

INCREASING CONSISTENCY IN THE HIGHWAY PERFORMANCE MONITORING SYSTEM FOR PAVEMENT REPORTING

FINAL REPORT

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Disclaimer

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ABSTRACT

This report documents and presents the results of a study to evaluate the comparability of pavement condition data submitted to the Federal Highway Administration under the Highway Performance Monitoring System (HPMS) and the information reported by state highway agencies as part of their pavement management program. The study involved a statewide survey of both HPMS and pavement management practitioners to identify state issues associated with HPMS submittal requirements and to evaluate the impact these issues have on the quality of the data submittal. The results of the survey were used to identify eight volunteer states to participate in a more detailed comparison of HPMS and pavement management data. The analysis focused on the following topics:

- The availability of comparable information in the pavement management and HPMS data sets.
- The amount of processing required for comparing HPMS and pavement management data.
- Differences in pavement conditions reported using HPMS and pavement management data.
- The impact of the reporting length (e.g., segment or route) on pavement condition statistics.

The findings from the study suggest that changes to the current HPMS requirements are needed to improve the consistency in pavement management and HPMS data. Suggested improvements and recommendations for further research are provided.

SUMMARY

The recent highway authorization, Moving Ahead for Progress in the 21st Century (MAP-21) promotes a performance-based approach for managing highways on the federal-aid system. The FHWA is responsible for developing the policies, guidance, tools, and training necessary to support this program. In the past, the FHWA has relied on HPMS data as the primary source for preparing the pavement-related information for the Condition and Performance Reports provided to Congress every other year. HPMS is populated using data provided by state transportation agencies on the condition, performance, use, and operating characteristics of the Nation's highways in accordance with reporting requirements specified by FHWA.

As part of its responsibilities under MAP-21, the FHWA would like to use HPMS data to report highway conditions on a national basis. However, states have raised concerns that HPMS data is not sufficient to be used at the national level for policy decisions and target setting due to perceived inconsistencies in the data across states. States have also raised concerns about differences between overall conditions reported in HPMS and the conditions reported for a state's pavement management program. This study investigated the differences between HPMS and pavement management data and conducted an objective assessment of the consistency of HPMS data with pavement management data.

The study found that:

1. There is a relatively high degree of confidence in the HPMS data on a state-by-state basis, but inconsistencies in how the information is collected nationwide result in a moderate to low degree of confidence in the ability to use the information to compare conditions across states. For example, on a statewide basis, the weighted average IRI data from pavement management and HPMS were very close. The same was true for rutting data, with only one exception. However, as smaller subsets of the data are evaluated, the variability in the data increases.
2. The HPMS pavement data requirements were implemented to populate new performance models based on the Mechanistic Empirical Pavement Design Guide (MEPDG). However, the information needed for the models, especially for roads off the state system, is not readily available in many states. Therefore, the states do not place a high degree of confidence in the reliability of the off-state system data. Other information, such as pavement cracking data, pavement structure information, and information on the last overlay and overlay thickness, was also rated as having a low degree of confidence by the participants in the survey of practice.
3. There are significant differences in the pavement condition information that states use to report network conditions. IRI is often a component of the overall condition, but ride is typically not a significant factor in selecting and prioritizing pavement preservation activities. Therefore, efforts by the FHWA to report pavement condition on a national basis using IRI alone will report substantially different conditions than what is being reported by the states to their constituents.
4. The variability in the reported pavement conditions varies based on the method of aggregating the data. The analysis showed significant differences in the percentage of pavements in Good, Fair, and Poor condition based on whether the data were summarized at the state, route, or segment levels.
5. Over three quarters of the states responding to the survey of practice indicate that the methodology used in their pavement management system for cracking differs from the HPMS requirements for reporting cracking information. As a result, some agencies have developed equations for converting their pavement management information for HPMS purposes and other states have developed other

approaches for responding to the requirement. The analysis of the cracking data illustrates the potential impact of using default values to meet the HPMS submittal requirements.

6. The requirement to report faulting data is also problematic for some states since several states do not include faulting in their pavement management survey procedures. Where faulting is measured, it is not always measured consistently with HPMS requirements, which requires states to develop a process for converting data. In one instance, it appeared that a volunteer state reported a single default value to HPMS for any section in which faulting appeared.
7. The comparison of HPMS data and pavement management data required a lot of manipulation to match sections. This exercise illustrated the issues that would arise if the FHWA chose to develop a process for verifying the quality of the state data submitted to HPMS or if the pavement management personnel wanted to check the quality of the HPMS submittal before being sent to FHWA.
8. There was no evidence that the size of the agency or the method of collecting and processing the data influenced the results of the analysis or the likelihood of finding variability in the data.

Based on the findings and observations made during this study, several recommendations for changes to the HPMS data requirements can be made. The recommendations have been prioritized based on their potential impact on the states, and an agency to take responsibility for implementing the recommendation is suggested.

