is primarily done using blind sites situated along various highways in each region. These sites are manually surveyed in advance using the same procedure described for the initial checks, and their location is unknown to the service provider. For larger surveys, the initial test sites are also resurveyed periodically. Blind sites are generally scheduled once every three days during the surveys. Each day during the production surveys, the service provider is required to contact and update the BCMoT representative as to their progress. At this time, the service provider is informed that they have passed over a site on the previous day and is provided with the site location, whereupon he or she immediately submits by fax the surface distress survey ratings, smoothness, and rut depth measurements (at 50-m intervals) for that section. Because of possible referencing differences, the service provider is required to submit 1.0 km of data with 250 m on either side of the blind site. The acceptance criteria are the same as for the initial test. The service provider is authorized to continue with the production surveys upon satisfactorily completing the blind site quality acceptance test (*99*). This criteria is being reviewed and consideration is given to the use of the Cohen's weighted Kappa Statistic to compare individual distress types and give more weight to those that have the most effect on PMS decisions (*86*).

Submitted Data Quality Acceptance

The last step in the quality acceptance process is the assessment of the submitted data, which is conducted using a 3-step process that involves both manual and system checks. The first step consists of conducting a thorough manual review of the submitted data files that verifies that data exist for all road segments, data file structure is correct, segment location and definition are correct, and data are within acceptable ranges. The initial quality acceptance results are summarized and provided to the service provider for correction. The second step involves comparing the current year submitted survey data to previously collected data to determine if there are any significant variations from cycle to cycle. The third and final step involves uploading the distress, smoothness, and rut depth data to the PMS, which conducts internal standardized and user-defined verification tests. The PMS generates a log report listing all discrepancies that can be reviewed, confirmed, or input data corrected and reloaded as required.

SUMMARY

This chapter documented the data management practices of four DOTs. The review included an agency that conducts most of the data collection in-house, and three agencies that

Class I Roughness Survey Manual Distress Survey Rut Depth Survey

FIGURE 23 Reference value determination in British Columbia, Canada (*99*).

contract most of the network-level pavement condition data collection with data collection service providers.

The first case study reviewed the MDSHA experience using an in-house automated system to measure smoothness, rutting, cracking, and other data. Its quality control plan includes checks to verify that all fields are processed, reviews of section-level data in search of abnormalities, and checks to verify that the data have been saved. The quality control program also monitors data repeatability and the accuracy of test equipment using control sections. The quality acceptance is conducted by a quality assurance auditor, who is not the operator. The auditor checks the data management spreadsheet, verifies that the data are complete and have been saved and backed-up, and re-checks a random sample of 10% of the data collected. Time-series comparisons of the percentage of the network in acceptable condition by route, county, district, and for the entire state, are used to flag potential data quality problems.

The second case study covers VDOT's most recent experience using a data collection service provider. It highlights two interesting approaches for comparing time-history pavement condition data and presents an example of a service provider-supplied quality control process that includes an independent validation and verification. Among other criteria, the acceptance plan requires that 95% of the data checked fall within plus or minus 10 index points of the data collected by a third-party validation and verification rater. The third party evaluates a 10% random sample of the pavement deliverables.

The third case study summarizes the ODOT experience using a data collection service provider to collect network-level sensor, geometric, and distress data by automated data collection techniques. The quality control plan developed by the data collection service provider includes quality control checks at all stages of the data collection, processing, reduction, and delivery processes. The quality acceptance procedure includes testing of known control and verification sections, checks of distress ratings on batches of submitted data using a modified version of the service provider's distress rating software, and automatic data quality assurance checks using specially developed software. ODOT has also recently begun using GIS for complementing the agency's quality acceptance procedures.

The final example reviews the experience in the BCMoT. The network-level surveys are conducted by contracted service providers that collect surface distress, rutting, and smoothness using automated equipment. The quality management procedures consist of three levels of testing: (1) initial tests completed by the service provider before the surveys, (2) blind site monitoring during the production surveys, and (3) final assessment of the submitted data files. The initial quality tests compare the results of five runs of the service providers' equipment with reference measurements on four 500-m test sites. These sites are also resurveyed periodically for quality control. Production quality acceptance is primarily done using blind sites situated along various highways in each region, which are manually surveyed in advance using the same procedure described for the initial checks. The final step in the quality acceptance process is the assessment of the submitted data using manual reviews and automated software time-series comparisons, and standardized and user-defined verification tests after the data have been entered into the pavement management database.

CHAPTER SIX

FINDINGS AND SUGGESTIONS FOR FUTURE RESEARCH

Pavement data collection quality control is receiving increased attention, not only because data collection is one of the most costly parts of operating a pavement management system, but also because data quality has a critical effect on the business decisions supported by the system. To ensure that the data collected meets the need of the pavement management process, agencies are developing procedures and guidelines for quality management of pavement data collection activities. The synthesis reviewed quality management practices being employed by public road and highway agencies for automated, semi-automated, and manual pavement condition data collection and delivery using in-house staff and contracted services. The following sections summarize the main findings of the study and provide topics for future research.

SUMMARY OF FINDINGS

The concepts of quality, quality management, quality control, and quality acceptance have been extensively used in manufacturing industrial processes. However, these same principles, methods, and tools have not been systematically applied to pavement data collection. This is partially because in these services the "product" is not clearly known and the reference value often is difficult to determine. The literature suggests that the most efficient way to achieve high-quality pavement condition data collection services is to adopt a comprehensive, systematic quality management approach that includes methods, techniques, tools, and model problem solutions.

Independent of the mechanism used to collect the data, in-house or through a service provider, a complete quality management system may include a clearly documented quality management plan, detailed and timely quality control and acceptance procedures, and established guidelines to monitor the entire data collection process. Before data collection, equipment is properly calibrated, procedures clearly defined and documented, and personnel trained. During data collection, pavement condition data is verified by a variety of possible methods to ensure data accuracy, consistency, and completeness during the collection effort. After data collection is complete, the data may then be validated before acceptance.

The main findings concerning the state of the practice and knowledge of quality management of pavement condition data are the following:

1. **Data Quality Requirements:** Data collection practices and quality management processes may be tailored to the use of the data and the level of decisions being supported. The level of detail, accuracy, and coverage (and consequently "quality") required is different for supporting network- and project-level pavement management decisions. In general, surface distress (98% of respondents) and smoothness (95%) data are collected for network-level analysis. Project-level surveys typically include more detailed distress surveys (oftentimes walking the section) and assessments of the structural capacity (71%) and frictional properties (55%) for specific projects.
2. **Quality Management Plan:** This plan documents how the agency plans, implements, and assesses the effectiveness of its pavement data collection quality control, quality acceptance, and independent verification operations. Approximately one-third of the state and provincial highway agencies (35%) already have a formal plan and an additional 27% are working on developing such a plan. Furthermore, agencies with larger networks were more likely to have a formalized quality management plan than the smaller agencies. An example of the components of a quality management plan is provided in Figure 24.
3. **Quality Management Tools and Methods:** The main tools/methods used for quality control and acceptance by state and provincial highway agencies are the following:
   - Calibration/verification of equipment and methods before the data collection (used by 94% of the agencies for quality control and by 80% for quality acceptance),
   - Testing of known control segments before data collection (94% for quality control and 73% for quality acceptance),
   - Testing of known control or verification segments during data collection (81% for quality control and 71% for quality acceptance), and
   - Software routines for checking the reasonableness (57% for quality control and 71% for quality acceptance) and completeness (55% for quality control and 61% for quality acceptance) of the data.

Other promising quality management techniques that are not yet as commonly used include:

- Analysis of time-series data both at the project and network-level (used by 42% of the agencies for quality control and by 50% for quality acceptance),

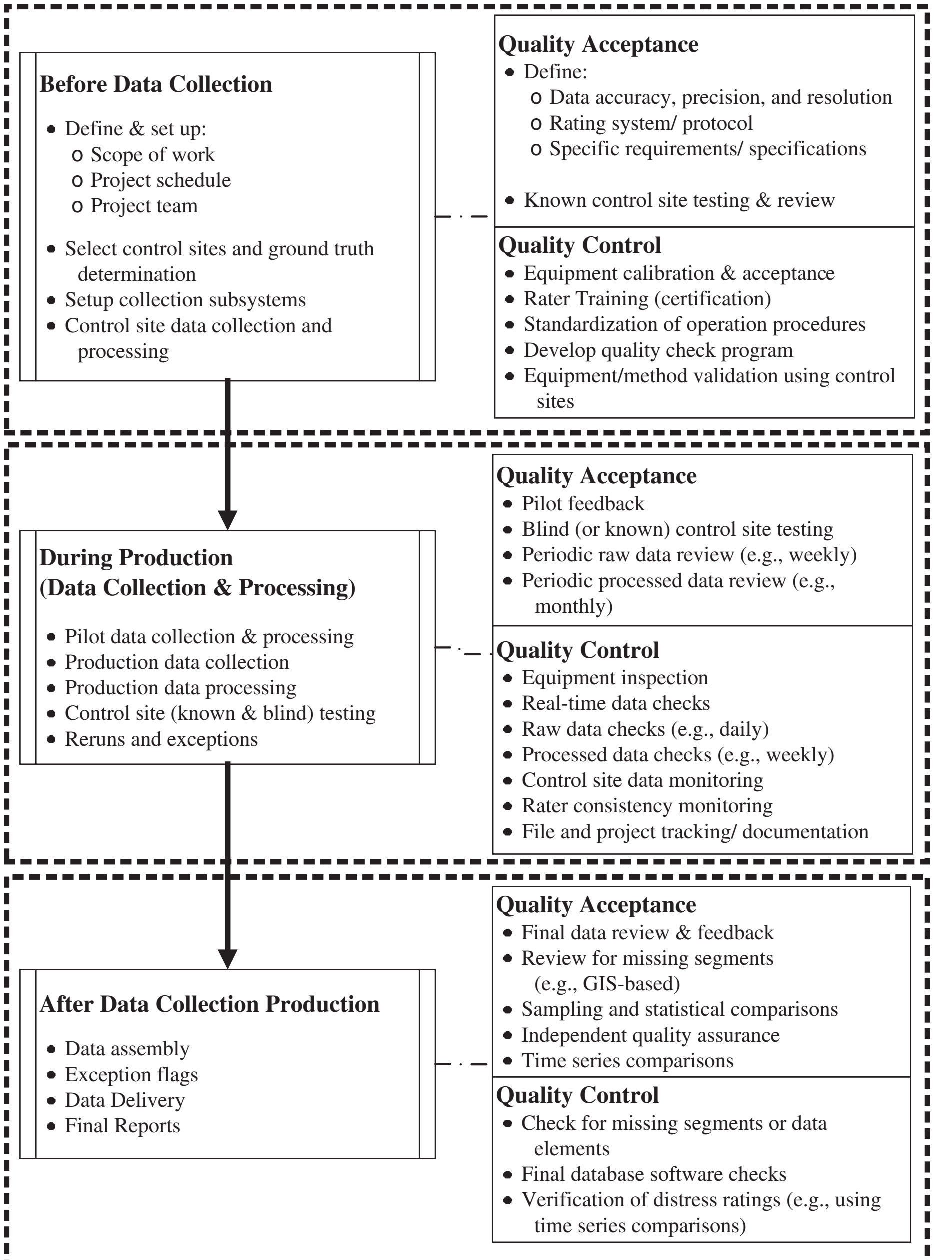

FIGURE 24 Example of quality management plan components [after Rada et al. (*67*) and Zhang and Smadi (*73*)].

- Independent (quality control or acceptance) verification and validation of the pavement condition data by an independent quality auditor (4% for quality control and 12% for quality acceptance), and
- Use of blind site monitoring during the production quality acceptance process (24% for quality control and 21% for quality acceptance).

4. **Quality Control** includes actions and considerations necessary to assess and adjust production processes to obtain the desired level of quality of pavement condition data. Approximately two-thirds of state and provincial highway agencies have a formal data collection quality control plan or require the service provider to develop such a plan. All pavement data collection service providers indicated having a formal data collection quality control plan.

Based on the examples reviewed, a comprehensive quality control plan typically includes the following elements:

- Clear delineation of the responsibilities,
- Documented (and available) manuals and procedures,
- Training requirements for the survey personnel,

- Equipment calibration and inspections procedures,
- Equipment and/or manual process verification procedures (e.g., testing of known control section) before starting production testing,
- Production quality verification procedures (e.g., testing of known or blind control sections during production testing), and
- Checks for data reasonableness and completeness.

5. **Quality Acceptance** includes the activities that govern the acceptance of the pavement condition data and ensure that the final product is in compliance with the specifications. It applies to the pavement condition data collected by the agency and by service providers. Approximate half of the state and provincial highway agencies have a formal quality acceptance plan. In the case of data collection contracts, quality acceptance is often also linked to payments.

   Typical quality acceptance activities include:

   - Establishing acceptance criteria (data accuracy and precision and reliability);
   - Verification of the equipment/analysis criteria before data collection;
   - Testing of known or blind (preferred) control or verification sites before and during data collection;
   - Software data check for reasonableness, completeness, and consistency; and
   - Time-series comparisons.
6. **Independent Assurance:** Quality engineering practices typically recommend the inclusion of at least some degree of external audit in the quality management plan. The purpose of the independent assurance testing is to validate the data for the user agency. However, only 4% of the agencies surveyed use independent verification for quality control and 12% for quality acceptance.
7. **Equipment/Method Calibration, Certification, and Verification:** The verification that the equipment is functioning according to expectations and that the collection and analysis methods are being followed is key for ensuring the quality of the collected data. This is typically done before the initiation of the data collection activities and periodically after that. Equipment or process verification and validation is typically assessed by determining their accuracy, repeatability, and reproducibility.
8. **Control and Verification Sites:** A common procedure to verify the quality of the pavement data collection during production is the use of a sample of control or verification roadway sections that are resurveyed or reanalyzed by an independent evaluator and the results compared with the production ratings. The locations of these segments can be known or "blind" for data collection teams. The reference measurements on these sections are determined using the best available practical technique for that particular pavement condition indicator. Statistical methods are typically used in conjunction with control site testing to establish acceptable ranges for various data collection techniques.
9. **Software Checks:** Many agencies and all service providers use software routines that check the data for inconsistencies for both quality control and quality assurance. Although there is some variation in verification methods, most software can perform checks for detecting missing segments, corrupted records, and ratings that are out of expected ranges. Some packages can also provide statistical analysis to check for data inconsistencies, compare condition time-series, and/or graphically display the results using geographic information systems.
10. **Data Collection Contracting:** Agencies are increasingly considering the outsourcing of data collection and processing. However, although most agencies have evaluated this possibility, most of the pavement data are still collected using in-house resources.
    - Pavement distress and smoothness data are the data types that are most frequently outsourced (by about one-third of the respondents, 43% and 38%, respectively).
    - The main factor considered for making the decision to outsource the pavement data collection is cost-effectiveness, followed by limitations of the in-house data collection capabilities and amount of data that is to be collected.
    - The main criterion used for service provider selection is past performance/technical ability, followed by best value and low bid.
    - Several of the data collection contracts include clauses that link payment to the quality of the data collected.
    - More than two-thirds of the agencies that have outsourced at least part of the data collection indicated that data collection outsourcing was a positive step.
11. **Changing Requirements/Technologies:** The adoption of automated (and semi-automated) data collection technologies has created challenges for the roadway agencies that verify that the new equipment results are consistent with the historical practices. Furthermore, institutional changes, such as the reassessment of the highway pavement management system or the adoption of mechanistic–empirical pavement analysis and design methodologies are also influencing the pavement condition data detail and quality requirements.

ISSUES IDENTIFIED

Some of the issues identified on the pavement management collection quality management practices include the following:

- There is lack of uniformity on the type of data collected by the various state and provincial departments of transportation and the approaches followed to manage the quality of the data collection process.
- Although there appears to be common agreement that data quality is important for effective pavement management,

several agencies still do not have formal quality management plans.
- Several agencies are facing problems with the consistency of data after the adoption of automated or semi-automated data collection methodologies, changes in the data collection equipment (in-house or service provider), or changes in service providers.
- Several agencies also reported problems with the consistency of their location referencing systems, especially as they migrate from linear to geodetic methods.
- There appears to be a need for guidelines to help agencies define the level of data quality and detail needed for the various pavement management functions and decision-making levels.

SUGGESTIONS FOR FUTURE RESEARCH

Based on the issues identified in the previous section, the following topics can be listed as future research needs:

- Identification and demonstration of "best quality management practices."
- Investigation of the effect of emerging pavement data collection technologies on pavement management recommendations.
- Development of processes and procedures for evaluating backward compatibility in data from year to year and/or developing correlations in data where variability exists.
- Development of commercially available tools for facilitating of the implementation of quality management checks at the various stages of the data collection process.
- Cost-effectiveness analysis of the implementation of different quality management tools, methods, and programs.
- Development of "generic" quality management, control, and assurance plans that agencies can customize for their specific needs, and/or software for guiding the development of these plans. These could be provided in the framework of an AASHTO Standard Practice.
- Investigation of the need and content for a workshop or training course and materials specifically on quality management of pavement data collection.
- Investigation of the impacts of alternative delivery methods including performance-based warranty contracts on pavement data quality management.

GLOSSARY

Acceptance plan: An agreed-upon method of evaluating the acceptability of the pavement condition data.

Acceptance testing: The activities required to determine the degree of compliance of the pavement data collected with contract requirements.

Accuracy: The degree to which a measurement, or the mean of a distribution of measurements, tends to coincide with the true population mean. When the true population mean is not known, as is the case with pavement data collection, the degree of agreement between the observed measurements and an accepted reference standard (ground truth) is typically used to quantify the accuracy of the measurements (*16*).

Automated data collection: Process of collecting pavement condition data by the use of imaging technologies or other sensor equipment (*6*).

Automated data processing: The reduction of pavement condition (surface distresses, such as cracking and patching, or pavement condition indices, such as IRI) from images or other sensors. The process is considered fully automated if the pavement condition (e.g., distresses) is identified and quantified through techniques that require either no or very minimal human intervention (e.g., using digital recognition software capable of recognizing and quantifying cracks on a pavement surface) (*6*).

Bias: A systematic error, constant in direction, that causes a measurement, or the mean of a distribution of measurements, to be offset from the true population mean (*16*).

Calibration: A systematic process to validate a specific measurement technique and equipment by comparing the measurements with a standard that is considered correct. This standard is commonly called "ground truth." Adjustment to the equipment or technique may be required to match the "correct" measurement.

Control site testing: The use of reference measurements on specific pavement sections (with well-defined locations) to assess the quality of a pavement condition data collection process. If the location of the session is not known to the data collection team, these are referred to as *blind control sites* or segments.

Data processing: Covers all the activities that are conducted to convert the raw data collected in the field surveys to useful information.

Ground truth: See "reference value."

Independent assurance: A management tool that requires a third party, not directly responsible for process control or acceptance, to provide an independent assessment of a product or service and/or the reliability of test results obtained from process control and acceptance testing (*16*).

Manual data collection: Pavement condition data collection through processes where people are directly involved in the observation or measurement of pavement properties without the benefit of automated equipment (e.g., visual surveys and faultmeters) (*6*).

Pavement condition: An evaluation of the degree of deterioration and/or quality of service of an existing pavement section at a particular point in time, either from an engineering or user (driver) perspective. The condition as it is perceived by the user is often referred to as functional condition. The estimated ability of the pavement to carry the load is referred to as structural condition.

Pavement condition indicator: A measure of the condition of an existing pavement section at a particular point in time. This indicator may be a specific measure of a pavement condition characteristic (e.g., smoothens or cracking severity and/or extent) or an index defined for a single distress (e.g., cracking), for multiple distresses (e.g., Pavement Condition Index), or for the overall pavement condition.

Pavement performance: The history of pavement condition indicators over time or with increasing axle load applications (*16*).

Precision: The degree of agreement among a randomly selected series of measurements of a particular characteristic (or attribute) or the degree to which tests or measurements on identical samples tend to produce the same results (*16*).

Quality: "The degree to which a set of inherent characteristics fulfill requirements" (*17*). These requirements could be features and characteristics of a product that are specified in a contract or identified and defined internally by the company/agency based on the customer expectations. The product could be a physical entity (e.g., a calculator) or a service (e.g., auto repair, or, as is the focus of this synthesis, data collection).

Quality acceptance: Those planned and systematic actions necessary to verify that the data meet the quality requirements before they are accepted and used to support pavement management decisions. These actions govern the acceptance of the pavement condition data collected using either a service provider or in-house resources. Quality acceptance is often referred to as quality assurance in the pavement engineering and management field.

Quality assurance: The part of quality management focusing on increasing the ability to fulfill requirements. It includes all those planned and systematic actions necessary to provide confidence that a product or facility will perform satisfactorily in service. Because this term is often used in practice to refer to quality acceptance activities, to avoid confusion it is not used in the remainder of the synthesis.

Quality audits: A quality audit is the process of systematic examination of a quality system carried out by an internal or external quality auditor or an audit team. It is a key element in the ISO quality system standard to verify that the institution has clearly defined internal quality monitoring procedures linked to effective action.

Quality control: Those actions and considerations necessary to assess and adjust production processes so as to control the level of quality being produced in the end product. It is also called process control. For purposes of this synthesis, quality control activities are those used to control the data collection activities, either by a data collection service provider or a road agency collecting data in-house, so that quality pavement condition data can be obtained.

Quality control plan: A document that describes the process to be followed for delivering the level of pavement condition data quality required. This plan typically includes data quality objectives (precision, accuracy, completeness, etc.), organization and responsibility, sampling procedures, equipment requirements (calibration, verification, etc.), processing of the quality control data, statistical analysis to be conducted, reporting, documentation of potential problems, and remedial solutions.

Quality management: The overarching system of policies and procedures that govern the performance of quality control and acceptance activities; that is, the totality of the effort to ensure quality in the pavement condition data.

Quality system: The organizational structure, procedures, processes, and resources needed to implement quality management to meet the quality objectives.

Reference value/ground truth: A measurement of a pavement characteristic (or attribute) that is considered to be the "correct" measurement for this characteristic.

Repeatability: The variation in measurements taken by a single piece of equipment on the same road segment(s) and under the same conditions (over a short period of time) [adapted from *Transportation Research Circular E-C037* (*16*)]. It is generally evaluated based on the standard deviation of repeated values from different measurements. Repeatability measures the ability of the equipment/technology/raters to produce the same values on repeated measurements.

Reproducibility: The ability of a technology or equipment to accurately reproduce or replicate measurements not in the same section [adapted from *Transportation Research Circular E-C037* (*16*)]. The reproducibility of pavement condition measurements is typically measured as the standard deviation of measurements taken with different equipment or using different technologies. It is a measure of how well two different devices/methods/raters are able to measure the same pavement condition value on the same road segment(s). Reproducibility relates to the agreement of test results with different operators, test devices, and/or testing conditions.

Semi-automated data processing: Process of collecting pavement condition data using imaging technologies or other sensor equipment but involving significant human input during the processing and/or recording of the data.

Time-history: A set of successive periodic measurements of pavement condition over time on the same roadway sections. This time-history can be used to determine pavement performance.

Validation: The process of verifying the soundness or effectiveness of a pavement data collection process thereby indicating official sanction.

Verification: The process of determining or testing the truth or accuracy of pavement condition data collection by examining the data and/or providing objective evidence. Verification sampling and testing may be part of an independent assurance program (to verify quality control and acceptance testing) or part of a pavement condition data collection acceptance program.

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APPENDIX A

State and Provincial Agency Survey Questionnaire

Quality Management of Pavement Data Collection

Survey Questionnaire for NCHRP Synthesis Topic 39-01

One of the most costly parts of operating a pavement management system relates to collecting network-level pavement condition information, and agencies are faced with developing procedures and guidelines for quality management of these activities. Agencies using contractor-provided services for pavement data collection have had to develop methods for contractor selection, monitoring during the contract period, and data acceptance. Agencies using staff resources for pavement data collection have had to develop similar quality control activities which include training of their staff.

The objective of this survey is to support the development of a synthesis project aimed at documenting quality management practices employed by public road and highway agencies for automated, semi-automated and network-level manual pavement condition data collection and delivery. The synthesis will document: (1) the quality management techniques used in contractor selection, monitoring, and data acceptance by agencies that outsource the data collection; (2) the quality management techniques used for operations by in-house staff including training, certification, monitoring, and data acceptance in agencies that conduct these efforts internally; and (3) how these practices have impacted the quality of the decisions made based on the data collected.

The survey consists of three types of questions: fill in the blank, chose one, and multiple choice. In the **fill in the blank** questions, please type the adequate answer. A **choose one** question allows you to choose only one response from the available response options. In the **multiple choice** questions you may mark/check more than one box as appropriate. Since the survey is "dynamic," you may notice that it skips some questions that are not relevant to your agency. For example, if you do not indicate that you are contracting some of the data collection activities, the survey will not display the questions on quality assurance of the delivered data. The survey has **persistence** if you have the *cookies allowed* option turned on in your computer; your response will be stored each time you press the *Next Page* button. Unfortunately, your stored responses will not be accessible from other computers.

If this survey would be better answered by somebody else within your office, please feel free to forward it to that individual.