1. Determine the appropriateness of the models being used for national performance management and the need for the level of detail currently required. It is evident from the comparison of Good/Fair/Poor that metrics other than IRI are needed to report pavement conditions on a national basis; however, the current level of detail required and the annual reporting frequency for IRI on the entire system has created a burden on the states without evidence of any benefit to the states. Recommended lead: FHWA
 - a. If the current models continue to be used, conduct a sensitivity analysis on the models to determine the impact of using unreliable information for pavement cracking, pavement structure, date of last overlay, and overlay thickness. Based on the findings, provide guidance to the states on the level of detail required and/or modify the models to place less emphasis on these data elements. Recommended lead: FHWA
 - b. If new models are developed, identify pavement condition metrics that more closely match the information normally collected as part of network-level pavement management surveys to report network conditions and to trigger pavement preservation activities. For instance, the survey procedures for non-load related cracking in the volunteer states typically was not limited to transverse cracking, and often included other types of cracking (such as block cracking) that make it difficult to report Cracking Length for only transverse cracks. A more simplistic approach at capturing all wheelpath and non-wheelpath cracking might be an acceptable substitute to the States. Alternatively, consider other methods of collecting consistent distress information on a national basis (e.g., a national data collection contract). Recommended lead: FHWA
2. Address the inconsistencies in the pavement management data collection activities that are impacting the ability to use HPMS data to compare pavement conditions across states. Begin by improving the consistency in the way IRI data is collected for HPMS purposes by strongly enforcing the existing HPMS section length recommendation and communicating the impact of inconsistent section lengths among practitioners. Recommended lead: FHWA with assistance from AASHTO to develop correlating data collection standards if they do not exist.

3. For pavement-related data only, require states to submit HPMS data using a consistent section length. Future research is needed to determine the appropriate length to minimize variability and processing time for reporting purposes. Recommended lead: FHWA
4. Demonstrate to the states the benefits associated with the availability and use of HPMS data. Based on the comments made during the HPMS Reassessment, many states do not see the return for the level of investment they are making in HPMS activities. Recommended lead: FHWA
5. Develop a strategy for obtaining the information necessary for evaluating or estimating the performance of the off-state system in a cost-effective manner. Recommended lead: States

CHAPTER 1 BACKGROUND

INTRODUCTION

State transportation agencies in the United States are increasingly relying on the use of performance data to drive investment decisions, to establish funding priorities and to improve agency transparency. Although the types of performance measures used by states differ, strategic performance targets related to system preservation, safety, mobility, and environment are common among transportation agencies. The Federal Highway Administration (FHWA) recently created a new office focused on transportation performance management. This office is responsible for developing the policies, guidance, tools, and training necessary to support a performance-based Federal-Aid Highway Program. The recent highway authorization, Moving Ahead for Progress in the 21st Century (MAP-21) requires States and Metropolitan Planning Organizations to establish performance targets and to report on progress for their portion of the federal-aid system to the FHWA, who will then report overall progress and accomplishments to Congress. MAP-21 establishes the following national performance areas for the Federal-Aid Highway Programs (FHWA 2012):

- **Safety** – To achieve a significant reduction in traffic fatalities and serious injuries on all public roads.
- **Infrastructure condition** – To maintain the infrastructure assets making up the National Highway System in a state of good repair.
- **Congestion reduction** – To achieve a significant reduction in congestion on the National Highway System.
- **System reliability** – To improve the efficiency of the surface transportation system.
- **Freight movement and economic vitality** – To improve the national freight network, strengthen the ability of rural communities to access national and international trade markets, and support regional economic development.
- **Environmental sustainability** – To enhance the performance of the transportation system while protecting and enhancing the natural environment.
- **Reduced project delivery delays** – To reduce project costs, promote jobs and the economy, and expedite the movement of people and goods by accelerating project completion through eliminating delays in the project development and delivery process, including reducing regulatory burdens and improving agencies' work practices.

In the past, the FHWA has relied on its Highway Performance Monitoring System (HPMS) as the primary data source in its efforts to prepare the pavement-related information contained in the Condition and Performance Reports that are provided to Congress every other year. HPMS is populated using data provided by state transportation agencies on the condition, performance, use, and operating characteristics of the Nation's highways. The content of the information provided by the states and the format used for submitting the information is specified by the FHWA.

These reporting requirements were updated in 2007 and 2008, to reflect such changes as expanding the types of pavement performance data reported and adding pavement layer information (FHWA 2008). The new HPMS requirements were not met positively by all state highway agencies (SHAs). In fact, several SHAs assert that their feedback to the proposed HPMS requirement changes was not acknowledged and/or considered in the final requirements. Other agencies indicate that their pavement management data cannot easily be converted to satisfy the HPMS requirements, which is increasing resource demands and creating inconsistencies in data reported to HPMS. In order for the FHWA to continue to rely on the HPMS database as the primary source for analyzing and reporting pavement performance information at the federal level, the extent and magnitude of these issues must be assessed.

PROBLEM STATEMENT AND RESEARCH OBJECTIVE

Based on the current state of the use of HPMS data, the research addressed three key issues raised by states related to the quality and consistency of HPMS data, including:

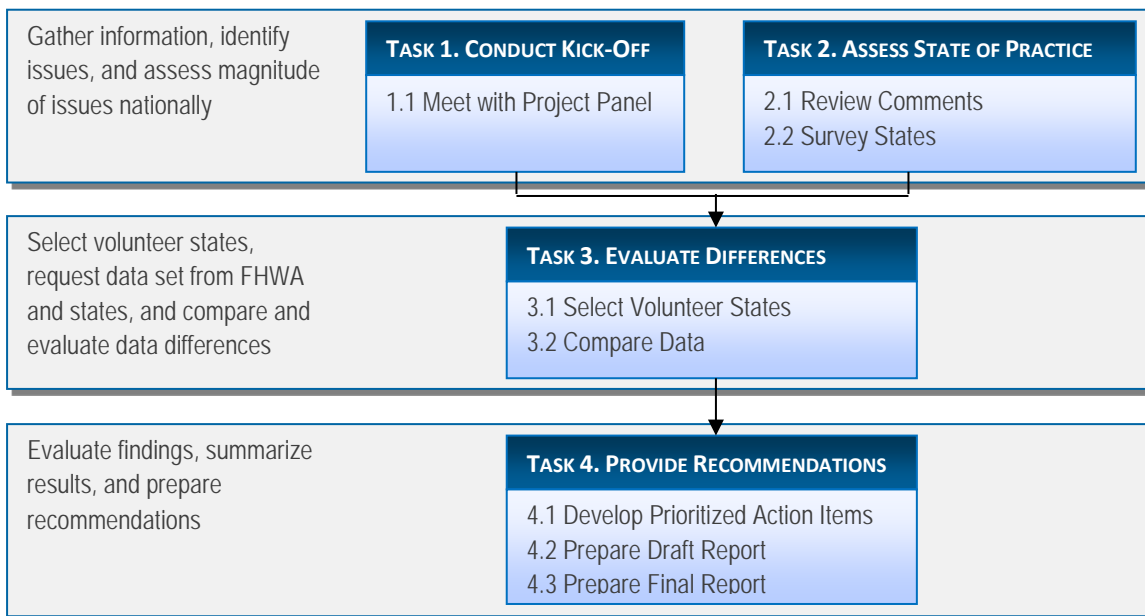
1. Several states indicated that the quality of the HPMS data is not sufficient to be used at the national level for policy decisions and target setting.
2. For many states, the process of preparing and reporting data by HPMS section introduces inconsistencies from the way the information is reported for pavement management purposes.
3. The data used for managing assets at the state level is not consistent with the information being reported to HPMS.

As a result, the objective for this study was to identify specific actions that can be taken to (a) increase confidence in the HPMS data and (b) increase the use of HPMS as a national source for reporting pavement performance information. This objective was to be achieved by better understanding the differences between HPMS and pavement management data and identifying strategies that would lead to more consistency between the two data sources. Therefore, the research team conducted an objective assessment of the quality of the HPMS submittals and the consistency of HPMS data with pavement management data compiled by states. The results provide a comprehensive summary of the issues associated with HPMS and their impact on data quality. Based on the findings, practical solutions for improving the quality and consistency of the data were developed.

CHAPTER 2 RESEARCH APPROACH

The project objective was achieved through the completion of four main tasks. First, the research team documented current concerns with HPMS and identified inconsistencies between the HPMS data and the states' pavement management condition reports. For a select number of states, the differences were explored in more detail so the primary source of the inconsistencies could be identified. Based on the findings, the research team prepared a prioritized list of actions that will reduce and/or eliminate these inconsistencies so the full benefits of having a national performance database can be realized. An overview of the project approach is provided in Figure 2-1 and a brief summary of the activities conducted during each task is provided in the following sections.

Figure 2-1. Overview of Project Approach



TASK 1: CONDUCT KICK-OFF

The project began with a kick-off telephone call with the NCHRP project panel to identify and discuss some of the issues that needed to be considered in the study, to make any necessary adjustments to the work plan, and to identify the type and level of support needed from members of the project panel over the course of the project. Several key issues were identified by the project panel as being important to the success of the project, including those items listed below:

- Volunteer states will be selected to provide pavement management data that will be compared to HPMS submittals. The selection of volunteer states will consider:
 - Whether the data are used for management purposes.
 - Organizational structure.
 - Method of collecting and processing data (i.e., manual, semi-automated, or automated).
 - Sampling rates.
 - Availability of off-system data.

- The challenges faced by the state in responding to the HPMS requirements.
- In addition to evaluating data consistency, the research team was asked to evaluate the completeness of data sets and the use of default data to comply with HPMS data requirements.
- State reports of roads in Good, Fair, and Poor condition should be compared to the Good, Fair, and Poor conditions reported based on the HPMS International Roughness Index (IRI) values.
- The panel indicated that the research team should determine whether uniform section lengths should be required under HPMS.

TASK 2: ASSESS STATE OF PRACTICE

First, the research team reviewed the comments that were submitted by states during the most recent HPMS Reassessment. This helped the research team classify the issues in categories, which were then incorporated into the state of practice survey (task 2.2) to help the team quantify the extent of each issue on a national basis. The survey also assisted the research team in selecting volunteer states.

TASK 2.1: REVIEW COMMENTS

As a first step in assessing the state of practice in terms of HPMS, the research team reviewed the comments that were made to FHWA during the most recent HPMS Reassessment. The comments were primarily concentrated in the five areas listed below.