DEFINITIONS: The following definitions are important to complete this survey.
Quality Assurance: All those planned and systematic actions necessary to provide confidence that a product or facility will perform satisfactorily in service. For purposes of this survey, quality assurance activities are those that govern the acceptance of the data.
Quality Control: Those actions and considerations necessary to assess and adjust production processes so as to control the level of quality being produced in the end product. It is also called process control. For purposes of this survey, quality control activities are those used to control the data collection activities, either by a data collection contractor or a road agency collecting data in-house.
Quality Management: The overarching system of policies and procedures that govern the performance of quality assurance and control activities; i.e., the totality of the effort to ensure quality in the data.

Please complete the electronic survey by **Saturday, March 15, 2008**

If you have any questions, please contact: Gerardo Flintsch, e-mail: flintsch@vt.edu, Tel: 540-231-9748.

Thank you in advance for your help and cooperation with this project

General Information

1) Please provide your contact information

Name: ______________________________
Agency: ______________________________
Current Position/Title: ______________________________
Address: ______________________________
City, State, Zip Code: ______________________________
Phone ______________________________
E-mail ______________________________

2) How long has your agency had a pavement condition data collection program?

❍ Less than 5 years
❍ Between 5 and 10 years
❍ Between 10 and 20 years
❍ More than 20 years
❍ Not sure

3) Approximately how many lane-miles of roadway is your agency responsible for?

❍ Less than 5,000 miles
❍ Between 5,000 and 10,000 miles
❍ Between 10,000 and 25,000 miles
❍ Between 25,000 and 50,000 miles
❍ More than 50,000 miles

Pavement Data Collection Practices

4) What pavement condition data does your agency collect? (Check all that apply)

	Network Level		Project Level	
	Yes	No	Yes	No
Surface Distress	❍	❍	❍	❍
Smoothness	❍	❍	❍	❍
Frictional Properties	❍	❍	❍	❍
Structural Capacity	❍	❍	❍	❍

5) Is the data collected being used to control pavement warranties, performance-based contracts, or other types of public-private partnerships (among other uses)?

❍ Yes ❍ No ❍ Not Sure

6) Does your agency use an overall pavement condition index when analyzing pavement condition? (If Yes, please name the index and list the pavement quality factors included in the "additional comments" box.)

❍ Yes ❍ No ❍ Not Sure

Additional comments:
____

7) What pavement distress data does your agency collect? (Check all that apply)

- ❑ Rutting
- ❑ Fatigue Cracking
- ❑ Longitudinal Cracking
- ❑ Transverse Cracking
- ❑ Map/Block Cracking
- ❑ Bleeding/Flushing
- ❑ Raveling
- ❑ Shattered Slab
- ❑ Faulting
- ❑ Spalling
- ❑ Durability Cracking
- ❑ Edge Cracking
- ❑ Pumping
- ❑ Punch-outs
- ❑ Other (please specify)

If you selected other please specify: ______________________________

8) What types of distress data collection methods are employed? (Check all that apply)

	Network Level		Project Level	
	Yes	No	Yes	No
Walking Survey	❍	❍	❍	❍
Windshield Survey	❍	❍	❍	❍
Automated image collection from pavement evaluation vehicles with automated distress identification	❍	❍	❍	❍
Automated image collection from pavement evaluation vehicles with manual distress identification	❍	❍	❍	❍

9) How often is <u>network-level</u> pavement distress condition data collected for the different types of roadways?

	Distress					
	More than once per year	Once a year	Every 2 to 3 years	Every 4 years or more	Varies based on previous condition	Not Sure
Rural Highway	❍	❍	❍	❍	❍	❍
Rural Arterial	❍	❍	❍	❍	❍	❍
Rural Collector/Local	❍	❍	❍	❍	❍	❍
Urban Highway	❍	❍	❍	❍	❍	❍
Urban Arterial	❍	❍	❍	❍	❍	❍
Urban Collector/Local	❍	❍	❍	❍	❍	❍

10) How often is network-level smoothness pavement condition data collected for the different types of roadways?

	Smoothness					
	More than once per year	Once a year	Every 2 to 3 years	Every 4 years or more	Varies based on previous condition	Not Sure
Rural Highway	❍	❍	❍	❍	❍	❍
Rural Arterial	❍	❍	❍	❍	❍	❍
Rural Collector/Local	❍	❍	❍	❍	❍	❍
Urban Highway	❍	❍	❍	❍	❍	❍
Urban Arterial	❍	❍	❍	❍	❍	❍
Urban Collector/Local	❍	❍	❍	❍	❍	❍

11) How often is network-level pavement friction/macrotexture condition data collected for the different types of roadways?

	Friction/Macrotexture					
	More than once per year	Once a year	Every 2 to 3 years	Every 4 years or more	Varies based on previous condition	Not Sure
Rural Highway	❍	❍	❍	❍	❍	❍
Rural Arterial	❍	❍	❍	❍	❍	❍
Rural Collector/Local	❍	❍	❍	❍	❍	❍
Urban Highway	❍	❍	❍	❍	❍	❍
Urban Arterial	❍	❍	❍	❍	❍	❍
Urban Collector/Local	❍	❍	❍	❍	❍	❍

12) How often is network-level pavement structural capacity condition data collected for the different types of roadways?

	Structural Capacity					
	More than once per year	Once a year	Every 2 to 3 years	Every 4 years or more	Varies based on previous condition	Not Sure
Rural Highway	❍	❍	❍	❍	❍	❍
Rural Arterial	❍	❍	❍	❍	❍	❍
Rural Collector/Local	❍	❍	❍	❍	❍	❍
Urban Highway	❍	❍	❍	❍	❍	❍
Urban Arterial	❍	❍	❍	❍	❍	❍
Urban Collector/Local	❍	❍	❍	❍	❍	❍

13) What type of location referencing is used to support the pavement data collection activities? (Check all that apply)

- ❑ Geographic Positioning System (GPS)
- ❑ National Differential GPS (NDGPS)
- ❑ Milepoints and milepost
- ❑ Link-node (relative references from landmarks such as bridges, intersections, and jurisdiction boundaries)
- ❑ Not sure
- ❑ Other (please specify)

If you selected other please specify:

---

14) Are you experiencing any problems with your location referencing system? (If Yes, please explain the "additional comments" box.)

❍ Yes ❍ No ❍ Not Sure

Additional comments:

---

15) Does your agency collect data for a single lane or multiple lanes? (If collecting data for a single lane causes any data issues please explain in the "additional comments" box.)

❍ Single Lane ❍ Multiple Lanes ❍ Not Sure

Additional comments:

---

16) Has your agency evaluated the option of out-sourcing pavement condition data collection?

❍ Yes ❍ No ❍ Not Sure

17) What criteria did your agency use to determine whether or not to privatize pavement condition data collection? (Check all that apply)

- ❑ Cost-effectiveness
- ❑ Scope of data collection requirements
- ❑ Availability of qualified contractors
- ❑ Capability of in-house data collection teams
- ❑ Experiences of other agencies that have out-sourced data collection
- ❑ N/A
- ❑ Other (please specify)

If you selected other please specify:

---

18) How does your agency currently collect pavement condition data? (Check all that apply)

	In-house Collection	Outsourced to a single contractor	Outsourced to multiple contractors	Not collected
Surface Distress	❑	❑	❑	❑
Smoothness	❑	❑	❑	❑
Frictional Properties	❑	❑	❑	❑
Structural Capacity	❑	❑	❑	❑

Pavement Data Quality Management

19) Does your agency have a formal pavement data collection quality management plan?

❍ Yes (If possible, please provide an upload link in the “additional comments” box)
❍ No, but there is one under development
❍ No
❍ Not sure

Additional comments:

---

20) Does your agency have a formal pavement data collection quality control plan or require the contractor to develop such a plan if the data collection has been outsourced? (If Yes, please indicate how the plan was developed.)

❑ Yes
❑ No
❑ Not sure
❑ Developed by the agency
❑ Prepared by the data collection contractor
❑ Prepared by an independent third-party
❑ Other (please specify)

If you selected other please specify:

---

21) Does your agency have a formal pavement data collection quality assurance plan? (If Yes, please indicate how the plan was developed.)

❑ Yes
❑ No
❑ Not sure
❑ Developed by the agency
❑ Prepared by an independent third-party
❑ Other (please specify)

If you selected other please specify:

---

22) If you have a pavement data collection quality assurance plan, what percentage of the data collected do you typically review in this plan?

❍ Less than 2%
❍ 2 to 5%
❍ 6 to 10%
❍ More than 10%
❍ None

23) What type of quality checks are applied to the pavement data collected as part of your quality management program? (Check all that apply)

	Quality Control		Quality Assurance	
	Yes	No	Yes	No
Calibration of equipment and/or analysis criteria before the data collection	❍	❍	❍	❍
Testing of known "control" segments before data collection	❍	❍	❍	❍
Periodic testing of known "control" segments during production	❍	❍	❍	❍
Periodic testing of blind "control" segments during production	❍	❍	❍	❍
Verification of sample data by an independent consultant	❍	❍	❍	❍
Verification of the post-survey processing software/procedures	❍	❍	❍	❍
Cross-measurements; i.e., random assignment of repeated segments to different data collection teams or automatic measuring devices	❍	❍	❍	❍
Statistical/software routines that check for inconsistencies in the data	❍	❍	❍	❍
Software routines that check if the data are within the expected ranges	❍	❍	❍	❍
Software routines that check for missing road segments or data elements	❍	❍	❍	❍
Comparison with existing time-series data	❍	❍	❍	❍

24) If you use automatic/semi-automatic equipment for distress data collection, have you experienced difficulties with matching the results of the automatic surveys with benchmark data collected manually? (If Yes, please explain in the "additional comments" box.)

❍ N/A ❍ Yes ❍ No

Additional comments:

____

25) For distress data collection, what parameters do you use to determine the accuracy of the data?

❑ Individual distresses classification, severities, and extents
❑ Overall pavement condition index
❑ Other (please specify)

If you selected other please specify:

---

26) If you use manual pavement distress surveys, approximately how many lane-miles does an average data collection team complete in a year?

---

27) Do you require a formal certification for the in-house and/or contracted distress raters? (If yes, please briefly explain the requirements in the “additional comments” box.)

❍ Yes, certification is required for both in-house and contracted personnel
❍ Yes, but for in-house personnel only
❍ Yes, but for contractor personnel only
❍ No
❍ Not sure

Additional comments:

Data Management Practices for Out-sourced Pavement Data Collection

28) Please select the type of data that are being collected by contractor(s) for the different types of roadways? (Check all that apply)

	Highway (Interstate)	Arterial (Primary)	Collector/Local (Secondary)
Surface distress	❑	❑	❑
Smoothness	❑	❑	❑
Frictional properties	❑	❑	❑
Structural capacity	❑	❑	❑

29) What type of data collection contract is in place?

❍ Lump-sum fixed price
❍ Cost per mile
❍ Performance-based
❍ Other (please specify)

If you selected other please specify:

---

30) How was the winning bidder selected?

❍ Low bid (including low bid—technically acceptable)
❍ Best value
❍ Past performance/technical ability
❍ Other (please specify)

If you selected other please specify:

____

31) How long is the contracting period?

❍ <1 year
❍ 1 year
❍ 2 years
❍ 3 years
❍ >3 years

32) Do you use the contractor quality control data as part of the quality assurance process?

❍ Yes ❍ No ❍ Not sure

33) Typically, what percentage of data must be corrected/resubmitted by the contractor?

❍ Less than 2%
❍ 2 to 5%
❍ 6 to 10%
❍ More than 10%

34) Do you have contract clauses that link payment to the quality of the collected data?

❍ Yes ❍ No ❍ Not Sure

Additional comments:

____

35) Overall, would you consider the outsourcing of pavement data collection a positive step in your pavement management practices?

❍ Yes
❍ No
❍ Not Sure

36) Overall, have you been satisfied with the performance of the data collection contractor(s) most recently or currently being used?

❍ Yes ❍ No ❍ Not Sure

Data Management Practices for In-House Pavement Data Collection

37) How do data collection personnel receive initial and ongoing training? (Check all that apply)

- ❑ On-the-job training from experienced staff
- ❑ In-house training programs
- ❑ Local colleges and universities
- ❑ Professional training programs (including professional certification programs)
- ❑ Other (please specify)

If you selected other please specify:

____

38) What is the highest average level of education for data collection personnel?

- ❍ Less than high school
- ❍ High school
- ❍ Associates degree
- ❍ Bachelor's degree
- ❍ Master's degree/ PhD

39) How many years of experience do data collection personnel have on average?

- ❍ Less than 2 years
- ❍ 2 to 5 years
- ❍ 6 to 10 years
- ❍ More than 10 years

40) Approximately how many hours per year do data collection personnel receive ongoing training?

- ❍ Less than 8 hours
- ❍ 8 to 16 hours
- ❍ 17 to 40 hours
- ❍ More than 40 hours

41) What percentage of collected data must be corrected/resurveyed?

- ❍ Less than 2%
- ❍ 2 to 5%
- ❍ 6 to 10%
- ❍ More than 10%

42) How would you rate your agency's ability to accurately collect pavement condition data?

- ❍ Excellent
- ❍ Good
- ❍ Fair
- ❍ Poor
- ❍ Not sure

Final Comments

43) Based on your experience, what factor(s) have the greatest impact on the quality of the pavement condition data?

____

____

____

44) Do you envision any changes in data collection activities over the next several years? (If Yes, please explain.)

❍ Yes ❍ No ❍ Not sure

Additional comments:

____

45) Do you have any additional comments or recommendations?

____

____

____

Please send any information and documentation that you think may be of use for this project to Gerardo Flintsch, e-mail: flintsch@vt.edu, 3500 Transportation Research Plaza, Blacksburg, VA 24061, Tel: 540-231-9748, Fax: 540-231-1555.

APPENDIX B

Service Providers Survey Questionnaire

Quality Management of Pavement Data Collection

Survey Questionnaire for NCHRP Synthesis Topic 39-01

One of the most costly parts of operating a pavement management system relates to collecting network-level pavement condition information, and agencies are faced with developing procedures and guidelines for quality management of these activities. The objective of this survey is to support the development of a synthesis project aimed at documenting quality management practices employed by public road and highway agencies for automated, semi-automated, and network-level manual pavement condition data collection and delivery.

The survey consists of three types of questions: fill in the blank, chose one, and multiple choice. In the **fill in the blank** questions, please type the adequate answer. A **choose one** question allows you to choose only one response from the available response options. In the **multiple choice** questions you may mark/check more than one box as appropriate. The survey has **persistence** if you have the *cookies allowed* option turned on in your computer; your response will be stored each time you press the *Next Page* button. Unfortunately, your stored responses will not be accessible from other computers.

If this survey would be better answered by somebody else within your company, please feel free to forward it to that individual.

DEFINITIONS: The following definitions are important to complete this survey.
Quality Assurance: All those planned and systematic actions necessary to provide confidence that a product or facility will perform satisfactorily in service. For purposes of this survey, quality assurance activities are those that govern the acceptance of the data.
Quality Control: Those actions and considerations necessary to assess and adjust production processes so as to control the level of quality being produced in the end product. It is also called process control. For purposes of this survey, quality control activities are those used to control the data collection activities.
Quality Management: The overarching system of policies and procedures that govern the performance of quality assurance and control activities; i.e., the totality of the effort to ensure quality in the data.

Please complete the electronic survey by **cob Monday, April 15, 2008**

If you have any questions, please contact: Gerardo Flintsch, e-mail: flintsch@vt.edu, Tel: 540-231-9748.

Thank you in advance for your help and cooperation with this project

General Information

1) Please provide your contact information

Name: ______________________
Company: ______________________
Current Position/Title: ______________________
Address: ______________________
City, State, Zip Code: ______________________
Phone: ______________________
E-mail: ______________________

2) Does your company provide pavement condition data collection services?

❍ Yes
❍ No

Types of Pavement Condition Data Collected

3) How long has your company been in the business of pavement condition data collection?

❍ Less than 5 years
❍ Between 5 and 10 years
❍ Between 10 and 20 years
❍ More than 20 years
❍ Not sure

4) What pavement condition data does your company collect? (Check all that apply)

	Yes	No
Surface Distress	❍	❍
Smoothness	❍	❍
Frictional Properties	❍	❍
Structural Capacity	❍	❍

5) If you collect pavement distress data, what types of distress data collection methods do you employ? (Check all that apply)

❑ N/A
❑ Automated image collection from pavement evaluation vehicles with automated distress identification
❑ Automated image collection from pavement evaluation vehicles with manual distress identification
❑ Walking Survey
❑ Windshield Survey

Pavement Data Quality Management Procedures

6) Does your company have a formal pavement data collection quality management plan?

❍ Yes (If possible, please provide an upload link in the “additional comments” box)
❍ No, but there is one under development
❍ No
❍ Not sure

Additional comments:

---

7) Does your company have a formal pavement data collection quality control procedure? (If Yes, please indicate how the plan was developed.)

❑ Yes
❑ No
❑ Not sure
❑ Prepared by us (data collection contractor)
❑ Prepared by an independent third-party
❑ Other (please specify)

If you selected other please specify:

---

8) If you have a formal pavement data collection quality control procedure, what percentage of the data collected do you typically review as part of this procedure?

❍ Less than 2%
❍ 2 to 5%
❍ 6 to 10%
❍ More than 10%
❍ None

9) What type of quality checks are applied to the pavement data collected as part of your quality control program? (Check all that apply)

	Yes	No
Calibration of equipment and/or analysis criteria before the data collection	❍	❍
Testing of known “control” segments before data collection	❍	❍
Periodic testing of known “control” segments during production	❍	❍
Periodic testing of blind “control” segments during production	❍	❍
Verification of sample data by an independent consultant	❍	❍
Verification of the post-survey processing software/procedures	❍	❍
Cross-measurements; i.e., random assignment of repeated segments to different data collection teams or automatic measuring devices	❍	❍
Statistical/software routines that check for inconsistencies in the data	❍	❍
Software routines that check if the data is within the expected ranges	❍	❍
Software routines that check for missing road segments or data elements	❍	❍
Comparison with existing time-series data	❍	❍

10) On average, what percentage of collected data must be corrected/resurveyed?

❍ Less than 2%
❍ 2 to 5%
❍ 6 to 10%
❍ More than 10%

11) If you use automatic/semi-automatic equipment for distress data collection, have you experienced difficulties with matching the results of the automatic surveys with benchmark data collected manually? (If Yes, please explain in the "additional comments" box.)

❍ N/A
❍ Yes
❍ No

Additional comments:

____

Pavement Data Collection Personnel Education and Training

12) Do you require a formal certification for the distress raters? (If yes, please briefly explain the requirements in the "additional comments" box.)

❍ Yes
❍ No
❍ Not sure

Additional comments:

____

13) How do data collection personnel receive initial and ongoing training? (Check all that apply)

❑ On-the-job training from experienced staff
❑ In-house training programs
❑ Local colleges and universities
❑ Professional training programs (including professional certification programs)
❑ Other (please specify)

If you selected other please specify:

____

14) What is the highest average level of education for data collection personnel?

❍ Less than high school
❍ High school
❍ Associates degree
❍ Bachelor's degree
❍ Master's degree/ PhD

15) How many years of experience do data collection personnel have on average?

❍ Less than 2 years
❍ 2 to 5 years
❍ 6 to 10 years
❍ More than 10 years

16) Approximately how many hours per year do data collection personnel receive ongoing training?

❍ Less than 8 hours
❍ 8 to 16 hours
❍ 17 to 40 hours
❍ More than 40 hours

Final Comments

17) Based on your experience, what factor(s) have the greatest impact on the quality of the pavement condition data?

____
____
____

18) Do you envision any changes in data collection activities over the next several years? (If Yes, please explain.)

❍ Yes
❍ No
❍ Not sure

Additional comments: ______________________________

19) Do you have any additional comments or recommendations?

____
____
____

Thanks for completing the survey!

Please send any information and documentation that you think may be of use for this project to Gerardo Flintsch, e-mail: flintsch@vt.edu, 3500 Transportation Research Plaza, Blacksburg, VA 24061, Tel: 540-231-9748, Fax: 540-231-1555.

APPENDIX C

Tabular Results of the State and Provincial Agency Survey

Agency	2. How long has your agency had a pavement condition data collection program?	3. Approximately how many lane-miles of roadway is your agency responsible for?	4. What pavement condition data does your agency collect? (check all that apply)							
			Network Level				Project Level			
			Surface Distress	Smoothness	Frictional Properties	Structural Capacity	Surface Distress	Smoothness	Frictional Properties	Structural Capacity
1	10 - 20 yr.	25,000 - 50,000 mi.	Yes	Yes	Yes	No	No	No	No	Yes
2	> 20 yr.	10,000 - 25,000 mi.	Yes	Yes	No	No	Yes	Yes	Yes	Yes
3	10 - 20 yr.	10,000 - 25,000 mi.	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
4	10 - 20 yr.	5,000 - 10,000 mi.	Yes	Yes	No	No	No	Yes	No	No
5	> 20 yr.	25,000 - 50,000 mi.	Yes	Yes	No	No	Yes	Yes	Yes	Yes
6	10 - 20 yr.	10,000 - 25,000 mi.	Yes	Yes	Yes	No	No	Yes	Yes	Yes
7	> 20 yr.	> 50,000 mi.	Yes	Yes	No	No	No	No	Yes	Yes
8	> 20 yr.	10,000 - 25,000 mi.	Yes	Yes	No	No	Yes	Yes	Yes	Yes
9	> 20 yr.	25,000 - 50,000 mi.	Yes	Yes	Yes	Yes	No	Yes	Yes	No
10	> 20 yr.	25,000 - 50,000 mi.	Yes	Yes	No	No	Yes	Yes	Yes	Yes
11	> 20 yr.	10,000 - 25,000 mi.	Yes	Yes	Yes	No	Yes	No	No	Yes
12	10 - 20 yr.	10,000 - 25,000 mi.	Yes	Yes	No	No	No	No	No	No
13	> 20 yr.	Less than 5,000 miles	Yes	Yes	No	No	Yes	No	Yes	Yes
14	> 20 yr.	> 50,000 mi.	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
15	> 20 yr.	25,000 - 50,000 mi.	Yes	Yes	No	No	Yes	Yes	Yes	Yes
16	10 - 20 yr.	Less than 5,000 miles	Yes	Yes	No	No	No	No	Yes	Yes
17	5 - 10 yr.	10,000 - 25,000 mi.	Yes	Yes	No	Yes	Yes	Yes	No	Yes
18	> 20 yr.	10,000 - 25,000 mi.	Yes	Yes	Yes	No	Yes	Yes	No	Yes
19	> 20 yr.	5,000 - 10,000 mi.	Yes	Yes	No	Yes	No	Yes	No	Yes
20	10 - 20 yr.	5,000 - 10,000 mi.	Yes	Yes	No	No	Yes	Yes	No	No
21	10 - 20 yr.	25,000 - 50,000 mi.	Yes	Yes	No	Yes	Yes	Yes	No	Yes
22	5 - 10 yr.	25,000 - 50,000 mi.	Yes	Yes	Yes	No	No	No	No	No
23	> 20 yr.	> 50,000 mi.	Yes	Yes	No	No	Yes	Yes	Yes	No
24	10 - 20 yr.	> 50,000 mi.	Yes	Yes	No	No	Yes	Yes	Yes	Yes
25	10 - 20 yr.	Less than 5,000 miles	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
26	> 20 yr.	10,000 - 25,000 mi.	Yes	Yes	Yes	No	No	No	No	Yes
27	5 - 10 yr.	10,000 - 25,000 mi.	Yes	No	No	No	No	Yes	No	No
28	5 - 10 yr.	> 50,000 mi.	Yes	Yes	No	No	No	No	Yes	Yes
29	> 20 yr.	25,000 - 50,000 mi.	Yes	Yes	Yes	No	Yes	No	Yes	Yes
30	> 20 yr.	5,000 - 10,000 mi.	Yes	No	No	Yes	No	No	No	Yes
31	10 - 20 yr.	Less than 5,000 miles	Yes	Yes	No	Yes	Yes	Yes	No	Yes
32	> 20 yr.	10,000 - 25,000 mi.	Yes	Yes	Yes	Yes	No	No	No	Yes
33	> 20 yr.	10,000 - 25,000 mi.	Yes	Yes	No	No	Yes	Yes	Yes	Yes
34	> 20 yr.	10,000 - 25,000 mi.	Yes	Yes	No	No	No	No	Yes	Yes
35	10 - 20 yr.	10,000 - 25,000 mi.	Yes	Yes	No	No	Yes	Yes	No	No
36	> 20 yr.	Less than 5,000 miles	Yes	Yes	No	No	Yes	Yes	Yes	No
37	10 - 20 yr.	25,000 - 50,000 mi.	No	Yes	Yes	No	Yes	Yes	Yes	Yes
38	> 20 yr.	> 50,000 mi.	Yes	Yes	No	No	Yes	Yes	Yes	Yes
39	> 20 yr.	> 50,000 mi.	Yes	Yes	Yes	No	Yes	No	No	Yes
40	10 - 20 yr.	10,000 - 25,000 mi.	Yes	Yes	No	Yes	Yes	Yes	No	Yes
41	10 - 20 yr.	> 50,000 mi.	Yes	Yes	No	No	No	No	Yes	Yes
42	10 - 20 yr.	> 50,000 mi.	Yes	Yes	No	No	No	No	No	No
43	> 20 yr.	5,000 - 10,000 mi.	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
44	> 20 yr.	10,000 - 25,000 mi.	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
45	10 - 20 yr.	10,000 - 25,000 mi.	Yes	Yes	No	No	No	Yes	No	No
46	> 20 yr.	25,000 - 50,000 mi.	Yes	Yes	No	No	Yes	Yes	Yes	No
47	10 - 20 yr.	5,000 - 10,000 mi.	Yes	Yes	No	No	Yes	Yes	No	Yes
48	5 - 10 yr.	10,000 - 25,000 mi.	Yes	Yes	No	No	No	No	No	No
49	10 - 20 yr.	25,000 - 50,000 mi.	Yes	Yes	No	No	Yes	Yes	Yes	Yes
50	10 - 20 yr.	25,000 - 50,000 mi.	Yes	Yes	No	No	No	Yes	Yes	Yes
51	> 20 yr.	> 50,000 mi.	Yes	Yes	Yes	No	Yes	No	No	No
52	10 - 20 yr.	> 50,000 mi.	Yes	Yes	No	No	Yes	Yes	Yes	Yes
53	> 20 yr.	25,000 - 50,000 mi.	Yes	Yes	No	No	Yes	Yes	No	No
54	> 20 yr.	> 50,000 mi.	Yes	Yes	No	No	No	No	Yes	Yes
55	10 - 20 yr.	25,000 - 50,000 mi.	Yes	Yes	Yes	No	No	Yes	Yes	Yes