- **Standardization** – States indicated that there is a great deal of variability in the data collected by various DOTs making it impractical to compare data on a state-by-state basis. In some cases, the recommended use of American Association of State Highway and Transportation Officials (AASHTO) Standard R43-07 (AASHTO 2007) for International Roughness Index (IRI), for example, would require agencies to either adopt the Standard for all of their data collection activities or to maintain a separate HPMS database.
- **New data fields** – Several states urged the FHWA to carefully scrutinize the need for additional data because states will respond with a variety of measured, estimated, or default values depending on the resources available for this effort. The additional data on the lower functional classifications, in particular, was called out by several states. They mentioned that pavement history, overlay thickness, pavement surface layer and base layer data, for example, is not readily obtainable for the non-state roadways and would be a significant burden to collect properly and default values were not considered to be reliable. Similarly, some agencies reported that default data about asphalt mix binder type, dowel bars, and joint spacing is not available by functional class since these vary based on individual project details.
- **Resource requirements** – The change to annual reporting cycle (from a 2-year reporting cycle) was cited by several states as a significant burden. In addition, the new data fields that were added were referenced as being both time-consuming and costly to the states.
- **Use of data** – Several states indicated that it was not clear how the data would be used by FHWA, but they were concerned about the use of the data for state-by-state comparisons due to variability in the procedures being used to collect that data. Other states indicated that including IRI at bridges and railroad crossings would result in worse pavement conditions and could become a source of criticism in the press. Some states asked FHWA to illustrate the benefits and need for the proposed changes to scope, frequency, and granularity of the HPMS data reporting requirements for system-level performance studies.

- **Inconsistencies with pavement management** – In some states, the data requested for HPMS are not used in the state’s pavement management system, so there is no established network-wide survey procedure for obtaining the information. For example, some states do not collect faulting or rutting information. In addition, HPMS requires a percentage of cracking (regardless of severity) that is inconsistent with state condition surveys. A number of states also indicated that relying solely on pavement roughness as the indicator of pavement condition and performance has limited validity.

The results from the review served as the basis for developing the survey in Task 2.2.

TASK 2.2: SURVEY STATES

To help determine the extent and magnitude of these and other issues among state highway agencies, a survey was created. The survey was based on the findings from the HPMS review comments (see Task 2.1) and involved assessing the current state of practice to begin quantifying trends in the issues that had been identified and to better understand the factors that contributed to these issues. To achieve this goal, the survey questions probed states regarding the following types of information:

- The number of states that are impacted by the issues identified during Task 2.1.
- General causes contributing to the issues identified.
- The type of inventory and condition information available in the state’s pavement management database.
- The degree of confidence in the accuracy of its HPMS submittal and its pavement management condition data.
- The perceived consistency between HPMS submittals and their pavement management condition reports.
- Offices responsible for collecting and reporting pavement management data.
- Offices responsible for preparing HPMS submittals.
- The presence of internal quality checks on the HPMS submittals.
- Potential uses of the HPMS database by states.

The survey was developed and administered using SurveyMonkey and consisted of 20 questions with a mix of objective and short answer type questions (refer to Appendix A for the complete survey). The survey was sent electronically to both the office responsible for preparing the state’s HPMS submittal and the office responsible for pavement management so that differences in the responses could be identified. The survey helped the research team better understand the issues that state highway agencies are facing as they comply with the HPMS requirements and provided good information to qualitatively assess the magnitude and impact of these issues on data quality and consistency. The results of the survey are presented in the next chapter of the report.

TASK 3: EVALUATE DIFFERENCES

The third task focused on comparing what were identified as the most common issues associated with the preparation of HPMS submittals and quantitatively discerning the impact of these issues on data quality and consistency. In order to do this, based on the survey, volunteer states were selected in order to 1) compare their HPMS and pavement management data and 2) to evaluate the completeness of their data sets.

TASK 3.1: SELECT VOLUNTEER STATES

Based on the state of practice survey results, the research team prepared a list of recommended, volunteer states to participate in a more detailed assessment of their HPMS and pavement management data. Ultimately 9 states were invited to participate in this part of the study, but only 8 states accepted the invitation. The final group of participating states represented agencies that vary in size, data collection practices (e.g., manual and automated), significance of new HPMS data items to the organization, organizational structure (i.e., related to who is responsible for submitting HPMS data), and perceived differences in HPMS and pavement management data. Table 2-1 illustrates this diversity in the 8 volunteer states that provided data for this portion of the study.

Table 2-1. Volunteer States

Agency	Agency Characteristics	Data Collection Practices	Significance of New Data Items on Operations	HPMS and PMS in Same Division?	Perceived Match in HPMS and PMS
State 1	Large, some significant urban areas	Automated	Some Items Significant But Not All	Yes	Good
State 2	Largely rural	Semi-automated	Moderate to Significant	No	Poor
State 3	Large, some significant urban areas	Automated	Moderate	Yes	Poor
State 4	Small, densely populated	Automated	Moderate to Significant	No	Very Poor
State 5	Large, some significant urban areas	Manual	Moderate to Significant	No	Good
State 6	Largely rural	Combination of survey types, sampling	Not a significant issue	No	Good
State 7	Large, some significant urban areas	Semi-automated surveys, sampling	Significant	No	Very Good
State 8	Largely rural	Automated	Significant	No	Good

TASK 3.2: COMPARE DATA

The research team requested data from FHWA and from the participating agencies so the differences between data prepared and submitted for HPMS and the pavement condition data reported by the states for pavement management purposes could be compared and analyzed. The HPMS data were obtained from FHWA for the most recent year for the participating states (i.e., the June 2012 submittal with 2011 data). Corresponding data from the state's pavement management system were requested from the volunteer states for the state system. The states

were asked to provide their pavement management data in a GIS format (e.g., shape file), if possible, or in an Excel file with linear referencing identifiers. The shape files were requested so that the research team would be able to match HPMS sections with pavement management sections. A list of the types of data that were obtained includes:

- All of the data fields required under HPMS, including items such as IRI, Present Serviceability Rating (PSR), rutting, faulting, fatigue and transverse cracking, year of last improvement, year of last construction, last overlay thickness, base type, base thickness, climate zone, and soil type.
- Aggregated condition indexes reported for each section in the pavement management system.
- Percentage of road segments in Good, Fair, and Poor condition based on the agency's definitions (if used).
- The agency's definitions for Good, Fair, and Poor condition.

The volunteer states were very cooperative in providing the information requested. There were some differences in the availability of information provided by the states, and in the research team's ability to match HPMS and pavement management sections for analysis. However, in general, the HPMS and pavement management data was analyzed and evaluated for:

- Completeness of the data set.
- Consistency of the data set (HPMS overall condition versus overall condition from pavement management).
- Impact of segment length on results.

The results of the data analysis serve as the basis for quantifying the inconsistencies between HPMS and pavement management results and documenting the data issues related to the HPMS data summary, conversion, reporting, and segmentation requirements. The results of the analysis are provided in Chapter 3, Findings and Applications.

TASK 4: DEVELOP AND PRESENT RECOMMENDATIONS

The results of the analysis served as the basis for the recommendations that were developed under Task 4 to improve the use of HPMS data for policy and management decisions, and to improve the consistency of HPMS and pavement management information. Under Task 4, a prioritized list of recommended action items was developed to reduce the HPMS data issues and to support the increased use of HPMS data at the federal and state levels. The recommendations are incorporated into this final report.

TASK 4.1: DEVELOP PRIORITIZED ACTION ITEMS

The results of the first three tasks were taken into consideration in developing a prioritized list of action items that can be undertaken to resolve or eliminate the inconsistencies in the data reported in HPMS and the condition information reported as part of pavement management. The action items were organized in a format that clearly conveys the issues that need to be addressed and identified what changes were needed to resolve the issue.

TASK 4.2: PREPARE DRAFT REPORT

The project results were compiled into a draft report and sent to NCHRP for review and comment. The draft final report documented the entire research effort and highlighted key findings and recommendations and was prepared in accordance with NCHRP report preparation guidelines.

TASK 4.3: PREPARE FINAL REPORT

The comments from the project panel on the draft report were incorporated into this final report. A summary of how each comment was resolved was also prepared. The final report was submitted to NCHRP both in hard and electronic format, suitable for publishing. Further, a presentation of the findings and recommendations was also submitted for presentation at the TRB Annual Meeting and at other technical conferences and meetings attended by pavement management practitioners.

CHAPTER 3 FINDINGS AND APPLICATIONS

SURVEY OF STATE PRACTICES

To help gain insight as to the magnitude and impact of the HPMS reporting issues on state highway agencies, a state survey was conducted of both HPMS and pavement management practitioners. The same survey instrument was used for each recipient; however, separate links were provided for HPMS and pavement management practitioners so the results could be analyzed separately. The survey was administered using SurveyMonkey and was sent to the appropriate individuals within the different state highway agencies, which included all fifty states, Washington DC and Puerto Rico. The response rate for both surveys is displayed in Table 3-1.

Table 3-1. State of Practice Survey Response Rate

	# of Surveys Distributed*	# of Responding Agencies	Overall Response Rate
HPMS Survey	52	42	81%
Pavement Management Survey	52	33	63%
Agencies Completing Both Surveys		28	54%

**Includes Washington DC and Puerto Rico*

As shown in Table 3-1, both surveys had very high response rates, with the HPMS survey having a response rate of 81% and the pavement management survey having a response rate of 63%. Further, 54% of the agencies surveyed replied to both the HPMS and pavement management survey. Agencies were only allowed to fill out each version of the survey once (i.e., one HPMS survey and one PM survey) so there were no duplicate responses for any of the responding agencies. Agencies were, however, able to collaborate and discuss the survey responses with other individuals or they could forward the survey to individuals who might have a better understanding of the HPMS or pavement management process. The goal was to get the collective knowledge of those conducting the HPMS reporting or who were working in pavement management to better understand the processes required to prepare the states' HPMS submittal packages. The results that follow provide an overview of the survey analysis and compare the results of the two response groups. Where applicable, a comparison of the responses from the 28 States that responded to both surveys is also provided. In addition to providing useful information about the state agencies in terms of their HPMS process and pavement management activities, the survey of state practice also served as a starting point in selecting volunteer states that provided the data used in the more detailed analysis (Task 3.2) and the development of prioritized action items (Task 4.1).

The results of the survey of practice are presented in a number of different ways. First, the research team investigated the percentage of agencies where both HPMS reporting functions and pavement management are found in the same division. Table 3-2 shows this dispersion.

Table 3-2. Percentage of Agencies with HPMS Reporting Functions and Pavement Management Located in the Same Division.

	Yes	No	
HPMS Survey	48%	52%	<i>n=42</i>
Pavement Management Survey	28%	72%	<i>n=32</i>

A review of table 3-2 shows that the majority of highway agencies, as reported by both HPMS and pavement management practitioners, do not have HPMS and pavement management located in the same division. It is interesting to note the discrepancy in responses between the two groups. Nearly three-fourths of the pavement management survey respondents state that the two activities are located in different divisions, while only half of the HPMS survey respondents provided the same response. Since the answers should be consistent, the research team assumes that some of the HPMS survey respondents may not be aware of the agency's pavement management functions. The responses provided by the 28 States that responded to both surveys were consistent.