Agency	5. Is the data collected being used to control pavement warranties, performance-based contracts, or other types of public-private partnerships ?	6. Does your agency use an overall pavement condition index when analyzing pavement condition?	Please name the index and list the pavement quality factors
1	No	Yes	PQI - Pavement Quality Index (developed in house)
2	Yes	Yes	PCI (Pavement Condition Index) is based on the combined effect of aggregated pavement distresses and pavement roughness(IRI)
3	Yes	Yes	Overall Condition Index
4	Yes	Yes	Pavement Serviceability Rating (PSR) which is a 0-5 scale. This may change this year to a 0-100 scale and/or we switch to RSL.
5	Yes	Yes	Pavement Quality Index = Sqrt(Ride Quality Index x Surface Rating). RQI is calculated from the IRI. SR is our distress index.
6	No	Yes	An Overall Condition Index is used for optimizing overall system condition in the modeling. This is a simple average of the seperate condition Index's used (Ride; Rut; Environmental Cracking; Fatigue Cracking)
7	Yes	Yes	Overall Pavement Index (OPI) is used to a limited extent. It is an amalgam of several individual condition values.
8	Yes	Yes	Nebraska Serviceability Index - cracking;rutting;faulting;
9	Yes	No	Individual Ratings for Crack Rut Ride
10	No	Yes	Pavement Serviceability Index (PSI) calculated using 60% Roughness and 40% Weighted Distress
11	No	Yes	Distress State: Smoothness; Transverse Cracking; Rutting; Joint Distress; Faulting
12	No	Yes	
13	No	Yes	agency-modified PCI; ASTM D6433
14	Yes	Yes	Condition Score - Distress; Ride; ADT; Speed Limit
15	Yes	No	We are about to implemement a Pavement Condition Index (PCI) that includes surface distress; IRI; rut; fault.
16	No	Yes	COMB index.
17	No	Yes	Condition State; Ride (G;P); Cracking (G;F;P); Rut (G;P) = (2x3x2)= 12 Condition States; 1 through 12
18	No	Yes	The index; Rate; includes cracking;rutting;IRI and a three year average of maintenance costs
19	No	No	
20	No	Yes	Our index is named PCI; for pavement condition index. Factors included are ravelling; bleeding; rippling; distortions; several types of cracking and ride score.
21	Yes	Yes	Pavement Quality Index - combines IRI and surface distress
22	Not Sure	Yes	Pavement Quality Index (PQI) - the range is 0-5 and is calculated from IRI; rutting; and distress measurements
23	Yes	Yes	We use a composite score which includes Fatigue Cracking; Other Cracking; Raveling; Patching; Appearance; IRI and Rutting.
24	Yes	Yes	PCR - Sqrt PDI x Sqrt RCI - see BCMoT Pavement Surface Condition Rating Manual. (currently being updated - copy available at: http://www.th.gov.bc.ca/publications/const_maint/2002_Pavement_Surface_Condition_Rating_Manual_V2.pdf
25	Yes	No	
26	No	Yes	Overall Condition Index = f(rutting; cracking; patching; other)
27	Not Sure	Yes	
28	No	Yes	
29	No	Yes	The original PMS used a composite index that was developed by incorporating manual surveys. Currently; we are trying to develop a new composite index based on automated distress surveys. We anticipate that the index will... see No. 45
30	No	No	Only SDI - Surface Condition Index
31	No	Yes	Smoothness and drivability at the posted speed limits - Ride Comfort Rating (RCR). Ohysical performance of the surfacing material - Pavement Condition Rating (PCR).
32	Yes	Yes	Overall Performance Index (OPI) IRI; Rut; Fatigue Cracking; Thermal Cracking Raveling; Block Cracking
33	Yes	Yes	PSR - IRI; cracking; patching
34	Yes	Yes	Distress Index; includes all items checked in question #7
35	No	No	Use 8 condition states based on good/ poor thresholds for 3 surface distresses.
36	No	Yes	
37	No	No	
38	Yes	Yes	Pavement Condition Rating (PCR)
39	Yes	Yes	Pavement Condition Rating based on % and severity of cracking; % patching; presence of bleeding and ravelling
40	Yes	Yes	PCR - Pavement Condition Rating
41	Yes	Yes	Composite Condition Index
42	No	Yes	PQI (composite of PDI and PSI)
43	No	No	
44	Yes	No	
45	Yes	Yes	Remaining Service Life; Pavement Serviceability Rating
46	Yes	Yes	Condition Rating Survey (CRS) - 1.0 (failed) to 9.0 (new) scale; based on surface distress; IRI; rutting
47	No	Yes	Composite Condition Index used for reporting only. Composite Index is a combination of four distress indices (Roughness; Rutting; Structural Cracking; Transverse Cracking).
48	No	Yes	RSL from smoothness; rutting; and cracking
49	Yes	Yes	0-100 Scale - combination of IRI; rut; distress
50	Yes	Yes	Pavement Quality Index - Roughness; Rut; Distress
51	No	Yes	PACES Rating
52	Yes	Yes	we have a combined index (PSR) but also evaluate the individual comnponents of roughness; cracking; rutting; etc.
53	Yes	Yes	Acceptable range of distress values based on history; and randomly selected checks on completed surveys.
54	No	No	
55	Not Sure	Yes	To a certain extent: Remaining service life (RSL) as overall indicator of health

Agency	7. What pavement distress data does your agency collect? (check all that apply) :														
	Rutting	Fatigue Cracking	Longitudinal Cracking	Transverse Cracking	Map/ Block Cracking	Bleeding/ Flushing	Raveling	Shattered Slab	Faulting	Spalling	Durability Cracking	Edge Cracking	Pumping	Punch-outs	Other
1	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	No	No	Yes	Yes
2	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes
3	Yes	No	Yes	Yes	No	No	No	No	No	No	No	No	No	No	No
4	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	Yes	No	No	No
5	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	No	No	Yes	Yes
6	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	Yes
7	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	No	No	No
8	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	No
9	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	No
10	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	No	No	Yes
11	Yes	Yes	No	Yes	Yes	No	No	No	Yes	No	Yes	No	No	No	No
12	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	No	Yes	No
13	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	No	No	No	No	No	Yes
14	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	No	Yes	Yes
15	Yes	Yes	No	No	No	No	No	No	Yes	Yes	No	No	No	No	Yes
16	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	Yes	No	No	Yes
17	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes	No	No	Yes
18	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes	No	No	Yes
19	Yes	No	Yes	Yes	No	Yes	Yes	No	No	No	No	Yes	No	No	No
20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	Yes	Yes	Yes	No
21	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No
22	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	No	No	No	No	No	No
23	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	No	Yes	No	No	No
24	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	Yes	No	Yes	No
25	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes	No	Yes
26	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	Yes	No
27	Yes	Yes	No	Yes	Yes	Yes	No	No	No	No	No	Yes	No	No	Yes
28	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	No	Yes	No
29	Yes	No	No	Yes	No	No	Yes	No	Yes	No	No	No	No	No	Yes
30	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No
31	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	No
32	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	No	No	No	No	No
33	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	No	No	No	No
34	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	No	No	No
35	Yes	No	No	No	No	No	No	No	No	No	No	No	No	No	Yes
36	Yes	No	Yes	Yes	No	No	No	No	No	No	No	No	No	No	Yes
37	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No
38	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
39	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No
40	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No	No
41	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	No	No	Yes	No	No	No
42	Yes	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes	No	No	Yes	Yes	No
43	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	No	No	No	No
44	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No
45	Yes	Yes	No	No	No	No	No	No	No	No	No	No	No	No	No
46	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes
47	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No
48	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No	Yes
49	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No
50	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	No	Yes	No	No	No
51	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No
52	Yes	No	No	No	No	No	Yes	No	No	Yes	No	No	No	No	Yes
53	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
54	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	No
55	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No

Agency	8. What types of distress data collection methods are employed? (check all that apply)							
	Network level				Project Level			
	Walking Survey	Windshield Survey	Automated	Semi-Automated	Walking Survey	Windshield Survey	Automated	Semi-Automated
1	No	No	No	Yes	No	No	No	No
2	No	Yes	No	No	Yes	Yes	Yes	Yes
3	No	No	Yes	No	Yes	Yes	No	No
4	No	Yes	No	No	No	Yes	No	No
5	No	No	No	Yes	No	No	No	Yes
6	Yes							
7	No	No	Yes	Yes	No	No	No	No
8		Yes		Yes	Yes	Yes		
9	Yes	Yes	No	No	No	No	No	Yes
10	Yes	No	No	No	Yes	No	No	No
11		Yes	No	No	Yes	Yes	No	No
12				Yes				
13		Yes	No	Yes	Yes	No	No	No
14	Yes	Yes	No	No				
15	No	Yes	No	No	Yes	No	No	No
16	No	No	No	Yes	Yes	No	No	No
17	Yes	Yes	No	No	Yes	Yes	No	No
18	Yes				Yes			
19	No	Yes	No	No	No	Yes	No	No
20	No	Yes	No	No	No	Yes	No	No
21	Yes	Yes	No	No	Yes	No	No	No
22	No	No	No	Yes	No	No	No	No
23	No	Yes	No	No	No	Yes	No	No
24	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
25	No	No	No	Yes	Yes	Yes	No	Yes
26		Yes	No	No	Yes			
27	No	Yes	No	No	No	No	No	No
28	No	No	Yes	No	No	No	No	No
29			No	Yes	Yes	Yes	No	No
30	No	Yes	No	No	No	No	No	No
31	Yes	Yes	No	No	Yes	Yes	No	No
32	Yes	No	No	No	No	No	No	No
33	Yes	No	No	No	Yes	Yes	No	No
34	No	No	No	Yes	Yes	No	No	No
35	No	No	Yes	No	No	No	No	No
36			Yes	No	Yes	Yes	Yes	No
37		Yes	No	Yes	Yes	No	No	No
38	Yes	Yes	No	No	Yes	Yes	No	No
39	Yes	Yes	No	No	Yes	No	No	No
40	No	No	Yes	No	No	No	No	No
41	No	No	Yes	Yes	Yes	No	Yes	No
42		Yes	Yes	Yes	No	No	No	No
43	No	Yes	No	Yes	Yes	Yes	Yes	Yes
44	No	No	No	Yes	No	No	No	Yes
45	No	Yes	No	No	No	No	No	No
46	No	No	No	Yes	No	Yes	No	Yes
47	No	No	Yes	No	No	No	No	No
48	No	No	Yes	Yes	No	No	No	No
49	No	No	No	Yes	No	No	No	Yes
50	No	No	No	Yes	Yes	Yes	No	No
51	Yes	Yes	No	No	Yes	No	No	No
52	No	No	No	Yes	Yes	Yes	No	Yes
53				Yes				Yes
54	Yes	Yes	No	No	Yes	Yes	No	No
55		Yes	No	Yes				

Agency	9-10. How often is network-level pavement distress condition data collected for the different types of roadways?											
	Distress						Smootheness					
	Rural			Urban Highway			Rural			Urban Highway		
	Highway	Arterial	Collector/ Local	Highway	Arterial	Collector/ Local	Highway	Arterial	Collector/ Local	Highway	Arterial	Collector/ Local
1	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.
2	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.
3	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.
4	Once/yr.	2-3 yrs.	2-3 yrs.	Once/yr.	2-3 yrs.	2-3 yrs.	Once/yr.	2-3 yrs.	2-3 yrs.	Once/yr.	2-3 yrs.	2-3 yrs.
5	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.
6	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.
7	Once/yr.	Once/yr.	2-3 yrs.	Once/yr.	Once/yr.	2-3 yrs.	Once/yr.	Once/yr.	2-3 yrs.	Once/yr.	Once/yr.	2-3 yrs.
8	Once/yr.	Not Sure	Not Sure	Once/yr.	Not Sure	Not Sure	Once/yr.			Once/yr.		
9	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.
10	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	2-3 yrs.	2-3 yrs.	Once/yr.	2-3 yrs.	2-3 yrs.
11	Once/yr.	Not Sure	Not Sure	Once/yr.	Not Sure	Not Sure	Once/yr.	Not Sure	Not Sure	Once/yr.	Not Sure	Not Sure
12	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.
13	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.
14	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.
15	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	2-3 yrs.	2-3 yrs.	Once/yr.	2-3 yrs.	2-3 yrs.
16	2-3 yrs.	2-3 yrs.	Not Sure	2-3 yrs.	2-3 yrs.	Not Sure	2-3 yrs.	2-3 yrs.	Not Sure	2-3 yrs.	2-3 yrs.	Not Sure
17	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.
18	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.
19	≥ 4 yrs.	≥ 4 yrs.	≥ 4 yrs.	≥ 4 yrs.			2-3 yrs.	2-3 yrs.	Varies*	2-3 yrs.		
20	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.
21	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	Not Sure	Not Sure	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Not Sure	Not Sure
22	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.
23	≥ 4 yrs.	≥ 4 yrs.	≥ 4 yrs.	2-3 yrs.	2-3 yrs.	≥ 4 yrs.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.
24	2-3 yrs.	2-3 yrs.	≥ 4 yrs.	2-3 yrs.	2-3 yrs.	≥ 4 yrs.	2-3 yrs.	2-3 yrs.	≥ 4 yrs.	2-3 yrs.	2-3 yrs.	≥ 4 yrs.
25	Not Sure	Not Sure	Not Sure	Not Sure	Not Sure	Not Sure	Not Sure	Not Sure	Not Sure	Not Sure	Not Sure	Not Sure
26	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.
27	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.						
28	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.
29	2-3 yrs.	2-3 yrs.		2-3 yrs.	2-3 yrs.		2-3 yrs.	2-3 yrs.		2-3 yrs.	2-3 yrs.	
30	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.						
31		> once/yr.	> once/yr.					> once/yr.	> once/yr.			
32	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.
33	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	Once/yr.	2-3 yrs.	2-3 yrs.	Once/yr.	2-3 yrs.	2-3 yrs.
34	Once/yr.	Once/yr.	Not Sure	Once/yr.	Once/yr.	Not Sure	Once/yr.	Once/yr.	Not Sure	Once/yr.	Once/yr.	Not Sure
35	Once/yr.	Not Sure	Not Sure	Once/yr.	Not Sure	Not Sure	Once/yr.	Not Sure	Not Sure	Once/yr.	Not Sure	Not Sure
36	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.
37							2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.
38	Once/yr.	Once/yr.	2-3 yrs.	Once/yr.	Once/yr.	2-3 yrs.	Once/yr.	2-3 yrs.		Once/yr.	2-3 yrs.	
39	Once/yr.	2-3 yrs.	2-3 yrs.	Once/yr.	2-3 yrs.	2-3 yrs.	Once/yr.	2-3 yrs.	2-3 yrs.	Once/yr.	2-3 yrs.	2-3 yrs.
40	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.
41	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.
42	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.
43	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.
44	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.
45	Once/yr.	2-3 yrs.	2-3 yrs.	Once/yr.	2-3 yrs.	2-3 yrs.	Once/yr.	2-3 yrs.	2-3 yrs.	Once/yr.	2-3 yrs.	2-3 yrs.
46	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.
47	2-3 yrs.	2-3 yrs.	Not Sure	2-3 yrs.	2-3 yrs.	Not Sure	2-3 yrs.	2-3 yrs.	≥ 4 yrs.	2-3 yrs.	2-3 yrs.	≥ 4 yrs.
48	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.
49	Not Sure	Not Sure	Not Sure	Not Sure	Not Sure	Not Sure	Not Sure	Not Sure	Not Sure	Not Sure	Not Sure	Not Sure
50	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.
51	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Not Sure	Not Sure	Not Sure	Not Sure	Not Sure	Not Sure
52	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.
53	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.
54	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.
55	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.

Agency	11-12. How often is network-level pavement distress condition data collected for the different types of roadways?											
	Friction/Macrotexture						Structural Capacity					
	Rural			Urban Highway			Rural			Urban Highway		
	Highway	Arterial	Collector/ Local	Highway	Arterial	Collector/ Local	Highway	Arterial	Collector/ Local	Highway	Arterial	Collector/ Local
1	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.						
2												
3	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.						
4												
5												
6	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.						
7												
8												
9	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	Not Sure	Not Sure	Not Sure	Not Sure	Not Sure	Not Sure
10												
11	2-3 yrs.	Not Sure	Not Sure	2-3 yrs.	Not Sure	Not Sure						
12												
13												
14	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	Varies*	Varies*	Varies*	Varies*	Varies*	Varies*
15												
16												
17							2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.
18	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.						
19							Varies*	Varies*	Varies*			
20												
21							≥ 4 yrs.	≥ 4 yrs.	≥ 4 yrs.	≥ 4 yrs.	Not Sure	Not Sure
22	Not Sure	Not Sure	Not Sure	Not Sure	Not Sure	Not Sure						
23												
24												
25	Not Sure	Not Sure	Not Sure	Not Sure	Not Sure	Not Sure						
26	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.						
27												
28												
29	2-3 yrs.	2-3 yrs.		2-3 yrs.	2-3 yrs.							
30							Not Sure	Once/yr.	Not Sure	Not Sure	Once/yr.	Not Sure
31								2-3 yrs.	2-3 yrs.			
32	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.
33												
34												
35												
36												
37	≥ 4 yrs.	≥ 4 yrs.	≥ 4 yrs.	≥ 4 yrs.	≥ 4 yrs.	≥ 4 yrs.						
38												
39	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.						
40							Not Sure	Not Sure	Not Sure	Not Sure	Not Sure	Not Sure
41												
42												
43	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.						
44	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.	Once/yr.						
45												
46												
47												
48												
49												
50												
51	≥ 4 yrs.	≥ 4 yrs.	≥ 4 yrs.	≥ 4 yrs.	≥ 4 yrs.	≥ 4 yrs.						
52												
53												
54												
55	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.	2-3 yrs.						

13. What type of location referencing is used to support the pavement data collection activities?							14. Are you experiencing any problems with your location referencing system? (If Yes; please explain the "additional comments" box)	
Geographic Positioning System (GPS)	**National Differential GPS (NDGPS)**	**Milepoints and milepost**	**Link-node**	**Not Sure**	**Other**	**Comments**		
No	Yes	Yes	No	No	No		Yes	Vendor doesn't always start in correct location
Yes	No	No	Yes	No	No		No	
No	No	Yes	No	No	No		No	
No	No	Yes	Yes	No	No		Yes	Planning is constantly updating
Yes	No	Yes	No	No	No		No	
No	No	Yes	No	No	No		Yes	It's an issue every year matching up history with route changes
No	No	Yes	Yes	No	Yes	all roads divided into segments; 1/2 mile long; and all uniquely identified	No	
No	No	Yes	No	No	No		No	
No	No	Yes	No	No	No		No	
No	No	Yes	No	No	No		No	
Yes	No	Yes	No	No	No		No	
Yes	No	No	No	No	Yes	Control section logmile	Yes	the department uses different LRS; difficult to access other data
No	No	Yes	Yes	No	No		No	
Yes	No	Yes	No	No	No		Yes	Tying GPS coordinate to actual lane or roadbed; instead of just some x-y point on the ground
Yes	No	Yes	No	No	No		Yes	Transitioning to new database system and transferred milepoints did not always match original; therefore creating many very short (0.01 mile) segments.
No	No	Yes	No	No	No		No	
No	No	Yes	No	No	No		No	
Yes	No	Yes	No	No	No		No	
Yes	No	Yes	Yes	No	No		No	
No	No	Yes	No	No	No		Yes	highway reconstruction over years changes the length of road
Yes	No	Yes	No	No	Yes	Numbered control sections long highways	No	
No	No	Yes	No	No	No		Yes	Only when a route is rebuilt or realigned and it affects the log mile to some extent.
No	No	Yes	Yes	No	No		No	There is a problem in that milepoints for routes will change as more accurate measuring techniques are used. This causes our data to shift and it is hard to keep track of.
Yes	No	Yes	Yes	No	No		Yes	Can be a challenge reconciling different years data collection...
Yes	Yes	Yes	Yes	No	No		No	
No	No	Yes	No	No	No		No	
No	No	Yes	Yes	No	No		Yes	As roads are being inventored again; realignments and other changes are changing the inventory milepoints and descriptions. This causes some confusion with our historical pavement condition data.
Yes	No	Yes	No	No	No		No	
Yes	No	Yes	No	No	No		Yes	Tracking changes to the LRS due to route re-alignment is sometimes difficult. Especially when the Division offices make changes that do not follow the established rules.
No	No	No	No	No	Yes	By "Route"by"Control Section"within the route and by meter chainage	No	
No	No	Yes	No	No	No		No	
Yes	No	Yes	No	No	No		Yes	Current department roadlog is not GIS compliant
No	No	No	Yes	No	No		Yes	Our naming convention is not standardized between divisions. We are currently working on the problem.
No	No	Yes	No	No	No		No	
Yes	No	No	No	No	Yes	DMI - Distance Measuring Instrument	Yes	We collect GPS information as part of our data collection program; however; we are in the process of spatially referencing our road network. Addtionally; the DMI does not account for changes in elevation in the 'z' coordinate.
Yes	No	Yes	No	No	No		No	
Yes	No	Yes	Yes	No	No		No	
No	No	Yes	No	No	No		Yes	Boundary changes; section length changes
No	No	No	Yes	No	No		Yes	Must coordinate closely with GIS regarding changes (additions/deletions; etc)
No	No	No	No	No	Yes	Route Log Mile	No	
Yes	No	Yes	No	No	No		Not Sure	
Yes	Yes	Yes	No	No	No		No	
Yes	No	Yes	No	No	No		Yes	Mileposts do not always match GPS distances
No	No	Yes	No	No	No		No	
Yes	Yes	Yes	No	No	No		Yes	Changing LRS Definitions; Variations in DMI Year to Year and between equipment types
No	No	Yes	Yes	No	Yes	key routes and key route stationing	No	
No	No	Yes	Yes	No	No		No	
No	No	Yes	No	No	No		No	
Yes	No	Yes	No	No	No		Yes	Hard to coordinate with other divisions; outdated software.
Yes	No	No	No	No	Yes	Reference Post	Not Sure	
No	No	Yes	No	No	No		No	
Yes	No	Yes	No	No	No		No	
Yes	No	Yes	Yes	No	No		Yes	Changes in location and distance occur outside of the Pavement Management functional area.
No	No	Yes	No	No	No		No	
Yes	No	Yes	No	No	No		Yes	Issues with legacy information as we migrate to a newer system of referencing

Agency	15. Does your agency collect data for a single lane or multiple lanes? (If collecting data for a single lane causes any data issues please explain in the "additional comments" box)	
1	Single Lane	
2	Single Lane	On divided highways; the survey is done in both directions
3	Single Lane	
4	Multiple Lanes	Multiple lanes on Interstates only. Single lane for all other roads.
5	Multiple Lanes	
6	Single Lane	
7	Single Lane	
8	Single Lane	
9	Single Lane	
10	Single Lane	
11	Single Lane	
12	Single Lane	
13	Multiple Lanes	
14	Single Lane	Single lane per roadbed on divided highways
15	Multiple Lanes	Windshield distress survey includes all lanes; IRI survey is in right hand travel lane only.
16	Multiple Lanes	Right travel lane in both directions.
17	Single Lane	
18	Single Lane	
19	Multiple Lanes	
20		
21	Multiple Lanes	except for IRI which is on single lane
22	Single Lane	
23	Single Lane	
24	Single Lane	multiple lanes for some project evaluations
25	Single Lane	Also multiple lanes depending the equipment used.
26	Single Lane	
27	Multiple Lanes	
28	Single Lane	
29	Single Lane	Collect data in the primary direction on two lane roads. Collect data in the outside lane in both directions on four lane roads. One issue with not collecting all lanes is cross-slope data has little meaning without adjoining lanes.
30	Multiple Lanes	
31	Single Lane	
32	Multiple Lanes	
33	Single Lane	
34	Single Lane	
35	Single Lane	Data is collected for multiple lanes on our 4 lane highway network.
36	Single Lane	
37	Single Lane	Outside lane in both directions on multi-lane facilities
38	Single Lane	We collect the worst lane for a given logpoint
39	Multiple Lanes	
40	Single Lane	
41	Multiple Lanes	Multiple for divided highway only
42	Multiple Lanes	
43	Single Lane	
44	Single Lane	
45	Single Lane	Potential to misrepresent conditions of unsurveyed lanes; comparison of year to year could be off somewhat
46	Single Lane	
47	Multiple Lanes	
48	Single Lane	
49	Single Lane	
50	Single Lane	
51	Single Lane	
52	Single Lane	In general we collect only the "right most continuous through lane"; however; should time permit we do run additional lanes in urban areas where there are different adjacent pavement types
53	Single Lane	Distress in adjacent lanes often differs.
54	Multiple Lanes	
55	Single Lane	