Next, the survey allowed the research team to look qualitatively at the perceived differences between HPMS and pavement management data. Two questions were provided to address these differences. The first question asked both HPMS and pavement management practitioners to indicate whether the information reported in the agency's HPMS submittal closely matched the pavement management data. A second question asked whether the HPMS information was representative of the information used in pavement management for project selection. The responses to these questions are displayed in Figure 3-1 for all responses. Figure 3-2 presents the consistency in the responses for the 28 States that responded to both surveys.

Overall, the responses to each of the questions from both the HPMS and the pavement management groups indicate that there is general agreement between the HPMS and pavement management information, with the majority of respondents either strongly agreeing or agreeing. However, there is less agreement in terms of the HPMS information representing the information used in pavement management for project selection, with the pavement management respondents providing slightly less positive responses than the HPMS respondents. Among the HPMS respondents, a total of 82% indicate there is a close match between the HPMS and pavement management information (i.e., strongly agree and agree) and 59% indicate that HPMS data is representative of the information used to select projects in pavement management. As noted earlier, the pavement management practitioners were slightly less agreeable than the HPMS practitioners, with 71% indicating that the HPMS information and pavement management information match closely and 57% indicating that the HPMS data is representative of the information used in pavement management to select projects. Figure 3-2 also shows that only 36% of the 28 States responding to both surveys answered this question consistently.

It is interesting to note that 17% of the HPMS practitioners responding to the survey and 10% of the pavement management practitioners responding to the survey did not know whether HPMS data is representative of the information used for project selection. This seems to indicate a separation of HPMS and pavement management functions within a number of the responding agencies.

Figure 3-1. Comparison of HPMS and Pavement Management (PM) Data for All Responses

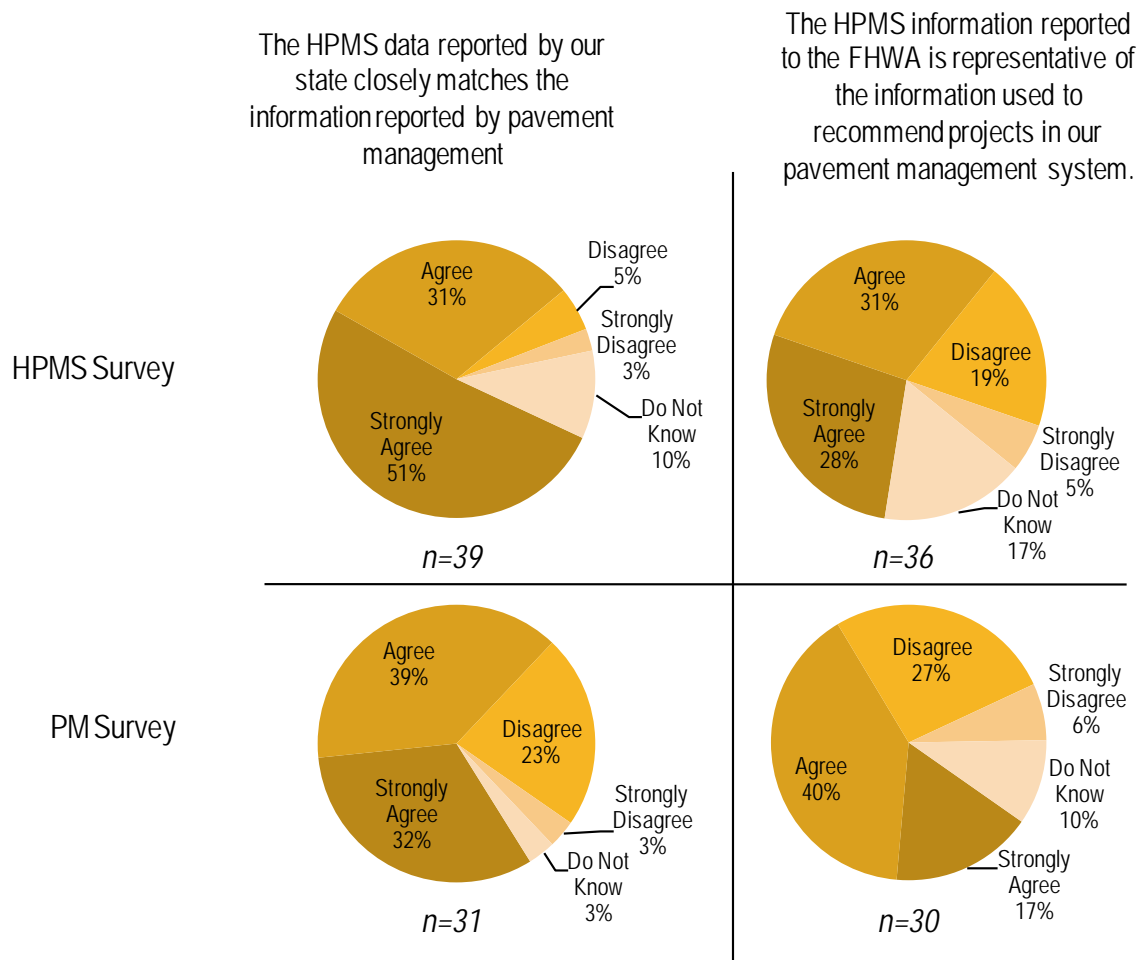
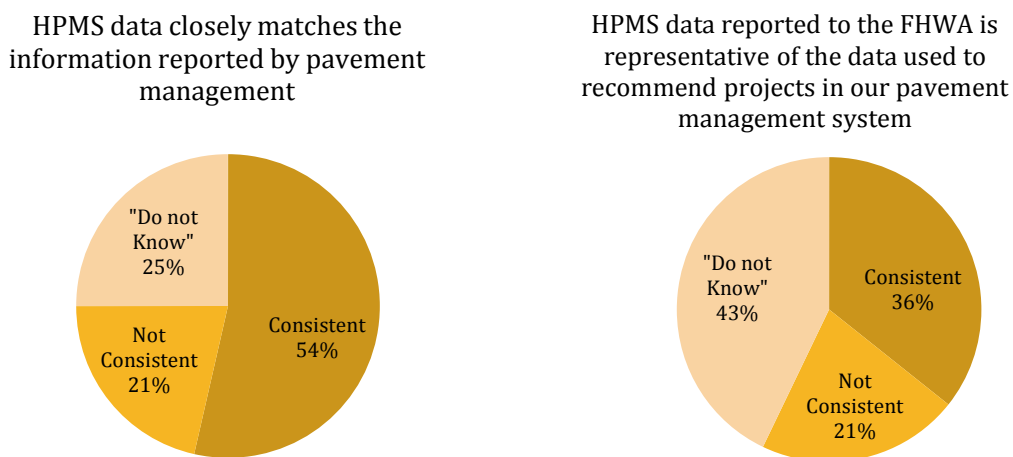