Agency	16. Has your agency evaluated the option of out-sourcing pavement condition data collection?	17. What criteria did your agency use to determine whether or not to privatize pavement condition data collection?							
		Cost-effectiveness	Scope of data collection requirements	Availability of qualified contractors	Capability of in-house data collection	Experiences of other agencies that have out-sourced data collection	N/A	Other	Description
1	Yes	Yes	Yes	Yes	Yes	Yes	No	No	
2	Yes	No	No	Yes	Yes	No	No	Yes	To ensure guaranteed data acquisition
3	No	No	No	No	No	No	No	No	
4	Yes	Yes	No	No	Yes	Yes	No	Yes	Quality of data and ability to recollect data if required.
5	No	No	No	No	No	No	No	No	
6	Yes	Yes	Yes	No	Yes	Yes	No	Yes	The quality of the sampled distress data being collected was unaceptable
7	Yes	Yes	No	No	Yes	No	No	Yes	lack of adequate internal resources
8	Yes	Yes	No	No	Yes	Yes	No	No	
9	Yes	Yes	No	No	Yes	Yes	No	No	
10	Yes	Yes	Yes	No	Yes	Yes	No	No	**
11	Yes	No	No	No	Yes	No	No	Yes	Quality & timeliness of delivery are very important and we have tighter control over both with in-house data collection.
12	Yes	Yes	Yes	No	Yes	Yes	No	No	
13	Yes	Yes	Yes	No	Yes	No	No	Yes	Availability of in-house data collection team. The pavement design and condition survey unit has just two engineers.
14	Yes	Yes	Yes	No	Yes	Yes	No	No	
15	Yes	Yes	No	No	Yes	No	No	Yes	++
16	Yes	Yes	No	No	No	No	No	Yes	Availability of the required number of staff to run survey equipment.
17	Yes	No	No	No	Yes	No	No	No	
18	No	No	No	No	No	No	No	No	
19	Yes	Yes	No	No	No	No	No	No	
20		No	No	No	No	No	Yes	No	
21	Yes	Yes	Yes	Yes	No	No	No	No	
22	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Our data collector also collects other measurements for various other divisions
23	Yes	Yes	Yes	No	Yes	Yes	No	No	
24	Yes	Yes	Yes	Yes	Yes	Yes	No	No	
25	Yes	Yes	No	Yes	Yes	No	No	No	
26	Yes	No	No	No	No	No	No	Yes	Safety concerns for manual rating
27	Yes	Yes	Yes	No	Yes	No	No	No	
28	Yes	Yes	Yes	Yes	Yes	No	No	No	
29		No	Yes	Yes	Yes	Yes	No	No	
30	No	No	No	No	No	No	No	No	
31	No	No	No	No	No	No	No	No	
32	Yes	Yes	No	No	Yes	No	No	No	
33	Yes	Yes	No	No	Yes	Yes	No	No	
34	Yes	Yes	No	No	No	No	No	No	
35	Yes	Yes	No	Yes	Yes	Yes	No	No	
36	No	No	No	No	No	No	No	No	
37	Yes	Yes	No	No	Yes	No	No	No	
38	Yes	Yes	No	Yes	No	No	No	No	
39	Yes	Yes	Yes	No	Yes	No	No	No	Timeliness of response
40	No	No	No	No	No	No	No	No	
41		Yes	Yes	Yes	Yes	Yes	No	No	
42	No	No	No	No	No	No	No	No	
43	Yes	Yes	Yes	Yes	Yes	No	No	No	
44	Not Sure	No	No	No	No	No	Yes	No	
45	Yes	Yes	Yes	Yes	No	No	No	Yes	Inability to fund in-house equipment and maintain trained staff and stay current with technology
46	Yes	Yes	No	No	No	No	No	Yes	manpower shortage in-house
47	Yes	Yes	Yes	Yes	No	No	No	No	
48	Yes	Yes	Yes	No	No	No	No	No	
49	Yes	Yes	Yes	No	No	No	No	No	Didnt have enough in house staff
50	Yes	Yes	Yes	No	Yes	No	No	No	
51	Yes	Yes	No	No	No	No	No	No	
52	Yes	Yes	Yes	Yes	Yes	Yes	No	No	
53	Yes	Yes	Yes	No	Yes	Yes	No	No	
54	Yes	Yes	No	No	No	No	No	No	
55	Yes	No	Yes	Yes	Yes	Yes	No	No	

** DOT has negotiated Professional Service Agreements with the state's universities for civil engineering students to collect pavement distress data over the entire system each year; no private vendors will do manual/visual surveys.

++ With windshield distress survey; experience = consistency. No guarantee that a contracted employee will return for following years; so always new raters will cause more variability in survey results.

Agency	18. How does your agency currently collect pavement condition data? (check all that apply)															
	Surface Distress				**Smoothness**				**Frictional Properties**				**Structural Capacity**			
	In-house	Outsourced to a single contractor	Outsourced to multiple contractors	**Not coll.**	**In-house**	Outsourced to a single contractor	Outsourced to multiple contractors	**Not coll.**	**In-house**	Outsourced to a single contractor	Outsourced to multiple contractors	**Not coll.**	**In-house**	Outsourced to a single contractor	Outsourced to multiple contractors	**Not coll.**
1	No	Yes	No	No	No	Yes	No	No	Yes	No	No	No	No	No	Yes	No
2	Yes	No	No	No	No	Yes	Yes	No	Yes	No	No	No	No	No	Yes	No
3	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
4	Yes	No	No	No	Yes	No	No	No	No	No	No	Yes	No	No	No	Yes
5	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
6	Yes	Yes	No	No	Yes	Yes	No	No	Yes	No	No	No	Yes	No	No	No
7	No	Yes	No	No	Yes	Yes	No	No	Yes	No	No	No	Yes	No	No	No
8	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No
9	Yes	No	No	No	Yes	Yes	No	No	Yes	No	No	No	Yes	Yes	No	No
10	No	No	Yes	No	Yes	No	No	No	Yes	No	No	No	No	No	No	Yes
11	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No
12	No	Yes	No	No	No	Yes	No	No	No	No	No	Yes	No	No	No	Yes
13	Yes	Yes	No	No	No	Yes	No	No	Yes	No	No	No	Yes	No	No	No
14	No	Yes	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No
15	Yes	No	No	No	Yes	No	Yes	No	Yes	No	No	No	Yes	No	No	No
16	No	Yes	No	No	No	Yes	No	No	Yes	No	No	No	Yes	No	No	No
17	Yes	No	No	No	Yes	No	No	No	No	No	No	Yes	Yes	No	No	No
18	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
19	Yes	No	No	No	Yes	No	No	No	No	No	No	Yes	Yes	No	No	No
20	Yes	No	No	No	Yes	No	No	No	No	No	No	Yes	No	No	No	Yes
21	Yes	No	No	No	No	Yes	No	No	No	No	No	Yes	No	No	Yes	No
22	No	Yes	No	No	No	Yes	No	No	Yes	No	No	No	No	No	No	Yes
23	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	No	No	No	Yes
24	No	Yes	No	No	No	Yes	No	No	No	No	No	Yes	No	Yes	No	No
25	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No
26	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No
27	No	Yes	No	No	Yes	No	No	No	Yes	No	No	Yes	No	No	No	Yes
28	No	Yes	No	No	No	Yes	No	No	Yes	No	No	No	Yes	No	No	No
29	No	Yes	No	No	Yes	Yes	No	No	Yes	No	No	No	Yes	No	No	No
30	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
31	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
32	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No
33	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No
34	Yes	No	No	No	Yes	No	No	No	No	Yes	No	No	Yes	No	No	No
35	Yes	No	No	No	Yes	No	No	No	No	No	No	Yes	No	No	No	Yes
36	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
37	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No
38	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No
39	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No
40	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
41	No	Yes	No	No	No	Yes	No	No	Yes	No	No	No	Yes	No	No	No
42	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
43	Yes	No	No	No	Yes	No	Yes	No	Yes	No	No	No	Yes	No	Yes	No
44	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No
45	No	Yes	No	No	No	Yes	No	No	No	No	No	Yes	Yes	No	No	Yes
46	No	Yes	No	No	No	Yes	No	No	Yes	No	No	No	No	No	No	Yes
47	No	Yes	No	No	No	Yes	No	No	No	No	No	Yes	Yes	No	No	No
48	No	Yes	No	No	No	Yes	No	No	No	No	No	Yes	No	No	No	Yes
49	No	Yes	No	No	No	Yes	No	No	Yes	No	No	No	Yes	No	No	No
50	No	Yes	No	No	No	Yes	No	No	Yes	No	No	No	Yes	No	No	No
51	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	No	No	No	Yes
52	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No
53	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No
54	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No
55	No	Yes	No	No	No	Yes	No	No	Yes	No	No	No	Yes	No	No	No

Agency	19. Does your agency have a formal pavement data collection quality management plan?	
1	Not Sure	We have a P&P manual describing QA pract
2	Yes	
3	Not Sure	
4	Not Sure	Informal plan in-place. Will be revised.
5	No	Ours is more informal
6	No	We just advertised for a Vendor to collect our distress; rutting & IRI data - and are in the process of making a selection
7	Yes	
8	Yes	
9	Yes	Intranet Website; Please send request
10	Yes	DOT's NMDOT's Quality Management Plan (Quality Assurance and Quality Control) are avaliable upon request.
11	No	see 45)
12	Yes	
13	No	We have written documentation of in-house data collection procedures. We collect network data with both in-house team and contractor.
14	No	
15	Yes	In-house windshield survey has QA re-rating on 10% of system; in-house IRI data is compared to previous years' values; contracted IRI services have random re-collection by in-house resources and statistical comparison.
16	Yes	Validation sections are used to determine a specified accuracy of data collection equipment. Data is also reviewed for accuracy by DOT staff.
17	No; under development	
18	No; under development	
19	No; under development	
20	No	
21	Not Sure	It is handled by individuals dealing with the data.
22	No; under development	
23	Yes	
24	Yes	see our pavement surface condition rating manual
25	No	
26	No	
27	Yes	
28	Yes	
29	Yes	
30	No	
31	No	
32	No; under development	
33	No	
34	No; under development	
35	No; under development	
36	No; under development	
37	No; under development	
38	Yes	
39	No; under development	
40	No	
41	No; under development	
42	Yes	
43	No; under development	
44	No; under development	
45	No	
46	Not Sure	
47	Not Sure	
48	Yes	
49	No; under development	
50	No; under development	
51	No	
52	Yes	nothing written down
53	Yes	
54	No	
55	Yes	Continuing to further develop and refine

Agency	20. Does your agency have a formal pavement data collection quality control plan or require the contractor to develop such a plan if the data collection has been outsourced?							
	Yes	**No**	**Not Sure**	**Developed by the agency**	**Prepared by the data collection contractor**	**Prepared by an independent third-party**	Other	Comments
1	Yes	No	No	No	Yes	No	No	
2	Yes	No	No	No	No	No	No	For distresses surveys; QC plans developed in-house are used. For roughness surveys calibration and blind site surveys are used.
3	No	No	Yes	No	No	No	No	
4	No	Yes	No	No	No	No	No	Under Development. Will be developed by agency.
5	No	No	No	No	No	No	No	
6	No	Yes	No	No	Yes	No	No	We will require the Contractor to develop a Plan
7	Yes	No	No	No	Yes	No	No	
8	Yes	No	No	Yes	No	No	No	
9	Yes	No	No	Yes	No	No	No	
10	Yes	No	No	Yes	Yes	No	No	
11	No	Yes	No	No	No	No	No	
12	Yes	No	No	No	Yes	No	No	
13	No	No	No	No	Yes	No	No	
14	Yes	No	No	Yes	No	No	No	
15	Yes	No	No	No	Yes	No	No	
16	Yes	No	No	Yes	No	No	No	
17	Yes	No	No	No	No	No	No	
18	Yes	No	No	Yes	No	No	No	
19	No	No	No	No	No	No	Yes	Not Yet - Under development
20	No	Yes	No	No	No	No	No	
21	No	No	No	No	No	No	Yes	QC is done jointly between the department and the contractor.
22	No	No	No	No	Yes	No	No	
23	Yes	No	No	Yes	No	No	No	
24	No	No	No	No	Yes	No	No	
25	Yes	No	No	No	No	No	No	
26	No	No	No	No	No	No	Yes	**
27	Yes	No	No	No	Yes	No	No	
28	Yes	No	No	No	No	Yes	No	
29	Yes	No	No	Yes	Yes	No	No	
30	No	Yes	No	No	No	No	No	
31	No	Yes	No	No	No	No	No	
32	Yes	No	No	No	No	No	No	Plan developed in house
33	No	Yes	No	No	No	No	No	
34	No	No	No	No	No	No	Yes	Under development
35	No	Yes	No	No	No	No	No	
36	Yes	No	No	Yes	No	No	No	
37	No	No	No	No	No	No	No	
38	Yes	No	No	Yes	No	No	No	
39	Yes	No	No	Yes	No	No	No	
40	Yes	No	No	No	No	No	No	In-house QA/QC activities
41	Yes	No	No	No	Yes	No	No	
42	Yes	No	No	No	No	No	No	
43	Yes	No	No	No	Yes	No	No	
44	Yes	No	No	Yes	No	No	No	
45	Yes	No	No	No	Yes	No	No	
46	Yes	No	No	Yes	No	No	No	
47	Yes	No	No	No	Yes	No	No	
48	No	No	No	No	Yes	No	No	
49	No	No	No	No	Yes	No	No	
50	No	No	Yes	No	No	No	No	
51	No	Yes	No	No	No	No	No	
52	No	No	Yes	No	No	No	No	
53	No	Yes	No	No	No	No	No	
54	No	Yes	No	No	No	No	No	
55	No	No	No	No	Yes	No	No	

** For IRI; we check against Dipstick annually. For friction; we calibrate every three years. For distress - we do some QC by cross checking but it is not a formal program

Agency	21. Does your agency have a formal pavement data collection quality assurance plan?							22. If you have a pavement data collection quality assurance plan; what percentage of the data collected do you typically review in this plan?
	Yes	No	Not Sure	Developed by the agency	Prepared by an independent third-party	Other	Commnets	
1	No	No	Yes	No	No	No	section in P&P manual	More than 10%
2	Yes	No	No	No	No	No		Less than 2%
3	Yes	No	No	No	No	No	Repeatability & Comparison & test loop	More than 10%
4	No	Yes	No	No	No	No	Informal plan.	
5	Yes	No	No	Yes	No	No		More than 10%
6	No	Yes	No	No	Yes	No	We will require the Contractor to develop a Plan	
7	Yes	No	No	No	No	No		2 to 5%
8	Yes	No	No	Yes	No	No		6 to 10%
9	Yes	No	No	Yes	No	No		2 to 5%
10	Yes	No	No	Yes	Yes	No		6 to 10%
11	No	Yes	No	No	No	No		
12	Yes	No	No	Yes	No	No		6 to 10%
13	No	No	Yes	No	No	Yes		
14	Yes	No	No	Yes	No	No		6 to 10%
15	Yes	No	No	Yes	No	No		2 to 5%
16	No	Yes	No	No	No	No		
17	Yes	No	No	No	No	No		More than 10%
18	Yes	No	No	Yes	No	No		More than 10%
19	No	Yes	No	No	No	No		None
20	No	Yes	No	No	No	No		
21	No	No	No	No	No	Yes	It is handled by individuals dealing with the data.	More than 10%
22	No	Yes	No	No	No	No		2 to 5%
23	No	No	Yes	No	No	No		
24	No	No	No	Yes	Yes	No	See manual	Less than 2%
25	Yes	No	No	No	No	No		More than 10%
26	No	Yes	No	No	No	No	For distress; QA reviews segments where distress indices deviate substantially from expected values	None
27	Yes	No	No	No	No	Yes	developed by contractor	2 to 5%
28	Yes	No	No	No	Yes	No		2 to 5%
29	Yes	No	No	Yes	No	No		2 to 5%
30	No	Yes	No	No	No	No		
31	No	Yes	No	No	No	No		None
32	Yes	No	No	No	No	No	Plan developed in house	More than 10%
33	No	Yes	No	No	No	No		
34	No	No	No	No	No	Yes	under development	6 to 10%
35	No	Yes	No	No	No	No		More than 10%
36	No	Yes	No	No	No	No		None
37	No	Yes	No	No	No	No		
38	Yes	No	No	Yes	No	No		More than 10%
39	Yes	No	No	Yes	No	No		2 to 5%
40	Yes	No	No	No	No	No	In-house QA/QC activities	More than 10%
41	No	Yes	No	No	No	No		2 to 5%
42	Yes	No	No	No	No	No		More than 10%
43	No	Yes	No	No	No	No		
44	Yes	No	No	Yes	No	No		Less than 2%
45	No	Yes	No	No	No	No		None
46	Yes	No	No	Yes	No	No		6 to 10%
47	Yes	No	No	Yes	No	No		More than 10%
48	No	No	No	Yes	No	No		Less than 2%
49	No	Yes	No	No	No	No		6 to 10%
50	No	Yes	No	No	No	No		
51	No	Yes	No	No	No	No		None
52	No	No	Yes	No	No	No	I am not sure the difference between a quality assurance; management or control plan	
53	Yes	No	No	Yes	No	No		More than 10%
54	No	Yes	No	No	No	No		
55	No	No	No	No	No	Yes	Continuing to further develop and refine	2 to 5%

Agency	23. What type of quality checks are applied to the pavement data collected as part of your quality management program?										
	Quality Control										
	Calibration of equipment and/ or analysis criteria before the data collection	Testing of known "control" segments before data collection	Periodic testing of known "control" segments during production	Periodic testing of blind "control" segments during production	Verification of sample data by an independent consultant	Verification of the post-survey processing software/ procedures	Cross-measurements i.e.; random assignment of repeated segments to diff. teams or devices	Statistical/ software routines that check for inconsistencies in the data	Software routines that check if the data is within the expected ranges	Software routines that check for missing road segments or data elements	Comparison with existing time-series data
1	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
2	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes
3	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes	Yes	Yes
4	Yes	Yes	Yes	No	No	Yes	No	No	No	No	No
5	Yes	No	No	No	No	No	No	No	No	No	No
6	Yes	Yes	Yes	No	No	Yes	No	No	No	No	No
7	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes
8	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	No
9	Yes	Yes	Yes	No	No	No	No	Yes	Yes	Yes	Yes
10	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	No	Yes
11	Yes	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes	No
12	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
13	No	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes	No
14	Yes	Yes	Yes	No	Yes	No	No	No	No	No	No
15	Yes	Yes	Yes	Yes	No	No	Yes	No	No	No	No
16	Yes	Yes	Yes	No	No	No	No	No	No	No	No
17	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes
18	Yes	Yes	Yes		No	Yes	No	Yes	Yes	Yes	Yes
19	Yes	Yes	No	No	No	No	No	No	No	No	Yes
20											
21	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No
22	Yes	Yes	Yes	No	No	No	No	No	No	No	No
23	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No
24	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes	Yes	Yes
25	Yes	Yes	No	No	No	No	No	No	Yes	No	No
26	Yes	Yes	Yes	No		Yes	Yes	Yes	Yes	Yes	
27											
28	Yes	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes
29	Yes	Yes	Yes	No	No	No	No	Yes	Yes	Yes	Yes
30	No	No	No	No	No	No	No	No	No	No	Yes
31											
32	Yes	Yes	Yes	No	No	No	Yes	No	No	No	No
33											
34	Yes	Yes	Yes	No	No	No	No	No	No	No	No
35	Yes	Yes	Yes	No	No	Yes	No	No	Yes	Yes	No
36	Yes	Yes	Yes	No	No	Yes	Yes	No	No	No	No
37	Yes	No	Yes	No	No	No	No	Yes	Yes	Yes	No
38	Yes	Yes	No	No	No	No	Yes	Yes	Yes	Yes	No
39	No	Yes	No	No	No	No	No	No	No	No	No
40	Yes	Yes	Yes	No	No	Yes	No	No	No	No	No
41	Yes	Yes	Yes	No	No	No	No	No	Yes	No	No
42	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes	Yes	
43	Yes	Yes	No	No	No	Yes	No	No	Yes	No	No
44	Yes	Yes	Yes	No	No	Yes	No	No	No	Yes	No
45	Yes	Yes	No	No	No	Yes	No	Yes	Yes	Yes	Yes
46	Yes	Yes	Yes	No	No	Yes	No	No	No	Yes	Yes
47											
48	Yes	Yes	Yes	No	No	No	No				
49	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	No	Yes
50	Yes							No	No	Yes	No
51	Yes	Yes	Yes	No	No	No	No	No	No	No	No
52	Yes	Yes	Yes	No	No	Yes	No	No	Yes	Yes	Yes
53											
54	Yes	Yes	No	No	No	No	No	Yes	Yes	Yes	Yes
55	Yes										

Agency	23. What type of quality checks are applied to the pavement data collected as part of your quality management program? (cont.)										
	Quality Assurance										
	Calibration of equipment and/ or analysis criteria before the data collection	Testing of known "control" segments before data collection	Periodic testing of known "control" segments during production	Periodic testing of blind "control" segments during production	Verification of sample data by an independent consultant	Verification of the post-survey processing software/ procedures	Cross-measurements i.e.; random assignment of repeated segments to diff. teams or devices	Statistical/ software routines that check for inconsistencies in the data	Software routines that check if the data is within the expected ranges	Software routines that check for missing road segments or data elements	Comparison with existing time-series data
1	No	No	No	No	No	No	No	Yes	Yes	Yes	No
2	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes
3	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes	Yes	Yes
4	Yes	Yes	Yes	No	No	Yes	No	No	No	No	No
5	Yes	No	No	No	No	Yes	No	No	Yes	Yes	No
6								Yes	Yes	Yes	Yes
7											
8	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	No
9	Yes	Yes	Yes	No	No	No	Yes	No	No	No	No
10	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	No	Yes
11	No	No	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes
12	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
13	No	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes	No
14	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes
15	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes
16	No	No	No	No	No	No	No	No	No	No	No
17	Yes	No	Yes	Yes	No	No	No	No	Yes	Yes	Yes
18	Yes	Yes	Yes		No	Yes		Yes	Yes	Yes	Yes
19											
20											
21	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes	No	Yes
22	Yes	Yes	Yes	No	No	No	No	No	No	No	No
23											
24	Yes	Yes	Yes	Yes	No	No	No	No	Yes	No	Yes
25	Yes	Yes	No	No	No	No	No	No	Yes	No	No
26			Yes			Yes		Yes	Yes	Yes	
27											
28	Yes	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes
29	Yes	Yes	Yes	No	No	Yes		Yes	Yes	Yes	Yes
30	No	No	No	No	No	No	No	No	No	No	No
31											
32	Yes	Yes	Yes	No	No	No	Yes	No	No	No	No
33											
34	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
35	Yes	Yes	Yes	No	No	Yes	No	No	Yes	Yes	No
36	Yes	Yes	Yes		No	Yes	Yes	No	No	No	No
37	Yes	No	Yes	No	No	No	No	Yes	Yes	Yes	No
38	Yes	Yes	No	No	No	No	Yes	Yes	Yes	Yes	No
39	No	No	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes
40	Yes	Yes	Yes	No	No	Yes	No	No	No	No	No
41	Yes	Yes	Yes	No	No	No	No	No	Yes	No	No
42	Yes				No	Yes			Yes		
43	No	No	No	No	No	No	No	No	No	No	No
44	Yes	No	No	No	No	Yes	No	No	No	No	No
45											
46	Yes	Yes	Yes	No	No	Yes	No	No	No	Yes	Yes
47	Yes	Yes	Yes	No	No	Yes	No	No	No	No	No
48								Yes	Yes	Yes	Yes
49	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	No	Yes
50				Yes							
51											
52											
53	Yes	Yes	Yes		Yes	Yes			Yes	Yes	Yes
54	Yes	Yes	No	No	No	No	No	Yes	Yes	Yes	Yes
55		Yes	Yes	No	No	Yes	No	Yes	Yes	Yes	No

Agency	24. If you use automatic/semi-automatic equipment for distress data collection; have you experienced difficulties with matching the results of the automatic surveys with benchmark data collected manually?	
1	Yes	Automated rutting measurements can vary significantly
2	N/A	
3	Yes	fault cracking; wet conditions have been identified as factors causing the differences.
4	N/A	Don't use automatic/semi-automatic equipment
5	N/A	
6	N/A	
7	No	
8	N/A	
9	N/A	
10	N/A	
11	N/A	
12	Yes	
13	No	
14	Yes	This is for automated distress system under development - difficulty in comparing algorithms between raters and machine.
15	N/A	
16	Yes	With some vendors' equipment; data can be far off the manually collected data.
17	N/A	
18	N/A	
19	No	
20	N/A	
21	N/A	
22	No	
23	N/A	
24	No	We verify that the contractor's equipment and manual distress rater are appropriately 'calibrated' before they begin work; and via blind sites throughout the testing.
25	N/A	
26	N/A	
27	N/A	
28	No	
29	Yes	The vendor's reported distresses vs. the benchmark distresses have never been close. We also have had DOT ALDOT raters; trained by the vendor; use the vendor's software to perform QA checks on randomly selected pavement images. see No. 45
30	N/A	
31	N/A	
32	N/A	
33		
34	No	
35	N/A	
36	Yes	When reads are wet and there is a lot of sand from the winter our numbers will be slightly off. We also have a problem with extra edge cracking from the line stripping; cameras sometimes are out of focus and we get shadow cracks.
37	N/A	
38	No	
39	N/A	
40	No	
41	No	
42	N/A	
43	N/A	
44	N/A	
45	N/A	
46	No	pavements are rated from the collected images in the office; teams check random sections in the field; sensor data matches manual collections
47	No	
48	No	But must account for individual subjectivity
49	N/A	
50	N/A	
51	N/A	
52	No	
53	Yes	
54		
55	N/A	Referring only to cracking recognition process. DOT doesn't utilize automated recognition routines.

Agency	25. For distress data collection; what parameters do you use to determine the accuracy of the data?				26. If you use manual pavement distress surveys; approximately how many lane-miles does an average data collection team complete in a year?	27. Do you require a formal certification for the in-house and/or contracted distress raters?	
	Individual distresses class., severities & extents	Overall pavement condition index	Other	Comments			
1	Yes	No	No		1	No	
2	Yes	No	No		600	No	Only trained personnel are assigned to rate the pavements.
3	Yes	Yes	No				N/A
4	No	No	Yes	Under development as we revise/update our PMS.	6000	No	
5	No	Yes	No		7500	No	
6	Yes	No	No			No	The in-house crews were trained but not certified
7	Yes	No	No			No	
8	Yes	Yes	No		19500	No	
9	Yes	No	No		42000	No	
10	Yes	Yes	No		1100	No	
11	Yes	No	No		22000	No	
12	Yes	Yes	No			Yes; contractor only	
13	No	Yes	Yes	Meet and discuss preliminary results with frontline pavement maintenance staff	2700	No	
14	Yes	No	No		3500	Yes; for both	
15	No	No	Yes	statistical analysis of rater data vs QA ratings	4000	No	No formal certification; but attendance at annual training program for rating team is required.
16	Yes	No	No		500	No	In house staff is a P.E.
17	Yes	No	No		1	Yes; in-house only	
18	Yes	No	No		25000	No	
19	Yes	No	No			No	
20	No	No	Yes	the question is not clear	6000	No	
21	Yes	Yes	No		1000	Not Sure	There is a periodical staff training program.
22	No	Yes	No			No	
23	Yes	No	No		6000	No	
24	Yes	Yes	No		2500	No	
25	Yes	No	No			Yes; for both	
26	No	Yes	No		4500	Yes; in-house only	We train and check up often
27	No	Yes	No			Not Sure	The consultant required to provide training for raters.
28	No	Yes	No			No	
29	Yes	No	No			No	8+ years manual field experience for in-house QA
30	Yes	No	No		3600	No	
31	Yes	Yes	No		1000	No	
32	Yes	No	No		24000	No	No formal certification but the raters undergo rigorous training
33	Yes	Yes	No		200	Yes; house only	
34	Yes	No	No		17000	No	
35	Yes	No	No		1		
36	Yes	No	Yes	Total length of crcaking/unit length of road.		No	
37	Yes	No	No			No	
38	Yes	Yes	No		65000	No	
39	Yes	Yes	No		700	Yes; in-house only	
40	Yes	Yes	No			No	
41	Yes	Yes	No			No	
42	No	Yes	No			No	
43	Yes	No	No		4300	No	
44	Yes	No	No			No	
45	No	No	Yes	Only collect rutting - equipment setup standards and calibration results		No	
46	Yes	No	No		13000	No	All pavement rating done in-house. All raters are to attend a yearly training session before rating
47	Yes	No	No			No	
48	Yes	No	No		11200	No	
49	Yes	Yes	No			No	
50	No	Yes	No			Not Sure	
51	No	Yes	No		1000	No	
52	Yes	Yes	No		100	No	
53	Yes	No	No			No	
54	Yes	No	No		49000	Yes; contractor only	
55	Yes	No	No		6000	No	Submitted survey data randomly sampled and scored for acceptance

Agency	28. Please select the type of data that is being collected by contractor(s) for the different types of roadways?											
	Surface Distress			Smoothness			Frictional properties			Structural capacity		
	Highway (Interstate)	Arterial (Primary)	Collector (Secondary)	Highway (Interstate)	Arterial (Primary)	Collector (Secondary)	Highway (Interstate)	Arterial (Primary)	Collector (Secondary)	Highway (Interstate)	Arterial (Primary)	Collector (Secondary)
1	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
2	No	No	No	No	Yes	Yes	No	No	No	No	Yes	Yes
3	No	No	No	No	No	No	No	No	No	No	No	No
4	No	No	No	No	No	No	No	No	No	No	No	No
5	No	No	No	No	No	No	No	No	No	No	No	No
6	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
7	Yes	Yes	Yes	No	Yes	Yes	No	No	No	No	No	No
8	No	No	No	No	No	No	No	No	No	No	No	No
9	No	No	No	Yes	Yes	No	No	No	No	Yes	Yes	No
10	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No
11	No	No	No	No	No	No	No	No	No	No	No	No
12	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
13	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
14	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No
15	No	No	No	No	Yes	Yes	No	No	No	No	No	No
16	Yes	Yes	No	Yes	Yes	No	No	No	No	No	No	No
17	No	No	No	No	No	No	No	No	No	No	No	No
18	No	No	No	No	No	No	No	No	No	No	No	No
19	No	No	No	No	No	No	No	No	No	No	No	No
20	No	No	No	No	No	No	No	No	No	No	No	No
21	No	No	No	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes
22	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
23	No	No	No	No	No	No	No	No	No	No	No	No
24	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
25	No	No	No	No	No	No	No	No	No	No	No	No
26	No	No	No	No	No	No	No	No	No	No	No	No
27	No	No	No	No	No	No	No	No	No	No	No	No
28	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
29	Yes	Yes	No	Yes	Yes	No	No	No	No	No	No	No
30	No	No	No	No	No	No	No	No	No	No	No	No
31	No	No	No	No	No	No	No	No	No	No	No	No
32	No	No	No	No	No	No	No	No	No	No	No	No
33	No	No	No	No	No	No	No	No	No	No	No	No
34	No	No	No	No	No	No	No	No	No	No	No	No
35	No	No	No	No	No	No	No	No	No	No	No	No
36	No	No	No	No	No	No	No	No	No	No	No	No
37	No	No	No	No	No	No	No	No	No	No	No	No
38	No	No	No	No	No	No	No	No	No	No	No	No
39	No	No	No	No	No	No	No	No	No	No	No	No
40	No	No	No	No	No	No	No	No	No	No	No	No
41	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
42	No	No	No	No	No	No	No	No	No	No	No	No
43	Yes	Yes	No	Yes	Yes	No	No	No	No	Yes	Yes	No
44	No	No	No	No	No	No	No	No	No	No	No	No
45	Yes	Yes	Yes	Yes	No	Yes	No	No	No	No	No	No
46	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
47	Yes	Yes	No	Yes	Yes	Yes	No	No	No	No	No	No
48	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
49	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
50	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
51	No	No	No	No	No	No	No	No	No	No	No	No
52	No	No	No	No	No	No	No	No	No	No	No	No
53	No	No	No	No	No	No	No	No	No	No	No	No
54	No	No	No	No	No	No	No	No	No	No	No	No
55	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No

Agency	29. What type of data collection contract is in place?		30. How was the winning bidder selected?		31. How long is the contracting period?
1	Cost per mile		Other	Total points for eight different factors; inc. price	2 years
2	Cost per mile		Low Bid (Technically Acceptable)		2 years
3					
4					
5					
6	Cost per mile	Will be for 2008 data collection	Past performance/technical ability		> 3 years
7	Cost per mile		Best Value		2 years
8					
9	Lump-sum		Low Bid (Technically Acceptable)		3 years
10	Lump-sum		Other	Negotiated Professional Service Agreements with state universities	> 3 years
11					
12	Lump-sum		Past performance/technical ability		2 years
13	Other	Some of our network data collection is lumped in with our videolog contract.	Low Bid (Technically Acceptable)		2 years
14	Cost per mile		Past performance/technical ability		> 3 years
15	Lump-sum		Low Bid (Technically Acceptable)		1 year
16	Lump-sum		Other	Past performance/technical ability; but cost is also factored in.	3 years
17					
18					
19					
20					
21	Lump-sum		Low Bid (Technically Acceptable)		3 years
22	Cost per mile		Low Bid (Technically Acceptable)		> 3 years
23					
24	Cost per mile	cost per km for network level evaluations; fee for services for project level surveys	Best Value		> 3 years
25					
26					
27	Other	invoices submitted and reviewed monthly	Past performance/technical ability		3 years
28	Cost per mile		Best Value		3 years
29	Cost per mile		Past performance/technical ability	Professional Services Contract - technical ability	2 years
30					
31					
32					
33					
34					
35					
36					
37					
38					
39					
40					
41	Lump-sum		Past performance/technical ability		1 year
42		n/a		n/a	
43	Lump-sum		Past performance/technical ability		2 years
44					
45	Cost per mile		Low Bid (Technically Acceptable)		2 years
46	Cost per mile		Past performance/technical ability		3 years
47	Cost per mile		Low Bid (Technically Acceptable)		> 3 years
48	Cost per mile		Past performance/technical ability		> 3 years
49	Cost per mile		Other	Qualification based selection committee	1 year
50	Cost per mile		Past performance/technical ability		2 years
51					
52					
53					
54					
55	Other	Qualifications based; low-bid with itemized cost-per-mile for various data deliverables	Other	Low bid after pre-qualification short listing	> 3 years

Agency	32. Do you use the contractor quality control data as part of the quality assurance process?	33. Typically; what percentage of data must be corrected/ resubmitted by the contractor?	34. Do you have contract clauses that link payment to the quality of the collected data?		35. Overall; would you consider the outsourcing of pavement data collection a positive step in your pavement management practices?	36. Overall; have you been satisfied with the performance of the data collection contractor(s) most recently or currently being used?
1	Yes	2 to 5%	No		Yes	Yes
2	Yes	Less than 2%	Yes		Yes	No
3					Not Sure	
4						
5						
6	Not Sure		No		Yes	
7	No	2 to 5%	Not Sure		Yes	Yes
8						
9	No	Less than 2%	No		Not Sure	Yes
10	Yes	Less than 2%	No		Yes	Yes
11						
12	No	Less than 2%	Yes		Yes	Yes
13	Yes	2 to 5%	Not Sure		Yes	Yes
14	Not Sure	Less than 2%	Yes		Yes	Yes
15	Yes	Less than 2%	Yes	Loosely - data must fall within boundaries for consistency with previous data or QA re-collected sections. If data fails; must be recollected.	Yes	Yes
16	No	2 to 5%	Yes	Data of acceptable quality is a condition to get the last percentage of payment.	Not Sure	Yes
17						
18						
19						
20						
21	Not Sure	2 to 5%	Not Sure		Yes	Yes
22	No	Less than 2%	Not Sure		Yes	Yes
23						
24	No	Less than 2%	Yes		Yes	Yes
25						
26						
27	Not Sure	2 to 5%	Not Sure		Yes	Yes
28	Yes	2 to 5%	Yes		Yes	Yes
29	No	More than 10%	Yes		Not Sure	No
30	No		No			
31	Not Sure	Less than 2%	No	N/A	Not Sure	Not Sure
32						
33						
34						
35						
36						
37						
38						
39						
40	No					
41	Not Sure		No		Yes	Yes
42	No				No	
43	No	Less than 2%	No		Not Sure	Yes
44						
45	No	Less than 2%	Not Sure		Yes	Yes
46	Yes		Yes	Collected data must be accepted by DOT or it shall be recollected at no additional cost	Not Sure	Yes
47	Yes	2 to 5%	No		Yes	Yes
48	Yes	2 to 5%	Not Sure		Yes	Yes
49	Not Sure	Less than 2%	Yes	General Terms	Yes	Yes
50	Not Sure		Not Sure		Yes	Yes
51						
52						
53						
54						
55	No	6 to 10%	Yes		Not Sure	Yes

Agency	37. How do data collection personnel receive initial and ongoing training?						38. What is the highest average level of education for data collection personnel?
	On the job training from experienced staff	In-house training program	Local colleges and universities	Professional training (certification) programs	Other	Comments	
1	Yes	No	No	No	No		High School
2	Yes	No	No	No	No	The ministry conducts a biennial in-house pavement rating workshop	Bachelor's Degree
3	No	No	No	No	No		
4	Yes	No	No	No	No		Associates Degree
5	No	No	No	No	No		
6	Yes	No	No	No	Yes	Vendor supplied for operation of Equipment	High School
7	No	Yes	No	No	No		High School
8	Yes	Yes	No	No	No		Associates Degree
9	Yes	Yes	No	No	No		High School
10	Yes	Yes	No	No	No		High School
11	Yes	Yes	No	No	No		High School
12	No	No	No	No	No		
13	Yes	No	No	No	Yes	Self learn to update method	Bachelor's Degree
14	Yes	Yes	No	No	No		High School
15	No	Yes	No	No	No		Bachelor's Degree
16	No	No	No	No	Yes	Perhaps review of the SHRP Distress Ident. Manual.	Master's Degree/ PhD
17	No	Yes	No	No	No		High School
18	No	No	No	No	No		
19	Yes	No	No	No	No		Associates Degree
20	Yes	No	No	No	No		Bachelor's Degree
21	Yes	No	No	No	No		Associates Degree
22	Yes	No	No	No	No		High School
23	Yes	No	No	No	No		Associates Degree
24	No	No	No	No	No		
25	Yes	Yes	Yes	Yes	No		Associates Degree
26	Yes	Yes	No	No	No		High School
27	No	No	No	No	No		
28	No	No	No	No	No		
29	Yes	No	No	No	No		High School
30	No	No	No	No	No		
31	No	No	No	No	No		
32	Yes	Yes	No	No	No		Associates Degree
33	No	Yes	No	No	No		High School
34	Yes	No	No	No	No		Associates Degree
35	Yes	No	No	No	No		Associates Degree
36	No	No	No	No	No		
37	Yes	No	No	No	No		High School
38	Yes	Yes	No	Yes	No		Associates Degree
39	No	Yes	No	No	No		Associates Degree
40	No	No	No	No	No		
41	No	No	No	No	No		
42	No	No	No	No	No		
43	Yes	No	No	No	No		High School
44	Yes	No	No	No	No		Associates Degree
45	No	No	No	No	No		
46	No	No	No	No	No		
47	No	No	No	No	No		
48	No	No	No	No	No		
49	Yes	No	No	No	No		Associates Degree
50	No	Yes	No	No	No		Associates Degree
51	Yes	Yes	No	No	No		Bachelor's Degree
52	Yes	No	No	No	No		Associates Degree
53	Yes	Yes	No	No	No		Associates Degree
54	Yes	No	No	No	No		
55	No	No	No	No	No		

Agency	39. How many years of experience do data collection personnel have on average?	40. Approximately how many hours per year do data collection personnel receive ongoing training?	41. What percentage of collected data must be corrected/ resurveyed?	42. How would you rate your agency's ability to accurately collect pavement condition data?
1	6 to 10 years	8 to 16 hours	Less than 2%	Good
2	6 to 10 years	8 to 16 hours	Less than 2%	Excellent
3				
4	2 to 5 years	8 to 16 hours	Less than 2%	Good
5				
6	6 to 10 years	8 to 16 hours	Less than 2%	Good
7	Less than 2 years	Less than 8 hours	Less than 2%	Good
8	6 to 10 years	8 to 16 hours	2 to 5%	Good
9	More than 10 years	8 to 16 hours	Less than 2%	Good
10	2 to 5 years	17 to 40 hours	Less than 2%	Excellent
11	6 to 10 years	17 to 40 hours	Less than 2%	Good
12				
13	Less than 2 years	8 to 16 hours	Less than 2%	Fair
14	2 to 5 years	8 to 16 hours	Less than 2%	Good
15	6 to 10 years	8 to 16 hours	Less than 2%	Excellent
16	More than 10 years	Less than 8 hours	2 to 5%	Good
17	More than 10 years	8 to 16 hours	Less than 2%	Good
18				
19	Less than 2 years	8 to 16 hours		Fair
20	6 to 10 years	Less than 8 hours	Less than 2%	Fair
21	More than 10 years	8 to 16 hours	2 to 5%	Good
22	6 to 10 years	8 to 16 hours	Less than 2%	Good
23	More than 10 years	8 to 16 hours	Less than 2%	Good
24				
25	6 to 10 years	8 to 16 hours	2 to 5%	Excellent
26	Less than 2 years	17 to 40 hours	2 to 5%	Good
27				
28				
29	6 to 10 years	8 to 16 hours	2 to 5%	Not Sure
30				
31				
32	2 to 5 years	More than 40 hours	2 to 5%	Good
33	6 to 10 years	Less than 8 hours	Less than 2%	Good
34	6 to 10 years	8 to 16 hours	Less than 2%	Good
35	More than 10 years	8 to 16 hours	6 to 10%	Excellent
36				
37	6 to 10 years	Less than 8 hours	6 to 10%	Fair
38	More than 10 years	8 to 16 hours	Less than 2%	Excellent
39	More than 10 years	8 to 16 hours	Less than 2%	Good
40				
41				
42				
43	6 to 10 years	8 to 16 hours	2 to 5%	Excellent
44	2 to 5 years	8 to 16 hours	2 to 5%	Excellent
45				
46				
47				
48				
49	More than 10 years	Less than 8 hours	Less than 2%	Excellent
50	2 to 5 years			Good
51				
52	2 to 5 years	17 to 40 hours	2 to 5%	Good
53	6 to 10 years	More than 40 hours		Excellent
54			Less than 2%	Good
55				

Agency	43. Based on your experience; what factor(s) have the greatest impact on the quality of the pavement condition data?
1	checking the data thoroughly during and after collection and pointing out all errors or inconsistencies to the contractor
2	a)Subjectivity in the evaluation of rating distresses.; b)Variations associated with the roughness measuring devices.; c)Availability of backup resources
3	change of equipment; weather condition; software; human resources
4	The equipment. Manual windsheild survey for surface distress as this is subjective as there are differences between raters and even when rating the same road multiple times.
5	Experienced raters. We have the same 2 raters for the entire state each year.
6	For smoothness: ability to drive in the lane & maintain speed; proper sampling rate selected; proper processing of collected data.; For Distress: Consistency of field crews in classifying & quantifying observed distress. Correct location.
7	for internal testing; adherance to calibration and testing procedures; for contractor testing; QA
8	continuous monitoring of your practices and procedures
9	Experience of our raters; established practices insure quality data.
10	The training of the raters.
11	With manual surveys; clear and concise definitions with strong training emphasizing those definitions and using peer reviews seems to work with distress.
12	quality assurance; penalty for late delivery; experiance of contractor
13	Definition of "quality" depnds on the intended data use. For network level maintenance planning; our current method seems to be the most cost effective way to get the job done.
14	Skill/experience of equipment operators; Interest of data users; Quality of instruments used; Skill/experience of distress raters.
15	Windshield distress survey - consistency or rater; ; IRI survey - location referencing (getting in the same location each time)
16	For cracking; presence of sand in cracks. For roughness; the presence or absence of stop and go traffic.
17	weather; rater training
18	well-trained and experienced condition survey raters
19	Experience of personnel; Available Manpower
20	experience/expertise of rating panel
21	Personal due diligence of the operator/collector
22	Contractor construction practices
23	Competent; properly trained personnel.
24	Good practices selecting contractor.; Quality staff.; Quality equipment.; Good working relationship.; Sound quality management practices.; ; A good start-up meeting and rigorous calibration of equipment and the visual distress rater at start of data collection season; a good program of blind sites and control sites to validate reliability; repeatability.; ; Angle of sunlight on pavement surface.;
25	Equipment calibratioin and maintenance.
26	Training; Sampling; Comprehensive QA; Knowledge of system and being able to easily spot suspect data
27	
28	Use of control sites; Independent data verfication and validation.
29	Camera resolution; image resolution; lighting; vendor understanding of agency distress rating protocol.
30	Regular review of open and blind test section surveys; without question; even by myself who has done this for 20+ years. (These comments relate to the windwhield method at a netork level process.)
31	N/A
32	Equipment calibration; Rater training; rater audits; experience however this can go both ways; somtimes the more experienced raters get complacent
33	During training; personnel may be reluctant to ask questions.
34	reliability of equipment and training/experience of distress rating staff
35	Consistency repeatability of the equipment and operators to collect the road condition data.
36	Wet surfaces; white sand and edge cracking which is picked up by the shoulder lines and skip markings on the highways.
37	Trusting training from experienced raters.
38	Well Trained Raters; Software to help with processing; edits; and quality control indicators
39	Personal commitment of the rater to do the job.
40	Weather...i.e. dry pavement surface.
41	
42	
43	familiarity with distress ratings and consistency among raters
44	Experienced personnel; Established and time-tested procedures; Commitment to quality
45	1. Equipment used and consistency of techniques from year to year; 2. Collection procedures and calibrations; 3. Proper processing and adjustment to LRS
46	Need to have good experienced; knowledgeable people doing the pavement rating/analysis. Raters need to know the purpose of the data and how it is utilized.
47	
48	Consistency in vendor; equipment; etc.
49	Rater Subjectivity
50	
51	
52	judgement of extent of distress evident from video logs.
53	Initial training; Ongoing training; Experience; Attitude
54	Consistent evaluations using the same staff who are knowledgeable of the highway system. Good equipment that is calibrated regularly.
55	1) Clear communication of expectations/deliverables to contractor.; 2) Agency QA diligence; tied to data acceptance

Agency	44. Do you envision any changes in data collection activities over the next several years?	
1	No	
2	Not Sure	
3	Yes	more reliable equipment with higher consistency; better software
4	Yes	Purchasing a new van in 2009 with automatic survey for surface distress.
5	Yes	We hope to move toward fully automated distress surveys
6	Yes	Will be using a Contractor to collect distress; IRI & rutting
7	No	
8	Yes	incorporate RWD data
9	Yes	Automated distress data collection and analysis
10	No	
11	Yes	We are trying to move from our manual surveys to automated distress.
12	Yes	fully automation for pavement distress if we can find one acceptable
13	Yes	
14	Yes	Move to in-house automated distress measurements.
15	Yes	Continue to look at automated surveys; move more to GPS as primary location reference.
16	Yes	We will be surveying pavements more frequently.
17	Yes	
18	Yes	GPS equipped data collectors
19	Yes	More Formalized Method of Data Collection and Storage
20	Not Sure	
21	Yes	Considering automated distress data collection
22	No	
23	Yes	We hope to purchase a downward imaging system in the future.
24	No	
25	Yes	Establish control sections.
26	Yes	We are going to try automated distress (manual rating from downward images) this year
27	Yes	possible addition of automated data collection and smoothness factors into the pavement management system
28	No	
29	Yes	Industry must use higher resolution imagry and probably use automated crack recogition programs to get repeatable data.
30	Yes	I am one of two in the department who have collected distress data. I've done the provincial network for the last 20 years and I retire in 2 weeks without anyone to replace or train.
31	Yes	Additional focus on structural capacity testing
32	Yes	Trying to ensure funding for video imaging/profile equipment
33	Yes	PDA's for pavement data collection.
34	Yes	further development of a QC/QA plan
35	Yes	The technology will improve accuracy and ease of data collection.
36	Yes	We will be converting our pavement management cameras to laser cameras. This should eliminate any extra noise cracking.
37	Yes	
38	Yes	More automation
39	Yes	Hoping to shift interstate and major primaries to automated distress data collection
40	No	
41	Yes	longer term contracts; subset of data collected in this contract
42	No	
43	Yes	currently trying to determine if we should continue to collect data in-house or contract it out.
44	Not Sure	
45	Yes	1. use of visual inspection of photolog to supplement distresses and overall rating and adjustment to LRS
46	No	This is the first year data collection has been out-sourced. Rating/Data Analysis is still being done in-house.
47	No	
48	Yes	New RFP means possibility of new vendor. Will be collecting more data for HPMS reassessment
49	Yes	Want to go to 100% automated & INO rut
50	Not Sure	
51		
52	Yes	I would hope that pattern recognition software would help automate crack ratings in the future.
53	Yes	Will be implementing new survey procedures
54	Yes	The Department will be going to an automated collection system and will be contracting it out to a vendor.
55	Yes	Potential for streamlining of detailed crack recognition process