Figure 3-2. Consistency in the Responses for the 28 States Responding to Both Surveys



The respondents were also asked to assess the degree of confidence they had with the HPMS data that is being reported and whether it is an accurate representation of the state’s overall pavement condition. Additionally, the survey asked participants to assess their confidence in using HPMS data to compare pavement performance across states and to assess national system performance. Table 3-3 displays these results.

Table 3-3. Degree of Confidence in HPMS Data Representation

Degree of Confidence – Individual State Representation

	High	Moderate	Low	
HPMS Survey	53%	42%	5%	n=40
Pavement Management Survey	45%	45%	10%	n=31

Degree of Confidence – Nationwide Representation (for Comparisons Across States)

	High	Moderate	Low	
HPMS Survey	20%	58%	22%	n=40
Pavement Management Survey	6%	36%	58%	n=31

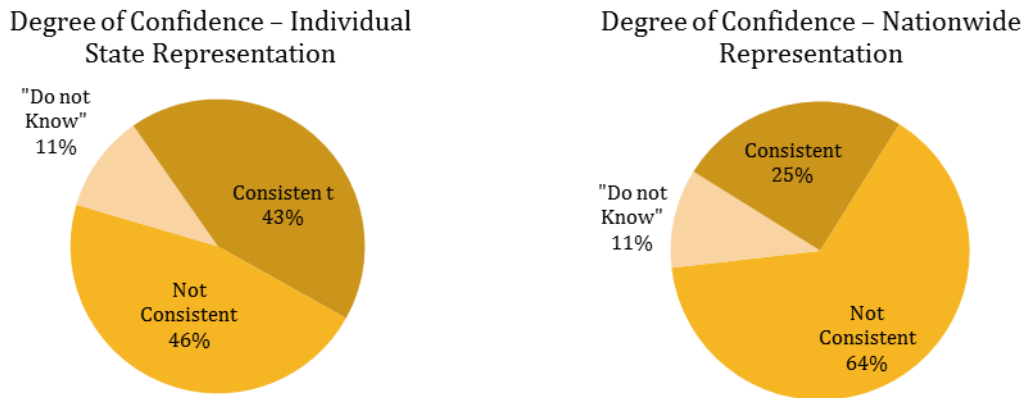
As the survey responses show, there is greater confidence among the survey participants regarding the use of HPMS data to represent individual state conditions than there is in using HPMS data to compare states on a national basis. For example, 95% of HPMS survey respondents and 90% of pavement management survey respondents have a high or moderate degree of confidence in the use of HPMS data to represent state pavement conditions, with 53% of the HPMS respondents and 45% of the pavement management respondents indicating a high degree of confidence.

The responses to the question posed about using HPMS for comparing pavement performance across states or to report national pavement performance were less positive, with 58% of the pavement management practitioners and 22% of the HPMS practitioners indicating they had a low degree of confidence. Only 6% of the pavement management practitioners and 20% of the HPMS practitioners indicated that they had a high degree of confidence in using HPMS for this purpose. This is likely due to the inconsistencies in collecting pavement condition data across states.

Figure 3-3 presents the consistency in the responses for the 28 States that responded to both surveys. The results show that 43% of the States were consistent in their rating of whether HPMS data is representative of the condition in an individual State, but only 25% responded consistently when asked if the HPMS data is representative on a national basis. In the 28 states, the pavement management practitioners typically reported a lower level of

confidence in using the HPMS data to compare conditions across states than the HPMS practitioners when the responses did not match.