Agency	Additional comments or recommendations
1	
2	To summarize; agency collects pavement distress and rutting in-house; and roughness measurements are outsourced.
3	Need FHWA to help with gound truth verfication applying nationwide criteria and standard. This would be crititcal in data quality management.
4	
5	
6	this should prove to be a timely & valuable exercise if you can generate some recommended Quality Control Plans
7	
8	
9	
10	DOT/state NMDOT negotiated Professional Service Agreements with NM's universities for civil engineering students to collect pavement distress data via manual/visual surveys over the entire system each summer. Pavement roughness and rutting are collected automatically in-house. Pavement roughness and rutting are measured on Interstates and NHS highways each year and on other routes every 2 years in accordance with HPMS requirements. Pavement friction data is collected in-house on a project basis.
11	Our process includes 1 week of training each year before our survey begins. During this training; we review the definitions and procedures the data collectors are to follow. This includes showing slides of various distresses and having the raters discuss what they see. We also take van loads of these folks out on the road and as one rates; the others critique. In all cases; one rater is listed as the lead worker and is held responsible for appropriate data collection. Oversampling is performed to compare ratings. Also a "check survey" is performed behind each rater. In both cases; the outcome is usually a better understanding of how raters see things differently. This typically leads to changes in definitions or training. Also; question 26 asks about lane miles per data collection team. We cover about 22,000 lane miles each year. This is done by 2 or 3 two-person teams over a period of about 10 weeks annually.
12	
13	Others outside this unit often overexpect that the network level survey can substitute project level design. The basic importance of having an as complete road inventory as possible should not be overlooked. We started to include freeway ramps;overpasses; underpasses; and frontage roads (~5% by ln-mi of our inventory) two years ago. It revealed some of the worst spots in our inventory. They were previously reported/averaged as in better condition when lumped in with bigger rating sections or not reported at all. We also started to pay more attention to average daily traffic volume PER LANE instead of just the traffic volume for the whole road. It gives us a more relevant prioritization and deterioration rate prediction factor.
14	None.
15	We are satisfied that the quality of the data we collect and/or receive from contractors is sufficient for network level analyses.
16	No.
17	
18	The following questions are not shown on the on-line survey form. Here are the Q&A:; 17-N/A; 18-In-house Collection; 37- On the job training; 38-BS degree; 39-More than 10 yrs; 40-More than 40 hrs; 41-Less than 2%; 42-Good
19	
20	
21	We would like to see a summary of the best practices from this study.
22	
23	
24	Here is a link to our last RFP for pavement condition surveys.; ; http://www.bcbid.gov.bc.ca/open.dll/welcome ; Search for: Solitication #: CMB 2005_03_31 or the phrase:; ; 2005/08 Network Level Automated Pavement Condition Surveys ;
25	
26	
27	I have filled out the survey to the best of knowledge with what I could find by the deadline. Smoothness and friction measurements do not necessarily come into play constantly with the pavement magagement section. They are done by a different section.
28	
29	**
30	Corporate knowledge and a buy-in by the administration and the user engineers as to it's validity and value. Appears to carry little weight in the engineering process for road planning and is given little attention by the engineers here for the last 5 years. Even when I did the annual network survey; no one reviewed my findings (except myself) for the last 5 years.
31	In the NWT; we are somewhat fortunate that the kilometerage of our Pavement Structures is quite low; therefore we have the resources necessary to visit our entire system at least once each year.
32	
33	
34	
35	
36	
37	We re in the process of purchasing a new data collection vehicle that will utilize automatic distress identification technologies. We are beginning to consider an official training program for all Department pavement rating personnel.
38	
39	It would have been easier to answer if roads were classified as interstate; primary and secondary rather than rural and urban.
40	
41	
42	We do our own data collection / proccess / load / QC / analysis. We do not hire a contractor.
43	
44	
45	
46	For our CRS; images and sensor data(IRI & Rut)are collected. These are reviewed at workstations where distresses are entered.The CRS value is then calculated from the distresses and sensor data. Data collection was out sourced beginning with the FY 2008 collection.
47	
48	
49	
50	
51	
52	
53	
54	Some of the questions I couldn't answer because I didn't have the information.
55	

** Questions 9, 10 & 11 - We do not collect data by functional classification of routes. We collect the NHS annually and the non-NHS biennially. Question 4 - Project level surface distress is collected by personnel from the Division offices. Project level smoothness is collected by construction inspectors with a California type profilograph. The data is used for incentive/disincentive payments. Question 23 - We currently have a research project going on that will develop a QA procedure based on a reliable statististical method. Question 6 - We anticipate that the index will include load associated/wheel path cracking; non-load associated/non-wheel path cracking; transverse cracking; smoothness/IRI; and rutting. Question 24-The DOT raters distress ratings do not match the vendor's ratings. In fact; the DOT raters do not match each other. We had our most experienced rater rate 12 sites in the office using the vendor's software; and then rate the pavement by walking the sites. His ratings did not agree. I feel that some background information is required for an understanding of the issues we are currently dealing with; with respect to distress data. In the mid-80's DOT developed a PMS based on manual surveys. Prior to the surveys being performed; experienced maintenance engineers (30+ years) looked at many pavements across the state and they gave a grade on the pavement condition. Then distress rating teams collected data on 200'samples where the maintenance engineers had given a grade and this data was then correlated to the maintenance engineers' opinions via a statistically developed algorithm. After it was determined that the algorithm gave similar results to the maintenance engineers opinions; the distress survey teams then went statewide and collected data on 200' samples every mile. The distress data was plugged into the pavement condition rating algorithm and a score was given for each segment. This score was used to prioritize maintenance resurfacing projects for the upcoming paving season. This algorithm was still being used; with little modification; in 1996 when DOT changed from manual distress surveys to automated distress surveys. After 3 cycles of automated distress data was collected it became apparent that the new data were not working with the old algorithm. Our pavement condition ratings were getting better with age. We discovered that the automated system was not adequately capturing the low or mid level distresses. In 2004; we initialized a research project with the goal of developing a new pavement condition rating algorithm based on automated data collection. We also want to get a statistically based QA procedure that looks at the vendor reported distresses vs. agency reported distresses. Also; we want to develop a condition prediction algorithm. This project has; so far; established one thing; it appears that automated distress data collection cannot provide data "good enough" to develop a pavement condition algorithm. Also; comparing vendor data vs. agency data shows that there is little correlation between the two. In fact; when office data from one rater is compared to that same rater's field survey data; there is little correlation.

APPENDIX D

Example of Pavement Condition Data Collection Request for Proposal—Louisiana Department of Transportation and Development

STATE OF LOUISIANA
Department of Transportation and Development

REQUEST FOR PROPOSALS
FOR
State Project No. 736-99-1362
F.A.P. No. SPR-0010(029)
Pavement Distress Data Collection
Statewide

January 13, 2006

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1.0. GENERAL INFORMATION

1.1 Purpose

This Request for Proposals (RFP) is issued by the Department of Transportation and Development (herein referred to as DOTD) for the purpose of providing pavement distress data. One Prime-Consultant/Sub-Consultant(s) (Consultant/Team) will be selected for this Contract.

The selected Consultant will use automated means to collect pavement condition, right of way (ROW)/shoulder images, and pavement images on approximately 20,000 directional miles of the State highway network over one data collection cycle. The system consists of asphalt-surfaced roads, concrete-surfaced roads, brick-surfaced roads and gravel-surfaced roads. The data will be used in a network-level pavement management system, and portions of the data are also necessary for Highway Performance Monitoring System (HPMS) data submittal.

The selected consultant will provide a plan of procedures and techniques to be used to collect each data element. The collection and analysis methods used must be able to analyze condition data by type, extent, and (where applicable) severity at the specified level of detail as set forth in the “Louisiana Cracking and Patching Protocol for Concrete Pavements” and “Louisiana Cracking and Patching Protocol for Asphalt Surface Pavements”.

1.2 Scope of Services

Attachment I details the scope of services and deliverables or desired results that DOTD requires of the Consultant.

1.3 Project Manager

The Project Manager is Mr. Said Ismail, P.E.; he may be reached at (225) 242-4547.

2.0 ADMINISTRATIVE INFORMATION

2.1 Expected Time Period for Contract

The period of any contract resulting from this RFP is tentatively scheduled to begin on or about **May 01, 2006** and to continue through **April 30, 2008.** The data collection cycle is expected to start on August 01, 2006, and be completed no later than May 01, 2007.

2.2 RFP Coordinator

Requests for copies of the RFP and written questions must be directed to the RFP Coordinator listed below:

Dr. Babak Naghavi, P.E., P.H.
Consultant Contract Services Administrator
1201 Capitol Access Road, **Room 405-T**
Baton Rouge, LA 70802-4438 or
Post Office Box 94245

Baton Rouge, Louisiana 70804-9245
Telephone: (225) 379-1989
Fax: (225) 379-1859

This RFP is available in electronic form at http://webmail.dotd.state.la.us/AgreStat.nsf/WebView?OpenPage and http://wwwsrch2.doa.state.la.us/osp/lapac/pubmain.asp, or in printed form by submitting a written request to the RFP Coordinator.

2.3 Consultant Inquiries

DOTD will consider written consultant inquiries regarding RFP requirements or Scope of Services before the date specified in the Calendar of Events. DOTD reserves the right to modify the RFP should a change be identified that is in the best interest of DOTD.

To be considered, written inquiries and requests for clarification of the content of this RFP must be received at the above address or via fax by 3:00 p.m. CST on the date specified in the Calendar of Events. Any and all questions directed to the RFP Coordinator will be deemed to require an official response. Official responses to each of the questions presented by the consultant will be posted on the DOTD Consultant Contract Services and LaPAC websites as an Addendum to the RFP by the deadline shown in the Calendar of Events.

2.4 Notice of Intent to Submit

A written Notification of Intent to Submit must be received by the RFP Coordinator by the submission deadline shown in the Calendar of Events.

2.5 Pre-proposal Conference

A ***mandatory*** pre-proposal conference will be held at **8:30 a.m. CST, February 03, 2006** in the DOTD Auditorium located in the DOTD Headquarters Building, 1201 Capitol Access Road, Baton Rouge, LA. Prospective Consultants should participate in the conference to obtain clarification of the requirements of the RFP and to receive answers to relevant questions. Consultants will be required to demonstrate their ability to collect and reduce data over eight half-mile segments and one mile segment. There will be no compensation for this demonstration. This demonstration will provide DOTD evidence of the Firm's understanding of the project requirements. Any Consultant/team intending to submit a proposal should have at least one duly authorized representative attend the Pre-proposal Conference.

Although questions will be permitted and answers will be provided during the conference, the only official answer or position of DOTD will be stated in writing in response to written questions. Therefore, Consultants should submit all questions in writing (even if an answer has already been given to an oral question). After the conference, questions will be researched and the official response distributed on the date specified in the Calendar of Events.

2.5 Calendar of Events

Event	**Date**
Advertise RFP and mail public announcements	January 13, 2006
Deadline for written notification of intent to submit	January 23, 2006
Pre-proposal conference	February 03, 2006
Beginning of Field Trials	February 06, 2006
Deadline for receiving Consultant inquiries	February 24, 2006
Issue responses to Consultant inquiries	March 03, 2006
Proposal submission deadline	March 20, 2006
Announce Award of "Successful Consultant"	March 31, 2006
Contract execution	May 01, 2006

NOTE: DOTD reserves the right to amend and/or change this schedule of RFP activities, as it deems necessary.

3.0 PROPOSAL INFORMATION

3.1 Proposal Response Location

Consultants who are interested in providing consulting services under this RFP must submit all proposals containing the information specified in Section 4.0. The fully completed original proposal with original signatures by an authorized representative and all copies must be received in hard copy (printed) version by the RFP Coordinator designated above by the deadline date specified in the Calendar of Events. Fax or e-mail submissions are not acceptable.

3.2 Determination of Responsibility

Determination of the Consultant's responsibility relating to this RFP shall be made according to the standards set forth in LAC 34: 136. DOTD must find that the Consultant:

- ✓ Has adequate financial resources for performance, or has the ability to obtain such resources as required during performance;
- ✓ Has the necessary experience, organization, technical qualifications, skills, and facilities, or has the ability to obtain them'
- ✓ Is able to comply with the proposed or required time of delivery or performance schedule;
- ✓ Has a satisfactory record of integrity, judgment, and performance; and

- ✓ Is otherwise qualified and eligible to receive an award under applicable laws and regulations.

3.3 Minimum Qualifications of Consultant

The Consultant must show the necessary expertise, personnel, and equipment necessary to perform the work outlined in the Scope of Services (Attachment I). The Consultant's Firm must have a minimum of three years experience in pavement data collection, and the Project Manager must have a minimum of five years experience in pavement data collection. These requirements must be met at the time of submittal.

The Consultant should ensure that their proposals contain sufficient information for DOTD to make its determination by presenting acceptable evidence of the above to perform the services called for by the contract.

3.4 Revisions to the RFP

DOTD reserves the right to change the calendar of events or revise any part of the RFP by issuing an addendum to the RFP at any time.

3.5 Waiver of Administrative Informalities

DOTD reserves the right, at its sole discretion, to waive administrative informalities contained in any proposal.

3.6 Proposal Rejection

Issuance of this RFP in no way constitutes a commitment by DOTD to award a contract. DOTD reserves the right to accept or reject, in whole or part, all proposals submitted and/or cancel this announcement if it is determined to be in DOTD's best interest.

3.7 Withdrawal and Re-submission of Proposal

A Consultant may withdraw a proposal that has been submitted at any time up to the date and time the proposal is due. To accomplish this, a written request signed by the authorized representative of the Consultant must be submitted to the RFP Coordinator.

3.8 Subcontracting Information

DOTD shall have a single Prime-Consultant as the result of any contract negotiation, and that Prime-Consultant shall be responsible for all deliverables referenced in the RFP or proposal. This general requirement notwithstanding, Consultants may enter into Sub-Consultant arrangements, however the Prime-Consultant should acknowledge in their proposal total responsibility for the entire contract.

If the Consultant intends to subcontract for portions of the work, the Consultant should include specific designations of the tasks to be performed by the Sub-Consultant. Information required of the Consultant under the terms of this RFP is also required for each Sub-Consultant.

Unless provided for in the contract with DOTD, the Prime-Consultant shall not contract with any other party for furnishing any of the work and professional services herein contracted for without the express written approval of DOTD.

3.9 Ownership of Proposal

All materials submitted in response to this request become the property of DOTD. Selection or rejection of a proposal does not affect this right.

3.10 Proprietary Information

Only information, which is in the nature of legitimate trade secrets or non-published financial data, may be deemed proprietary or confidential. Any material within a proposal identified as such must be clearly marked in the proposal and will be handled in accordance with the Louisiana Public Record Act, R.S. 44: 1-44 and applicable rules and regulations. Any proposal marked as confidential or proprietary in its entirety may be rejected without further consideration or recourse.

3.11 Cost of Preparing Proposals

DOTD is not liable for any costs incurred by prospective Consultants prior to issuance of or entering into a contract. Costs associated with developing the proposal, preparing for oral presentations, and any other expenses incurred by the Consultant in responding to this RFP are entirely the responsibility of the Consultant, and shall not be reimbursed in any manner by DOTD.

3.12 Errors and Omissions in Proposal

DOTD will not be liable for any errors in proposals. DOTD reserves the right to make corrections or amendments due to errors identified in proposals by DOTD or the Consultant. DOTD, at its option, has the right to request clarification or additional information from the Consultants.

3.13 Contract Award and Execution

DOTD reserves the right to enter into a Contract without further discussion of the proposal submitted based on the initial offer received. DOTD reserves the right to contract for all or a partial list of services offered in the proposal.

The RFP and proposal of the selected Consultant will become part of any contract initiated by DOTD.

The selected Consultant will be expected to enter into a contract which is basically the same as the sample contract included in Attachment V. In no event is a Consultant to submit its own standard contract terms and conditions as a response to this RFP. The Consultant should submit with their proposal any exceptions or exact contract deviations that their firm wishes to negotiate. Negotiations may begin with the announcement of the selected Consultant.

If the contract negotiation period exceeds ten working days or if the selected Consultant fails to sign the final contract within ten working days of delivery of it, DOTD may elect to cancel the award and award the contract to the next-highest-ranked Consultant.

3.14 Code of Ethics

Consultants are responsible for determining that there will be no conflict or violation of the Ethics Code if their company is awarded the contract. Ethics issues are interpreted by the Louisiana Board of Ethics.

4.0 RESPONSE INSTRUCTIONS

4.1 Proposal Submission

One original (**stamped original**) and four copies of the proposal should be submitted to DOTD. Any Consultant/Team failing to submit any of the information required in this RFP will be considered non-responsive.

The proposal will be identified with the State Project No. **736-99-1362** and will be submitted **prior to 3:00 p.m. CST on March 20, 2006**, by hand delivery or mail addressed to:

Dr. Babak Naghavi, P.E., P.H.
Consultant Contract Services Administrator
1201 Capitol Access Road, **Room 405-T**
Baton Rouge, LA 70802-4438 or
Post Office Box 94245
Baton Rouge, Louisiana 70804-9245
Telephone: (225) 379-1989
Fax: (225) 379-1859

The proposal must be signed by those company officials or agents duly authorized to sign proposals or contracts on behalf of the organization. A certified copy of a board resolution granting such authority should be submitted.

It is solely the responsibility of each Consultant to assure that their proposal is delivered at the specified place and prior to the deadline for submission. Proposals, which for any reason are not received timely, will not be considered.

4.2 Cover Letter

A cover letter should be submitted on the Consultant's official business letterhead explaining the intent of the Consultant.

4.3 Proposal Format

The Consultant should submit a proposal as specified in Attachment II (S.F. DOTD 24-102 or similar format) which shall include adequate information that the Consultant has the appropriate experience and qualifications to perform the scope of services as described herein. In Section 14 of the S.F. DOTD 24-102 (or similar format), the Consultant should submit a work plan reflecting their understanding of the project. The Consultant should respond to all areas requested.

4.4 Price Proposal

The Consultant should submit a Price Proposal (included in Section 14 of the SF 24-102 or similar format) to perform the services shown in the Scope of Services.

4.5 Certification Statement

The Consultant must sign and submit the Certification Statement shown in Attachment IV.

5.0 EVALUATION AND SELECTION

5.1 Evaluation Team

The evaluation of proposals will be accomplished by the Project Technical Selection Committee, which will determine the proposal most responsive and advantageous to DOTD.

5.2 Administrative and Mandatory Screening

All proposals will be reviewed to determine compliance with administrative and mandatory requirements as specified in the RFP. Proposals found not to be in compliance will be rejected from further consideration.

5.3 Evaluation and Review

Each proposal will be rated from 0 to 4 for criteria one through four. For reference, the ratings are based on the following:

0	-	Unsatisfactory
1	-	Poor
2	-	Fair
3	-	Good
4	-	Excellent

Each Consultant will receive a price score computed as follows:

$$\text{Price Score} = \frac{\text{Lowest Proposed Total Price x 36}}{\text{Consultant's Proposed Total Price}}$$

Each applicable criterion (1-4) also has a weighting factor that is applied to place them in the proper relationship with each other.

CRITERIA	WEIGHTING FACTOR	HIGHEST POSSIBLE SCORE
1) Firm experience on similar projects	4	16
2) Personnel experience as related to the project	4	16
3) Consultant's understanding of the project requirements, evidenced in the proposed work plan (Section 14 of the S.F. 24-102 or similar format)	4	16
4) Consultant's understanding of the project requirements, evidenced in the field trials	4	16
5) Price	-	36
Total	-	**100**

The Project Technical Selection Committee will compile the scores and make a recommendation to the secretary based on highest score. The award of a contract is subject to the approval of the Division of Administration, Office of Contractual Review.

5.4 Announcement of Consultant

DOTD will notify the successful Consultant and proceed to negotiate terms for final contract. Unsuccessful Consultants will be notified in writing accordingly.

6.0 CONSULTANT REQUIREMENTS

6.1 Corporation Requirements

Upon the award of the contract, if the Consultant is a corporation not incorporated under the laws of the State of Louisiana, the Consultant shall have obtained a certificate of authority pursuant to R. S. 12:301-302 from the Secretary of State of Louisiana prior to the execution of the contract. Upon the award of the contract, if the Consultant is a for-profit corporation whose stock is not publicly traded, the Consultant shall ensure that a disclosure of ownership form has been properly filed with the Secretary of State of Louisiana.

6.2 Compensation

Compensation to the Consultant for the services rendered for this Project shall consist of the proposed lump sum by the Consultant for all services for a period of two years, payable in installments as specified in 6.3, Billing and Payment.

6.3 Billing, Payment, and Damages

Payments to the Consultant for services rendered shall be made based on a certified invoice directly proportional to the percentage of completed work as shown in the monthly progress schedule. The monthly progress schedule shall: a) show in detail the status of the work; b) be subdivided into appropriate Stages with estimated percentages for each Stage, and c) be of a form and with a division of items as approved by the DOTD. The allowable costs shall be in accordance with the cost principles and procedures set forth in 48 CFR 31, as appropriate.

The Consultant will submit invoices as outlined below:

Invoice 1	Preliminary Activities @ 5% of lump sum value plus any hardware invoices
Invoice 2*	District delivery and acceptance
Invoice 3*	District delivery and acceptance
Invoice 4*	District delivery and acceptance
Invoice 5*	District delivery and acceptance
Invoice 6*	District delivery and acceptance
Invoice 7*	District delivery and acceptance
Invoice 8*	District delivery and acceptance
Invoice 9*	District delivery and acceptance
Invoice 10*	District delivery and acceptance
Invoice 11	Submittal of Final Reports and supporting documentation @ 5% of lump sum value
Invoice 12	Retainage recovery
*Each District will be invoiced @ 10% of lump sum value.	

The Consultant will develop and present a master schedule for the Pavement Condition data collection and Distress quantification for each District. Failure of the Consultant to deliver the required number of Districts within the time frame will be subject to damages at $300 per day. Failure to complete the delivery of all nine Districts quantified pavement distress data will be subject to damages at $500 per day. Failure to complete delivery of the Final Report will subject the Consultant to damages at $300 per day until all deliverables have been accepted.

The original and three copies of the invoice shall be submitted to the Project Manager. The invoice must be signed and dated by a principal member of the Consultant's firm.

Upon receipt of each invoice, the DOTD shall pay the amount due within 30 calendar days, according to Louisiana R.S. 251.5.

NOTE: All travel related expenses will be compensated under direct expenses and will be in accordance with Louisiana Office of State Travel regulations found at: http://www.state.la.us/osp/travel/travelOffice.htm.

6.4 Contract Terms & Conditions

The Consultant will be required to enter into a Contract with DOTD that is basically the same as Attachment V. Any changes to those terms will be negotiated if state law allows such egotiation.

6.5 Indemnification

Neither party shall be liable for any delay or failure in performance beyond its control resulting from acts of God or force majeure. The parties shall use reasonable efforts to eliminate or minimize the effect of such events upon performance of their respective duties under Contract.

Consultant shall be fully liable for the actions of its agents, employees, partners or Sub-Consultants and shall fully indemnify and hold harmless DOTD and its Authorized Users from suits, actions, damages and costs of every name and description relating to personal injury and damage to real or personal tangible property caused by Consultant, its agents, employees, partners or Sub-Consultants, without limitation; provided, however, that the Consultant shall not indemnify for that portion of any claim, loss or damage arising hereunder due to the negligent act or failure to act of DOTD.

Consultant will indemnify, defend and hold DOTD and its Authorized Users harmless, without limitation, from and against any and all damages, expenses (including reasonable attorneys' fees), claims, judgments, liabilities and costs which may be finally assessed against DOTD in any action for infringement of a United States Letter Patent with respect to the Products furnished, or of any copyright, trademark, trade secret or intellectual property right, provided that DOTD shall give the Consultant: (i) prompt written notice of any action, claim or threat of infringement suit, or other suit, (ii) the opportunity to take over, settle or defend such action, claim or suit at Consultant's sole expense, and (iii) assistance in the defense of any such action at the expense of Consultant. Where a dispute or claim arises relative to a real or anticipated infringement, DOTD or its Authorized Users may require Consultant, at its sole expense, to submit such information and documentation, including formal patent attorney opinions, as the Commissioner of Administration shall require.

The Consultant shall not be obligated to indemnify that portion of a claim or dispute based upon: i) Authorized User's unauthorized modification or alteration of a Product; ii) Authorized User's use of the Product in combination with other products not furnished by Consultant; iii) Authorized User's use in other than the specified operating conditions and environment.
In addition to the foregoing, if the use of any item(s) or part(s) thereof shall be enjoined for any reason or if Consultant believes that it may be enjoined, Consultant shall have the right, at its own expense and sole discretion as the Authorized User's exclusive remedy to take action in the following order of precedence: (i) to procure for DOTD the right to continue using such item(s) or part (s) thereof, as applicable; (ii) to modify the component so that it becomes non-infringing equipment of at least equal quality and performance; or (iii) to replace said item(s) or part(s) thereof, as applicable, with non-infringing components of at least equal quality and performance, or (iv) if none of the foregoing is commercially reasonable, then provide monetary compensation to DOTD up to the dollar amount of the Contract.