Figure 3-3. Consistency in Responses for the 28 States Responding to Both Surveys



The survey also looked at the methods state agencies were using when compiling data for HPMS reporting. In other words, respondents were asked whether they collect data specifically for HPMS reporting or whether they use and/or convert pavement management data for HPMS reporting. The survey offered the following four responses to this question:

- Collect pavement-related data specifically for HPMS.
- Use pavement management data without a conversion.
- Use a conversion of pavement management data.
- Use a combination of approaches.

The HPMS respondents were almost equally split across the four responses, while those responding to the pavement management survey had a little more variation in their responses. For instance, there were no pavement management responses that indicated data were collected specifically for HPMS and 68% said they use a combination of approaches. The survey asked respondents to identify information that is only collected to satisfy HPMS requirements. The most common responses to this request from both HPMS and pavement management respondents were *cracking data* (percent and length) and *pavement data for non-state owned roads*. These two items were both factors that were frequently mentioned in the states' comments during the 2010+ HPMS Reassessment.

Finally, the survey of state practice asked participants to rate the significance of each of the items listed in Table 3-4 on the overall quality of the HPMS submittal. Looking at each of the issues individually, *data availability on non-state owned roads* was cited as the greatest impact on the quality of HPMS reported data by both the HPMS (75%) and pavement management practitioners (76%). Among the HPMS practitioners responding to the survey, all but one of the factors listed was reported as significant or somewhat significant by more than 50% of the agencies. According to the HPMS practitioners, data conversion is not considered to be significant by 58% of the respondents. There were fewer items that were noted as having a major impact or somewhat of an impact among the pavement management practitioners. For instance, more than 50% of them identified the *type and extent of the*

pavement distress data, the type and extent of pavement structure data, and the efforts to convert data as having a major impact or somewhat of an impact on quality. Other items, such as the number of data items required and the type and extent of inventory data, had essentially little to no impact on quality. The consistency in the responses to these questions among the 28 States that responded to both surveys is presented in Table 3-5.

Table 3-4. Level of Impact on the Quality of HPMS Data Reporting

Items Impacting Quality of HPMS Data Reported (HPMS Responders)	Percent of States – Major Impact or Somewhat of an Impact	
	HPMS	Pavement Management
Number of data items required impact the quality of the data reported	61%	33%
Type and extent of pavement distress data required impact the quality of the data reported?	67%	58%
Type and extent of pavement structure data required impact the quality of the data reported?	72%	55%
Type and extent of inventory data required impact the quality of the data reported?	56%	30%
Efforts to convert data to the format required by HPMS impact the quality of the data reported	42%	55%
Issues with data availability on non-state owned roads impact the quality of the data reported	75%	76%
	<i>n=36</i>	<i>n=33</i>

Table 3-5. Consistency in Responses to the Impact on Quality for the 28 States Responding to Both Surveys

Items Impacting Quality of HPMS Data Reporting	Consistent	Not Consistent	“Do Not Know”
Number of data items required impact the quality of the data reported	29%	46%	25%
Type and extent of pavement distress data required impact the quality of the data reported?	39%	36%	25%
Type and extent of pavement structure data required impact the quality of the data reported?	32%	43%	25%
Type and extent of inventory data required impact the quality of the data reported?	21%	54%	25%
Efforts to convert data to the format required by HPMS impact the quality of the data reported	29%	46%	25%
Issues with data availability on non-state owned roads impact the quality of the data reported	32%	43%	25%
	<i>n=28</i>		

The responses from the States responding to both surveys show that nearly one-third of the States were consistent in their responses to these questions (actual values ranged from 21% to 39%). However, nearly half of the States

were inconsistent in their responses, which again illustrates the disconnect between HPMS and pavement management practitioners in many agencies.

There were several other interesting findings from the pavement management survey results, which are summarized below.

- All but two of the responding agencies have steps in place to check the HPMS data before submitting the information to the FHWA. The two agencies that responded negatively to that question indicated that they have steps in place to check the quality of pavement management condition data, as did all but one of the other pavement management respondents.
- For the most part, information reported on the state system is measured (although there was one state that indicated the information is estimated). Off the system, 17 states (63%) indicate that the information is measured, 6 states (22%) report it is estimated, and 4 (15%) states indicate that they use default values.
- A total of 9 out of 31 (29%) responding pavement management practitioners indicate that the IRI reporting requirements in HPMS do not match the survey methodology used for pavement management purposes.
- A total of 24 out of 31 (77%) responding pavement management practitioners indicate that the HPMS cracking requirements do not match their pavement management survey methodology. Five of the agencies (16%) indicate that their pavement management survey procedures match the HPMS requirements and 2 agencies (6%) indicate that they did not know the answer to the question.
- When asked about pavement structure information, a total of 17 out of 29 pavement management practitioners (59%) indicated that the HPMS requirements do not match what is available in their pavement management system. Only 7 (24%) indicate that there is a match and 5 (17%) indicate that they did not know the answer.
- A total of 25 out of 31 (81%) of the pavement management respondents indicate that different segments are used in their pavement management system than are used to report pavement conditions in HPMS.
- A total of 19 out of 31 respondents (61%) typically include bridges and railroad crossings in the pavement management IRI data as required under HPMS.

COMPARISON OF VOLUNTEER STATE DATA

In addition to evaluating the findings of the state practice survey, the research team evaluated the HPMS data provided by FHWA and the pavement management data provided by each of the volunteer states to evaluate the types and extent of differences in the information reported for HPMS and as part of the state's pavement management reporting. Differences in the content and formatting of these two information