For all other claims against the Consultant where liability is not otherwise set forth in the Contract as being "without limitation", and regardless of the basis on which the claim is made, Consultant's liability for direct damages, shall be the greater of $100,000, the dollar amount of the Contract, or two (2) times the charges rendered by the Consultant under the Contract. Unless otherwise specifically enumerated herein or in the work order mutually agreed between the parties, neither party shall be liable to the other for special, indirect or consequential damages, including lost data or records (unless the Consultant is required to back-up the data or records as part of the work plan), even if the party has been advised of the possibility of such damages. Neither party shall be liable for lost profits, lost revenue or lost institutional operating savings.

DOTD and Authorized User may, in addition to other remedies available to them at law or equity and upon notice to the Consultant, retain such monies from amounts due Consultant, or may proceed against the performance and payment bond, if any, as may be necessary to satisfy any claim for damages, penalties, costs and the like asserted by or against them.

6.6 Confidentiality

All financial, statistical, personal, technical and other data and information relating to DOTD's operation which are designated confidential by DOTD and made available to the consultant in order to carry out this contract, or which become available to the Consultant in carrying out this contract, will be protected by the Consultant from unauthorized use and disclosure through the observance of the same or more effective procedural requirements as are applicable to DOTD. The identification of all such confidential data and information as well as DOTD's procedural requirements for protection of such data and information from unauthorized use and disclosure will be provided by DOTD in writing to the Consultant. If the methods and procedures employed by the Consultant for the protection of the Consultant's data and information are deemed by DOTD to be adequate for the protection of DOTD's confidential information, such methods and procedures may be used, with the written consent of DOTD, to carry out the intent of this paragraph. The Consultant will not be required under the provisions of the paragraph to keep confidential any data or information, which is or becomes publicly available, is already rightfully in the Consultant's possession, is independently developed by the consultant outside the scope of the contract, or is rightfully obtained from third parties.

Under no circumstance is the Consultant to discuss and/or release information to the media concerning this project without prior express written approval of the DOTD.

ATTACHMENT I
SCOPE OF SERVICES

SCOPE OF SURVEY

A. Approximately 20,000 directional miles of pavement condition data will be collected during the data collection cycle. Both directions shall be collected on interstates and multi-lane, divided highways, and one direction shall be collected for two lane highways. The Consultant will also collect, for the opposite direction, only the right way images not specified for pavement condition analysis on approximately 15,000 miles of the state network.

B. The following data will be reported for every 0.100 mile of the surveyed length on all Control Sections:
- GPS Coordinates (longitude, latitude and elevation)
- International Roughness Index (IRI) (measured in inches per mile)
- Bridges (count)

C. The following data will be reported for every 0.100 mile of the surveyed length on all Control Sections that consist of Portland cement concrete pavements:
- Transverse cracking (measured in linear feet)
- Longitudinal cracking (measured in linear feet)
- Joint Faulting (measured in inches), (count of positive faulting), (count of negative faulting)
- Patching (measured in square feet) (count)
- Blowups (measured in square feet) (count)
- Punch outs (Continuously Reinforced Concrete only) (measured in square feet), (count)

D. The following data will be reported for every 0.100 mile of the surveyed length on all Control Sections that consist of asphalt-surfaced pavements:
- Alligator Cracking (measured in square feet)
- Random Cracking (measured in linear feet)
    - Block cracking
    - Longitudinal cracking
    - Transverse cracking
- Rutting (measured in inches)
- Patching (measured in square feet), (count)
- Blowups (measured in square feet), (count)
- Potholes (count)

DELIVERABLES

A. Grayscale digital images shall be collected by one or more cameras oriented normal to the pavement for distress identification and shall provide coverage of greater than 12 feet of the survey lane. These images should contain minimal shadows. The resolution of the pavement images shall be sufficient to identify cracks of 0.125 inch in width when traveling at survey speed. The pavement images shall be provided on USB 2.0 hard drives or other approved storage media.

B. The quantified pavement condition data shall be delivered using the database shell which will be provided for the Consultant. The structure of the data will be agreed upon with the Consultant prior to the beginning of the contract.

C. Color digital images of the right of way shall be collected by one camera and delivered in .jpg format. The collected images shall show the right of way and as much as possible of the left and right shoulder. The right of way images should be collected at a minimum of 0.002 miles (10.56 feet). The Consultant shall attach distinguishing information to each image specifically identifying District number, Parish number, Control Section, Route, Direction, Control Section Logmile, Speed, Date, and GPS Coordinates of Collection. The Consultant will be responsible for providing a means to simultaneously view and process (i.e., play) all associated images; the provided means should include the synchronization of the pavement and right of way images. The provided means should also be able to operate on most personal computers thus allowing virtually any user to review the images and data from an IBM compatible personal computer. The provided mean should include the necessary software licenses (if applicable) for DOTD Headquarters office and all District offices. The data should be summarized to 0.100 miles and also be synchronized with the pavement and right of way images. The images and data should use a location reference method such as by District, Parish, Route, Control Section and Direction. The right of way images shall be provided on USB 2.0 hard drives or other approved storage media.

D. The Consultant shall supply a workstation at DOTD offices in Baton Rouge, Louisiana for DOTD's use that shall duplicate the means the Consultant uses to evaluate digital images and distress data. The workstation shall include all necessary software licenses (as applicable) that do not expire. The workstation must allow DOTD to review and verify the quantity of distresses determined by the Consultant from pavement images. The workstation shall also have software that allows the user to automatically retrieve a specific segment of road and view its right of way and pavement images by entering the District, Parish, Route, Control Section Direction and Control Section Logmile. The Consultant shall provide training to DOTD personnel for operating the workstation and shall furnish copies of all manuals duration of the contract. The CONSULTANT shall maintain, repair, and update this workstation for the duration of the contract. After the end of the contract, DOTD will return the workstation to the Consultant. The workstation shall be configured with the ability to allow a minimum of four USB 2.0 drives, or other approved media, to be connected to the workstation at the same time. The workstation should also be configured to connect to DOTD's network using a Gigabit Ethernet connection. The Consultant shall also provide to DOTD the software used for viewing the Images and data. This software shall have the ability to access the digital images and pavement distress data via the DOTD statewide network and allow unlimited users. DOTD will retain user rights to this software after the project completion.

E. DOTD personnel will evaluate the pavement images and condition data summary. If discrepancies are found, the Consultant shall be required to re-rate the entire Control Section in which discrepancies were found. Failure to correct the Control Section and deliver the District(s) condition data as outlined in the master schedule will subject the Consultant to damages.

F. DOTD personnel will evaluate the right of way images for quality assurance. Any necessary corrections are to be made by the Consultant. Failure to correct the Control Section and deliver the District(s) condition data as outlined in the master schedule will subject the Consultant to damages.

G. The Consultant shall collect rutting data using a Laser Rut Measurement System (or similar product).

H. The Consultant shall provide a web-enabled viewer for the right of way images. This would allow anyone, using any web browser, to view the right of way images VIA an internet/intranet connection.

I. The Consultant shall deliver only the right of way images that were collected, on a weekly basis. The means provided by the Consultant shall allow DOTD to automatically retrieve a specific segment of road, using the workstation or any IBM compatible personal computer. The weekly delivery should also include the raw data from the Consultant's Data Collection Vehicle's electronic sensors (rutting, IRI, faulting and GPS data). All weekly equipment calibrations test results (i.e. DMI, rut measurement device, video foot print, etc.) and electronic sensor verification results should be included in the weekly delivery.

J. The Consultant shall provide a means of giving any user the ability to make measurements of highway features/assets from the right of way images.

K. The Consultant will provide a Storage Area Network (SAN) server for the DOTD Headquarters building, and nine Network-Attached Storage (NAS) type devices, one to each DOTD District office. Each of the NAS devices will be appropriate in size to house all the digital images and pavement condition data for that District. (Server specifications and vendor source and approximate cost will be provide by DOTD prior to proposal submittal).

L. The Consultant shall collect, for the opposite direction, only the right of way images not specified for pavement condition analysis on approximately 15,000 miles of the state highway network.

M. The Consultant shall provide all collected electronic data at the smallest possible interval.

N. The Consultant shall provide pricing for the following options:

- Vertical Clearance Measurements
  These measurements shall be taken of all overhead obstructions.

- Geotechnical (Cross-slope) information
- Collection of pavement marking reflectivity from the surveyed lane.
- Collection of ROW digital images for Ramps along the State Highway network.

OBLIGATION OF DOTD TO CONSULTANT

DOTD will provide the base data items necessary for the data collection, including a Control Section map for each District and the approximate location of each multilane, divided highways. DOTD will designate the lane(s) and direction(s) of travel to be surveyed or rated based on management needs within the agency. In general, the following guidelines will be used to provide long-term uniformity:

• Survey the primary direction (south to north; west to east).
• For multi-lane, divided highways survey the outside lane in both directions.

ATTACHMENT II
PROPOSAL FORMAT

Consultants should submit their proposal to the RFP Coordinator using either the Standard Form DOTD 24-102 (S.F. 24-102) or a similar proposal format that includes all applicable information (in the same order) as the S.F. 24-102. Consultants are not required to be registered with the Louisiana Secretary of State prior to selection. Questions regarding the S.F. 24-102 may be directed to the RFP Coordinator.

The S.F. 24-102 and the Instructions for Completing the S.F. 24-102 may be downloaded from DOTD's Website. The DOTD Website address is http://www.dotd.louisiana.gov and Consultant Contract Services is listed under Doing Business with DOTD, and/or Pre-Construction. The S.F. 24-102 and the Instructions for Completing the S.F. 24-102 are listed under "Forms" on the Consultant Contract Services Website.

ATTACHMENT III - PRICE PROPOSAL

I/We propose to furnish all materials, equipment, travel, and incidentals necessary to provide the scope of services as outlined in this RFP for the sum of:

- $__________________________ (Total Price)
- $__________________________ (Price per mile for pavement condition data and analysis)

NOTE: All travel related expenses will be compensated under direct expenses and will be in accordance with Louisiana Office of State Travel regulations found at: http://www.state.la.us/osp/travel/travelOffice.htm.

Name of Firm: ____

Address of Firm: ____

____

____

Telephone Number: ____

Signature: ____

Name and Title: ____

Date: __________________________

ATTACHMENT IV
CERTIFICATION STATEMENT

The undersigned hereby acknowledges she/he has read and understands all requirements and specifications of the Request for Proposals (RFP), including attachments.

OFFICIAL CONTACT. DOTD requires that the Consultant designate one person to receive all documents and the method in which the documents are best delivered. Identify the Contact name and fill in the information below: (Print Clearly):
Date: ______________________ Official Contact Name:______________________________________

A. E-mail Address: ____

B. Facsimile Number with area code: (______)________________________

C. US Mail Address: ____

D. Telephone Number: ____

Consultant certifies that the above information is true and grants permission to DOTD or Agencies to contact the above named person or otherwise verify the information I have provided.

By its submission of this proposal and authorized signature below, Consultant certifies that:

(1) The information contained in its response to this RFP is accurate;

(2) Consultant complies with each of the mandatory requirements listed in the RFP and will meet or exceed the functional and technical requirements specified therein;

(3) Consultant accepts the procedures, evaluation criteria, contract terms and conditions, and all other administrative requirements set forth in this RFP.

(4) Consultant's quote is valid for at least one year from the date of Consultant's signature below;

(5) Consultant understands that if selected as the successful Consultant, he/she will have (#) business days from the date of delivery of final contract in which to complete contract negotiations, if any, and execute the final contract document.

Authorized Signature: ____

Typed or Printed Name: ____

Title: ____

Company Name: ____

Address:____

City: ____________________________________ State:_________ Zip: ________________

____/___________________
SIGNATURE of Consultant's Authorized Representative DATE

ATTACHMENT V

SAMPLE

CONSULTING SERVICES CONTRACT

STATE OF LOUISIANA
DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

CONTRACT FOR SPECIAL SERVICES
STATE PROJECT NO. 736-99-1362
FEDERAL AID PROJECT NO. SPR-0010(029)
PAVEMENT DISTRESS DATA COLLECTION
STATEWIDE

On this _____day of _____________ , 2005, the State of Louisiana through the Louisiana Department of Transportation & Development, hereinafter sometimes referred to as “DOTD”, and **XXX, Inc., XXXXX Baton Rouge, Louisiana, 70809**, hereinafter sometimes referred to as “Consultant”, do hereby enter into a Contract under the following terms and conditions.

Scope of Services

Attachment I details the Scope of Services and the Functional and Technical Requirements of the Consultant.

Substitution of Key Personnel

The Consultant’s key personnel assigned to this Contract may not be removed, replaced, or substituted without the written consent of the DOTD. Consent shall not be unreasonably withheld or delayed provided an equally qualified replacement is offered. In the event that any Consultant personnel become unavailable due to resignation, illness, or other factors outside of the Consultant’s control, excluding assignment to a project outside of the Contract, the Consultant shall be responsible for providing an equally qualified replacement to avoid delays in completing tasks. Any such replacement of key personnel must be approved by DOTD.

Term of Contract

This Contract shall begin on **XXX 01, 200X,** and shall end on **XXX 31, 200X**, unless modified by an executed supplemental agreement. Notwithstanding the foregoing, in no event shall this Contract be valid until it has been approved, in writing, by the Director of the Office of Contractual review of the Division of Administration. Such approval authorizes a Contract term for not more than three years.

DOTD Furnished Resources

Mr. Said Ismail will serve as the DOTD Project Manager for this Contract. The DOTD Project Manager shall provide oversight of the activities conducted hereunder. Notwithstanding the Consultant’s responsibilities for the performance of this Contract, the DOTD Project Manager shall be the principal point of contact on behalf of the DOTD and shall be the principal point of contact for Consultant.

Taxes

Consultant is responsible for payment of all applicable taxes from the funds to be received under this Contract. Consultant's federal tax identification number is **XX-XXXXXX**.

Compensation

Compensation to the Consultant for the services rendered for this Project shall consist of the proposed lump sum by the Consultant for all services for a period of two years, payable in monthly installments as specified in the Payment Terms.

Payment Terms

Payments to the Consultant for services rendered shall be made based on a certified invoice directly proportional to the percentage of completed work as shown in the monthly progress schedule. The monthly progress schedule shall: a) show in detail the status of the work; b) be subdivided into appropriate Stages with estimated percentages for each Stage, and c) be of a form and with a division of items as approved by the DOTD. The allowable costs shall be in accordance with the cost principles and procedures set forth in 48 CFR 31, as appropriate.

The Consultant will submit invoices as outlined below:

Invoice 1	Preliminary Activities @ 5% of lump sum value plus any hardware invoices
Invoice 2*	District delivery and acceptance
Invoice 3*	District delivery and acceptance
Invoice 4*	District delivery and acceptance
Invoice 5*	District delivery and acceptance
Invoice 6*	District delivery and acceptance
Invoice 7*	District delivery and acceptance
Invoice 8*	District delivery and acceptance
Invoice 9*	District delivery and acceptance
Invoice 10*	District delivery and acceptance
Invoice 11	Submittal of Final Reports and supporting documentation @ 5% of lump sum value
Invoice 12	Retainage recovery
*Each District will be invoiced @ 10% of lump sum value.	

The Consultant will develop and present a master schedule for the Pavement Condition data collection and Distress quantification for each District. Failure of the Consultant to deliver the required number of Districts within the time frame will be subject to damages at $300 per day. Failure to complete the delivery of all nine Districts quantified pavement distress data will be subject to damages at $500 per day. Failure to complete delivery of the Final Report will subject the Consultant to damages at $300 per day until all deliverables have been accepted.

The original and three copies of the invoice shall be submitted to the Project Manager. The invoice must be signed and dated by a principal member of the Consultant's firm.

Upon receipt of each invoice, the DOTD shall pay the amount due within 30 calendar days, according to Louisiana R.S. 251.5.

NOTE: All travel related expenses will be compensated under direct expenses and will be in accordance with Louisiana Office of State Travel regulations found at: http://www.state.la.us/osp/travel/travelOffice.htm.

Termination for Cause

DOTD may terminate this Contract for cause based upon the failure of Consultant to comply with the terms and/or conditions of the Contract; provided that the DOTD shall give the Consultant written notice specifying the Consultant's failure. If within thirty (30) days after receipt of such notice, the Consultant shall not have either corrected such failure or, in the case of failure which cannot be corrected in thirty (30) days, begun in good faith to correct said failure and thereafter proceeded diligently to complete such correction, then the DOTD may, at its option, place the Consultant in default and the Contract shall terminate on the date specified in such notice. Failure to perform within the time specified in the solicitation shall constitute a default and may cause cancellation of the Contract. Where the DOTD has determined the Consultant to be in default, the DOTD reserves the right to obtain any or all products or services covered by the Contract on the open market and to charge the Consultant with cost in excess of the Contract price. Until such assessed charges have been paid, no subsequent proposal from the defaulting Consultant shall be considered.

Consultant may exercise any rights available to it under Louisiana law to terminate for cause upon the failure of the DOTD to comply with the terms and conditions of this Contract provided that the Consultant shall give the DOTD written notice specifying the DOTD's failure and a reasonable opportunity for the DOTD to cure the defect.

Termination for Convenience

DOTD may terminate the Contract at any time without penalty by giving thirty (30) days written notice to the Consultant of such termination or negotiating with the Consultant an effective date. Consultant shall be entitled to payment for deliverables in progress, to the extent work has been performed satisfactorily.

Termination for Non-Appropriation of Funds

The continuation of this Contract is contingent upon the appropriation of funds by the legislature to fulfill the requirements of the Contract. If the legislature fails to appropriate sufficient monies to provide for the continuation of the Contract, or if such appropriation is reduced by the veto of the Governor or by any means provided in the appropriations act of Title 39 of the Louisiana Revised Statutes of 1950 to prevent the total appropriation for the year from exceeding revenues for that year, or for any other lawful purpose, and the effect of such reduction is to provide insufficient monies for the continuation of the Contract, the Contract shall terminate on the date of the beginning of the first fiscal year for which funds have not been appropriated.

Indemnification & Limitation of Liability

Neither party shall be liable for any delay or failure in performance beyond its control resulting from acts of God or force majeure. The parties shall use reasonable efforts to eliminate or minimize the effect of such events upon performance of their respective duties under Contract.

Consultant shall be fully liable for the actions of its agents, employees, partners or Sub-Consultants and shall fully indemnify and hold harmless the DOTD and its authorized users from suits, actions, damages and costs of every name and description relating to personal injury and damage to real or personal tangible property caused by Consultant, its agents, employees, partners or Sub-Consultants, without limitation; provided, however, that the Consultant shall not indemnify for that portion of any claim, loss or damage arising hereunder due to the negligent act or failure to act of the DOTD.

Consultant shall indemnify, defend and hold the DOTD and its authorized users harmless, without limitation, from and against any and all damages, expenses (including reasonable attorneys' fees), claims, judgments, liabilities and costs which may be finally assessed against the DOTD in any action for infringement of a United States Letter Patent with respect to the Products furnished, or of any copyright, trademark, trade secret or intellectual property right, provided that the DOTD shall give the Consultant: (i) prompt written notice of any action, claim or threat of infringement suit, or other suit, (ii) the opportunity to take over, settle or defend such action, claim or suit at Consultant's sole expense, and (iii) assistance in the defense of any such action at the expense of Consultant. Where a dispute or claim arises relative to a real or anticipated infringement, the DOTD or its authorized users may require Consultant, at its sole expense, to submit such information and documentation, including formal patent attorney opinions, as the Commissioner of Administration shall require.

The Consultant shall not be obligated to indemnify that portion of a claim or dispute based upon: i) authorized user's unauthorized modification or alteration of a Product; ii) authorized user's use of the Product in combination with other products not furnished by Consultant; iii) authorized user's use in other than the specified operating conditions and environment.

In addition to the foregoing, if the use of any item(s) or part(s) thereof shall be enjoined for any reason or if Consultant believes that it may be enjoined, Consultant shall have the right, at its own expense and sole discretion as the authorized user's exclusive remedy to take action in the following order of precedence: (i) to procure for the DOTD the right to continue using such item(s) or part (s) thereof, as applicable; (ii) to modify the component so that it becomes non-infringing equipment of at least equal quality and performance; or (iii) to replace said item(s) or part(s) thereof, as applicable, with non-infringing components of at least equal quality and performance, or (iv) if none of the foregoing is commercially reasonable, then provide monetary compensation to the DOTD up to the dollar amount of the Contract.

For all other claims against the Consultant where liability is not otherwise set forth in the Contract as being "without limitation", and regardless of the basis on which the claim is made, Consultant's liability for direct damages, shall be the greater of $100,000, the dollar amount of the Contract, or two (2) times the charges rendered by the Consultant under the Contract. Unless otherwise specifically enumerated herein or in the work order mutually agreed between the parties, neither party shall be liable to the other for special, indirect or consequential damages, including lost data or records (unless the Consultant is required to back-up the data or records as part of the work plan), even if the party has been advised of the possibility of such damages. Neither party shall be liable for lost profits, lost revenue or lost institutional operating savings. The DOTD and authorized user may, in addition to other remedies available to them at law or equity and upon notice to the Consultant, retain such monies from amounts due Consultant, or may proceed against the performance and payment bond, if any, as may be necessary to satisfy any claim for damages, penalties, costs and the like asserted by or against them.

Contract Controversies

Any claim or controversy arising out of the Contract shall be resolved by the provisions of Louisiana Revised Statute 39:1524-26.

Fund Use

Consultant agrees not to use Contract proceeds to urge any elector to vote for or against any candidate or proposition on an election ballot nor shall such funds be used to lobby for or against any proposition or matter having the effect of law being considered by the Louisiana Legislature or any local governing authority. This provision shall not prevent the normal dissemination of factual information relative to a proposition on any election ballot or a proposition or matter having the effect of law being considered by the Louisiana Legislature or any local governing authority.

Ownership

All records, reports, documents and other material delivered or transmitted to the Consultant by DOTD shall remain the property of DOTD, and shall be returned by the Consultant to DOTD, and all records, reports, documents and other material delivered or transmitted to the Consultant by the Department of Culture, Recreation, and Tourism, Office of Cultural Development, Division of Archaeology and Division of Historic Preservation shall remain the property of Division of Archeology and Division of Historic Preservation, and shall be returned by the Consultant to the Divisions of Archeology and Historic Preservation at the Consultant's expense, at termination or expiration of this Contract. All records, reports, documents, or other material related to this Contract and/or obtained or prepared by the Consultant in connection with the performance of the services contracted for herein shall become the property of DOTD, and shall, upon request, be returned by the Consultant to DOTD, at the Consultant's expense, at termination or expiration of this Contract.

Assignment

No Consultant shall assign any interest in this Contract by assignment, transfer, or novation, without prior written consent of the DOTD. This provision shall not be construed to prohibit the Consultant from assigning to a bank, trust company, or other financial institution any money due or to become due from approved Contracts without such prior written consent. Notice of any such assignment or transfer shall be furnished promptly to the DOTD.

Right to Audit

The DOTD Auditor, State Legislative auditor, federal auditors and internal auditors of the Division of Administration, or others so designated by the DOA, shall have the option to audit all accounts directly pertaining to the Contract for a period of five (5) years from the date of the last payment made under this Contract. Records shall be made available during normal working hours for this purpose.

Contract Modification

No amendment or variation of the terms of this Contract shall be valid unless made in writing, signed by the parties and approved as required by law. No oral understanding or agreement not incorporated in the Contract is binding on any of the parties.

Confidentiality of Data

All financial, statistical, personal, technical and other data and information relating to the DOTD's operation which are designated confidential by the DOTD and made available to the Consultant in order to carry out this Contract, or which become available to the Consultant in carrying out this Contract, shall be protected by the Consultant from unauthorized use and disclosure through the observance of the same or more effective procedural requirements as are applicable to the DOTD. The identification of all such confidential data and information as well as the DOTD's procedural requirements for protection of such data and information from unauthorized use and disclosure shall be provided by the DOTD in writing to the Consultant. If the methods and procedures employed by the Consultant for the protection of the Consultant's data and information are deemed by the DOTD to be adequate for the protection of the DOTD's confidential information, such methods and procedures may be used, with the written consent of the DOTD, to carry out the intent of this paragraph. The Consultant shall not be required under the provisions of the paragraph to keep confidential any data or information which is or becomes publicly available, is already rightfully in the Consultant's possession, is independently developed by the Consultant outside the scope of the Contract, or is rightfully obtained from third parties. In accordance with the requirements of the Division of Archeology, the Consultant shall maintain the confidentiality of the location of archaeological sites.

Sub-Consultants

The Consultant may, with prior written permission from the DOTD, enter into subcontracts with third parties for the performance of any part of the Consultants duties and obligations. In no event shall the existence of a subcontract operate to release or reduce the liability of the Consultant to the DOTD for any breach in the performance of the Consultant's duties.

Discrimination Clause

The Consultant agrees to abide by the requirements of the following as applicable: Title VI and VII of the Civil Rights Act of 1964, as amended by the Equal Opportunity Act of 1972, Federal Executive Order 11246, the Federal Rehabilitation Act of 1973, as amended, the Vietnam Era Veteran's Readjustment Assistance Act of 1974, Title IX of the Education Amendments of 1972, the Age Act of 1975, and the Consultant agrees to abide by the requirements of the Americans with Disabilities Act of 1990.

Consultant agrees not to discriminate in its employment practices, and will render services under this contract without regard to race, color, religion, sex, sexual orientation, national origin, veteran status, political affiliation, or disabilities.

Any act of discrimination committed by the Consultant, or failure to comply with these statutory obligations when applicable shall be grounds for termination of this contract.

Insurance

Insurance shall be placed with insurers with an A.M. Best's rating of no less than A-:VI. This rating requirement shall be waived for Worker's Compensation coverage only.

Consultant's Insurance: The Consultant shall not commence work under this Contract until he has obtained all insurance required herein. Certificates of Insurance, fully executed by officers of the Insurance Company written or countersigned by an authorized Louisiana state agency, shall be filed with the State of Louisiana for approval. The Consultant shall not allow any Sub-Consultant to commence work on his subcontract until all similar insurance required for the Sub-Consultant has been obtained and approved. If so requested, the Consultant shall also submit copies of insurance policies for inspection and approval of the State of Louisiana before work is commenced. Said policies shall not hereafter be canceled, permitted to expire, or be changed without thirty (30) days notice in advance to the State of Louisiana and consented to by the State of Louisiana in writing and the policies shall so provide.

Compensation Insurance: Before any work is commenced, the Consultant shall maintain during the life of the Contract, Workers' Compensation Insurance for all of the Consultant's employees employed at the site of the project. In case any work is sublet, the Consultant shall require the Sub-Consultant similarly to provide Workers' Compensation Insurance for all the latter's employees, unless such employees are covered by the protection afforded by the Consultant. In case any class of employees engaged in work under the Contract at the site of the project is not protected under the Workers' Compensation Statute, the Consultant shall provide for any such employees, and shall further provide or cause any and all Sub-Consultants to provide Employer's Liability Insurance for the protection of such employees not protected by the Workers' Compensation Statute.

Commercial General Liability Insurance: The Consultant shall maintain during the life of the Contract such Commercial General Liability Insurance which shall protect him, the DOTD, and any Sub-Consultant during the performance of work covered by the Contract from claims or damages for personal injury, including accidental death, as well as for claims for property damages, which may arise from operations under the Contract, whether such operations be by himself or by a Sub-Consultant, or by anyone directly or indirectly employed by either or them, or in such a manner as to impose liability to the DOTD. Such insurance shall name the DOTD as additional insured for claims arising from or as the result of the operations of the Contactor or his Sub-Consultants. In the absence of specific regulations, the amount of coverage shall be as follows: Commercial General Liability Insurance, including bodily injury, property damage and contractual liability, with combined single limits of $1,000,000.

Insurance Covering Special Hazards: Special hazards as determined by the DOTD shall be covered by rider or riders in the Commercial General Liability Insurance Policy or policies herein elsewhere required to be furnished by the Consultant, or by separate policies of insurance in the amounts as defined in any Special Conditions of the Contract included therewith.

Licensed and Non-Licensed Motor Vehicles: The Consultant shall maintain during the life of the Contract, Automobile Liability Insurance in an amount not less than combined single limits of $1,000,000 per occurrence for bodily injury/property damage. Such insurance shall cover the use of any non-licensed motor vehicles engaged in operations within the terms of the Contract on the site of the work to be performed there under, unless such coverage is included in insurance elsewhere specified.

Sub-Consultant's Insurance: The Consultant shall require that any and all Sub-Consultants, which are not protected under the Consultant's own insurance policies, take and maintain insurance of the same nature and in the same amounts as required of the Consultant.

Applicable Law

This Contract shall be governed by and interpreted in accordance with the laws of the State of Louisiana. Venue of any action brought with regard to this Contract shall be in the Nineteenth Judicial District Court, parish of East Baton Rouge, State of Louisiana.

Code of Ethics

The Consultant acknowledges that Chapter 15 of Title 42 of the Louisiana Revised Statutes (R.S. 42:1101 et. seq., Code of Governmental Ethics) applies to the Contracting Party in the performance of services called for in this Contract. The Consultant agrees to immediately notify the DOTD if potential violations of the Code of Governmental Ethics arise at any time during the term of this Contract.

Severability

If any term or condition of this Contract or the application thereof is held invalid, such invalidity shall not affect other terms, conditions, or applications which can be given effect without the invalid term, condition, or application; to this end the terms and conditions of this Contract are declared severable.

Complete Contract

This is the complete Contract between the parties with respect to the subject matter and all prior discussions and negotiations are merged into this Contract. This Contract is entered into with neither party relying on any statement or representation made by the other party not embodied in this Contract and there are no other agreements or understanding changing or modifying the terms. This Contract shall become effective upon final statutory approval.

Order of Precedence

This Contract shall, to the extent possible, be construed to give effect to all of its provisions; however, where provisions are in conflict, first priority shall be given to the provisions of the Contract, excluding the Request for Proposals, its amendments and the Proposal; second priority shall be given to the provisions of the Request for Proposals and its amendments; and third priority shall be given to the provisions of the Proposal.

APPENDIX E

Example of Pavement Condition Data Collection Request for Proposal (Oklahoma DOT)

OKLAHOMA DEPARTMENT OF TRANSPORTATION
REQUEST FOR PROPOSALS FOR
PAVEMENT MANAGEMENT SYSTEM DATA COLLECTION

July 25, 2007

DESCRIPTION: This request for proposals identifies the Oklahoma Department of Transportation's requirements for the automated collection of pavement condition data with sufficient detail and accuracy to evaluate project-level pavement conditions, model pavement deterioration, and perform multi-year planning with a Pavement Management System (PMS). Additional data items necessary for the Highway Performance Monitoring System (HPMS) data submittal are to be collected. This will provide data for use in both network-level pavement management and project-level pavement evaluation.

DEFINITIONS: The term DEPARTMENT shall mean the Oklahoma Department of Transportation (ODOT), 200 NE 21st Street, Oklahoma City, Oklahoma 73105. The term CONSULTANT shall mean the offeror awarded the contract.

GENERAL QUALIFICATIONS FOR DATA COLLECTION: All offerors must have performed pavement condition data collection of a similar size and scope for other state departments of transportation, and this fact should be supported by references.

QUALITY CONTROL/ASSURANCE PLAN: Offerors shall submit a quality control plan as described herein. The collected data shall, at the minimum, be able to satisfy the requirements explained in Appendix 1. The CONSULTANT shall be responsible for resurveying, in a timely manner, any segments of roadway for which the delivered data do not meet the specified quality standards. Acceptance of the final data submission shall be made in writing by the DEPARTMENT'S Contract Administrator.

COLLECTION METHODS: Using a vehicle traveling at or near highway speeds, the CONSULTANT shall collect data on the entire length of each segment. The CONSULTANT shall provide a plan of procedures and techniques to be used to collect each data element. The collection and analysis methods used must be able to analyze distresses by type, extent, and severity at the specified level of accuracy, resolution, and repeatability as set forth in Appendix 1.

The DEPARTMENT shall provide the base data items necessary for the data collection, including maps, route numbers, counties, control sections, subsections, ending of subsection descriptions, segment length, number of lanes, lane miles, and HPMS number (if applicable). The DEPARTMENT shall designate the lane(s) and direction(s) of travel to be surveyed or rated based on management needs within the agency. In general, the following guidelines will be used to provide long-term uniformity:

a. Survey the outside lane.
b. For undivided highways survey one direction (to be provided by the DEPARTMENT).
c. For divided highways survey the outside lane in both directions.
d. For each survey cycle use the same direction(s) of travel and survey lane(s) as any previous survey, unless directed otherwise by the DEPARTMENT.

DATA COLLECTION CYCLE: Approximately 16,700 lane-miles of state highway system pavement condition data will be collected on a two-year cycle with about half of the mileage collected each year. The National Highway System (NHS) routes (5,322 lane-miles) and approximately one-fourth of the non-NHS routes (about 3,008 lane-miles) will be collected the first year of the cycle. The remaining three-fourths of the non-NHS routes (about 8,330 lane-miles) will be collected the second year of the cycle. An additional 700–800 centerline miles of non-highway HPMS sample sections are to be collected.

DISTRESSES TO BE COLLECTED: Distresses shall be collected over 100 percent of the length of the network and reported at 0.01 mile increments. See Appendix 2 for a list of the data items to be collected.

DATA REPORTING FORMAT: Data will be provided in an Access database, unless otherwise specified by the DEPARTMENT. The DEPARTMENT will provide a database shell to be populated with final data by the CONSULTANT.

VIDEO OR DIGITAL IMAGE COLLECTION: The CONSULTANT shall provide options and costs (including any software required for viewing) to collect video or digital images of the pavement and right-of-way (ROW). Past image collection has included two forward facing ROW cameras, one rear facing ROW camera and the pavement video. CONSULTANT may be required to provide thumbnail images for use with the DEPARTMENT'S web-based video log software.

DELIVERY OF DATA: The CONSULTANT may use any practical means to provide the data to the DEPARTMENT and shall provide the necessary hardware and/or software to transfer the data to the DEPARTMENT'S computer system. A backup copy of the final, processed data and images shall be provided by the CONSULTANT on permanent storage media.

PERIOD OF CONTRACT: The CONSULTANT will be responsible to collect, process, and deliver highway condition data for a two-year collection cycle. The DEPARTMENT may choose to renew the contract for an additional one successive cycle of data collection (one survey per year for a total of two additional years).

SUBCONTRACTS: The CONSULTANT shall not subcontract any portion of the work items of this contract without approval of the DEPARTMENT.

BASIS FOR AWARD: The DEPARTMENT reserves the right to award—without discussion—any contract to the offeror whose initial proposal is determined to be within the competitive range, offers the best value, and is most advantageous to the DEPARTMENT. To the extent that the DEPARTMENT does not exercise its reserved right to make an award without discussion, the DEPARTMENT will invite those offerors whom the DEPARTMENT determines are within the competitive range to make an oral presentation and to participate in a demonstration to collect specified condition data at ODOT control sites (see Appendix 3).

The specific evaluation criteria for the initial proposal are: (1) Past Performance, (2) Relevant Technical and Staffing Capabilities, (3) Quality Control/Quality Assurance Plan, and (4) Price. When evaluating relevant capabilities of the remaining offerors, the DEPARTMENT will consider the information provided by the offerors via their presentation/demonstration and any other information obtained by the DEPARTMENT through its own research.

GENERAL REQUIREMENTS FOR PROPOSALS: To be considered, offerors must submit three (3) copies of their proposal by the stated closing date and time, which shall include the following information:

1. Business Organization—The full name and address of the organization and, if applicable, the branch office or subordinate element that will perform or assist in performing the work. Indicate whether the company operates as an individual, partnership, or corporation. If as a corporation, include the state in which the company is incorporated.

2. Project Approach and Work Plan—A description of the scope, effort, and approach that will be utilized to accomplish the work. Provide a plan of procedures and techniques to be used to collect each data element. Specify the method to be used for analysis of patching and cracking data, such as automated computer pavement distress analysis or post-collection video analysis.

3. Quality Control/Quality Assurance Plan—Submit a quality control plan which covers all data elements and includes procedures to detect and correct equipment malfunctions, data processing errors, and errors in data accuracy, resolution, and repeatability in a timely fashion. Include a description of when and how the checks will be made, the qualifications of those conducting the checks, the percentage of data that will be checked, and how errors will be reported and corrected.

4. Consultant Qualifications and Prior Experience—Submit information on all contracts/subcontracts involving similar or related services over the past three years. The information must include:

- Customer name and address
- Point of contact for each customer (name and telephone number)
- Date of contract award and period of performance
- Type of contract and brief description of services
- Total contract dollar value at time of award

The DEPARTMENT may contact previous customers to obtain information regarding past performance. Offerors must identify any contract that was terminated for convenience of the customer within the past three years, and any contract that was terminated for default within the past five years. Failure to provide complete information regarding previous similar and/or related contracts may result in disqualification.

5. Personnel—Provide background information on key individuals who are to be assigned to the project. The information should emphasize their experience relative to the project requirements.

6. Authorized Negotiators—Include the names and telephone numbers of personnel authorized to negotiate the proposed contract.

7. Price—State the cost per mile for all work necessary to provide the processed data as described herein and an additional cost per mile to provide the video log images, thumbnails, and any other items necessary for viewing the video log.

SUBMISSION OF PROPOSAL: Proposals must be received by the ODOT Planning Division by 4:30 p.m., September 7, 2007. Proposals should be submitted to:

Planning and Research Division
Attn.: Pavement Management
Oklahoma Department of Transportation
200 NE 21st Street
Oklahoma City, OK 73105

FURTHER INFORMATION: Any questions regarding this Request for Proposals may be directed to:

Ginger McGovern, P.E.
Pavement Management Engineer
Phone: (405) 522-1447
or
Bill Dickinson
Transportation Manager
Phone: (405)522-1448

APPENDIX 1—DATA QUALITY REQUIREMENTS

The following describes the required accuracy, resolution, and repeatability of the collected data. Accuracy refers to the deviation of the data collected by the CONSULTANT compared to that item collected or provided by the DEPARTMENT.

Data Element	Required Minimum Accuracy	Required Resolution (Measure to the Nearest)	Required Minimum Repeatability
Rut Depth	±0.08 in. compared to manual survey	0.01 in.	±0.08 in. run to run for three repeat runs
International Roughness Index	±5% compared to Dipstick or Class I Profiler	1 in./mi	±5% run to run for three repeat runs
Faulting	±0.04 inches compared to manual survey	0.01 in.	±0.04 in. run to run for three repeat runs
Distress Ratings	±10% compared to ODOT ratings	N/A	N/A
GPS Coordinates	±0.0005 degrees as compared to ODOT provided coordinates	0.000001 degree	N/A

APPENDIX 2—DESCRIPTION OF DISTRESSES AND OTHER DATA ITEMS TO BE COLLECTED

Each distress or data item is to be collected for the entire length of the segment, unless otherwise noted, and reported at 0.01 mile increments. Visible pavement distresses are to be identified and rated according to ODOT's *Pavement Management Distress Rating Guide*. The distresses to be rated for Asphalt Concrete and Composite pavements are: Transverse Cracking (4 severity levels), Fatigue Cracking (3 severity levels), Miscellaneous Cracking (3 severity levels), and AC Patching (no levels). For Jointed Concrete Pavements the distresses to be rated are: Transverse Cracked Slabs (2 severity levels), Longitudinally Cracked Slabs (2 severity levels), Multi-Cracked Slabs (2 severity levels), Spalled Joints (2 severity levels), D-Cracked Joints (2 severity levels), Corner Breaks (2 severity levels), AC Patching (no levels), and PC Patching (no levels). For Continuously Reinforced Concrete Pavements the distresses to be rated are: Longitudinal Cracking (2 severity levels), Punchouts (3 severity levels), AC Patching (no levels), and PC Patching (no levels). ODOT may elect to change its distress rating protocol before data collection begins and will provide the CONSULTANT adequate time to prepare for any such modifications.

In addition to those distress items, the following items are to be collected:

Chainage—The distance in 0.01-mile from the beginning of the control section regardless of the direction of the travel.

Direction—The direction of the travel relative to the direction of the control section.

Surface Type—Asphalt Concrete, Jointed Concrete Pavement, or Continuously Reinforced Concrete Pavement.

International Roughness Index (IRI)—IRI in each wheel path and the average of the two wheel paths, in units of inches/mile. Measurements are to be taken at six inch intervals.

Rutting—Rut measurements are to be taken in both wheel paths with a minimum of five readings longitudinally (typically every 10.56 feet) for each 0.01-mile segment. Rut average, rut max, and the percentage of measurements with rut depth greater than 0.5 inch are to be reported. Measurements are to be taken over a width of at least 10 feet and with a minimum of 11 sensors.

Faulting—Faulting measurements will be taken in the right wheel path. The average fault, maximum fault, standard deviation, and number of faulted joints within each segment are to be reported.

Joints—The number of joints in concrete pavements.

Raveling—Report the length of raveling (if present) within each segment.

Macrotexture—The right wheel path RMS amplitude of texture for wavelengths from 0.50 to 50 mm.

Geometrics—

- Cross slope of the pavement lane as a percentage.
- Radius-of-curvature of the pavement in longitudinal direction shown in feet.
- Longitudinal grade of the pavement shown as a percentage.

Global Positioning System (GPS) Coordinates—Latitude, longitude, and elevation for the beginning of each record. Accuracy shall be within five feet.

Events—The following events on the state highway network shall be marked on the corresponding 0.01 mile record according to a 3-digit code provide by the DEPARTMENT:

- The beginning and ending points of bridges and approach slabs
- Railroad crossings
- The beginning and ending point of any segment of highway that is under construction or marked for construction along the highway
- Any time the test vehicle must move out of the outside lane
- Any time the test vehicle is diverted to a temporary detour
- Any time the tested length is longer or shorter than the supplied length

APPENDIX 3—PAVEMENT MANAGEMENT DATA COLLECTION DEMONSTRATION AND ORAL PRESENTATION

Vendors on the short list will be asked to make an oral presentation and to participate in a demonstration to collect specified condition data at ODOT control sites. ODOT scoring of vendor proposals will take into account the information presented in the proposal document, the oral presentation, and the results of the control site demonstration collection as described in this document.

Control site data will be collected by the vendor between September 1, 2007, and November 30, 2007, at the vendor's expense. Any vendor that does not meet the requirements of the control site demonstration will be eliminated from further consideration. All short-listed vendors that meet the requirements of the control site demonstration will be asked to make an oral presentation displaying the company's services and results from the demonstration collection. Oral presentations will be scheduled in January 2008. Expenses incurred for the control site demonstration collection and oral presentation are the responsibility of the vendor; there will be no compensation from ODOT. Requirements related to the control site demonstration collection and oral presentation are as follows.

Control Site Demonstration of Data Collection Capabilities

Each short-listed vendor will be required to collect pavement data for the outside lane for the specified four control sites. The control sites are mapped and described below. Vendors should contact ODOT to schedule a specific day(s) for collection. An ODOT employee will accompany the vendor's representatives during the collection if requested. Sites may be run up to five times consecutively and up to five runs may be submitted for each control site.

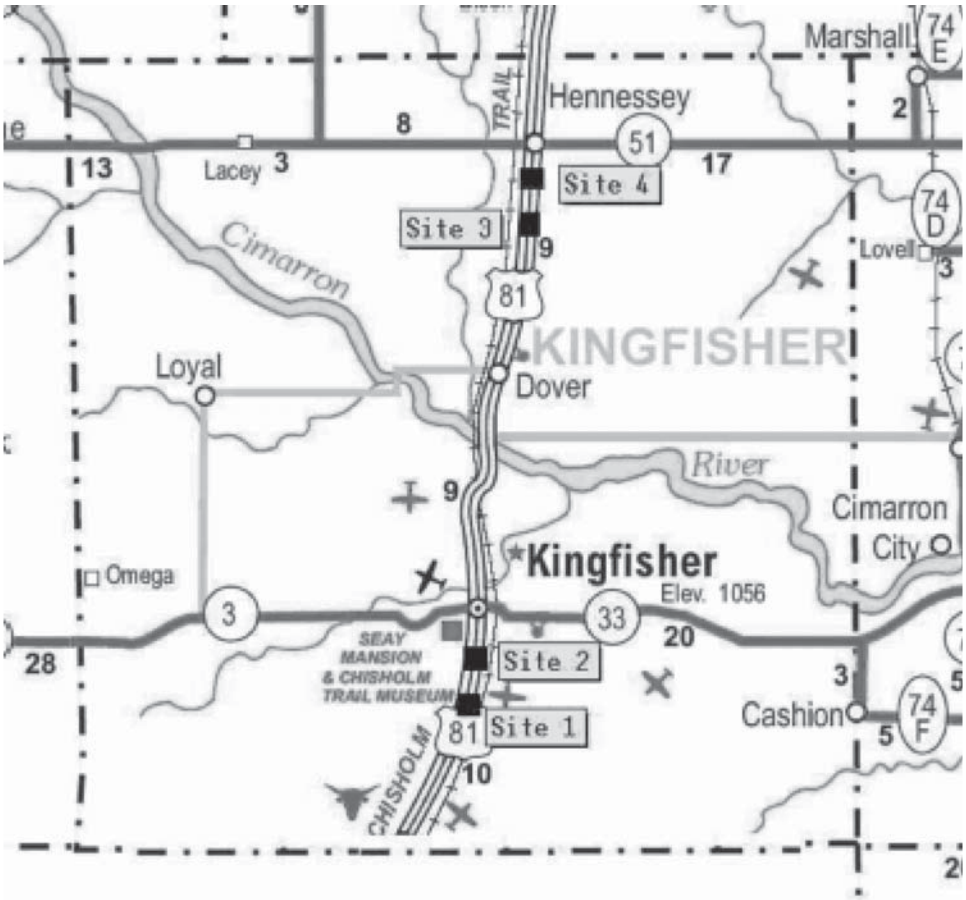

Figure 1. ODOT Control Site Locations

The four control sites are each 0.50 mile long and are located on southbound U.S. 81 in Kingfisher County (see Figure 1). Sites 1 and 2 are jointed concrete pavement and are located approximately 4.54 and 6.23 miles north of the Canadian County Line, respectively. Sites 3 and 4 are asphaltic concrete pavements and located approximately 12.62 and 13.50 miles north of Jct. SH-33 in Kingfisher. All of these sites are in the southbound direction and the chainage will be decreasing in the direction of travel. For example, on site 1, chainage will be 5.04 at the north end and 4.54 at the south end. Begin and end points of each control site are marked on the shoulder.

Control Site Data Collection Items

Each short-listed vendor will be required to present, and will be evaluated on, the following:

- **Video log images.** Provide the pavement (downward-facing) and two right-of-way views (one forward and slightly right, one forward and slightly left) for the entire length of each control site. ROW views should be collected and presented at intervals of 0.005 mile (200 images/mile for each view). The Pavement view should provide continuous 100% coverage of the driving lane.

The vendor may choose the resolution of images they wish to submit but all images should be in jpeg format.

- **GPS data.** Provide latitude and longitude in degrees and decimals of a degree to 6 decimal places for the beginning of each 0.01-mile interval for the entire length of each control site.

- **IRI data.** Provide International Roughness Index in English units for the left and right wheel paths and the average of both wheel paths at a data summary interval of 0.01 mile. Collect IRI according to AASHTO Standard PP37-00, but use data summary interval of 0.01 mile instead of 0.1 km and report in English units.

- **Rut data.** For the asphalt control sites, provide Left Rut, Right Rut, Rut Average, Rut Max, and the percent of measurements less than 0.5 inch, in English units, for each 0.01-mile interval. Rut measurements should be taken a maximum of every 10.56 feet longitudinally for a minimum of 5 measurements per wheel path for every 0.01 mile. Collect rutting according to AASHTO Standard PP38-00, but using a minimum of 11 sensors and a data summary interval of 0.01 mile instead of 0.1 km, and reporting in English units.

- **Faulting data.** For the jointed concrete control sites, provide the Average Fault, Maximum Fault, number of Faults, and standard deviation for each 0.01 mile interval. Collect faulting according to AASHTO Standard PP38-00, but use a data summary interval of 0.01 mile instead of 0.1 km and report in English units.

- **Geometric data.** For each control site, provide longitudinal grade, cross slope, and curve radii in English units for each 0.01-mile interval.

- **Distress data.** Provide processed pavement distress ratings for the control sites using the ODOT Distress Rating Manual protocols. Aggregate and report distress data at 0.01-mile intervals.

Submit data and video log images to ODOT by December 15, 2007, in Microsoft Excel or Microsoft Access format for comparison with manually collected data for each control site. All data and images will be evaluated for proper format, quality, and accuracy.

Advance Software Evaluation Copy

Each short-listed vendor will be required to deliver to ODOT a demonstration copy of their video log/pavement distress viewing software by December 15, 2007. This advance demo software should be able to display the video and data for each control site and is intended to allow some user investigation of the software capabilities and features in preparation for the oral presentation.

The advance software demo copy must be accompanied by an explanation of:

- Licensing requirements for the software and if it is proprietary;
- The vendor's capability and process to respond to technical questions, database problems, etc.;
- Whether the vendor provides a help desk for user inquiries;
- Data storage environment, networking capability, etc. Software must run on the DEPARTMENT's existing computer network.

Oral Presentation and Demonstration of Software

Using the data collected from the ODOT control sites, each short listed vendor will be required to present, and will be evaluated on, the following with respect to pavement condition data collection and software:

- **Video:** Features such as clarity, contrast, consistency, and viewing options.
- **Sensor and Distress Data:** Discuss the process used to collect and process sensor data and to rate the visual distresses (i.e., cracking, joint spalling, etc.) on asphalt and concrete pavements and the advantages and limitations of the process. Present information about rater qualifications, training and QC/QA of data.
- **Software:** Features such as user-friendliness, functionality, quality, ability to query and display data, and response times. Capabilities for viewing both the images and the processed Pavement Management data. If applicable, demonstrate the software capabilities for offset and height measurement and for creating a library of roadside inventory features.

The vendor may demonstrate any enhancements or other features they are capable of collecting, even if not required for the proposal. These may be of locations collected from other than ODOT routes.

Abbreviations used without definitions in TRB publications:

AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	Air Transport Association
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation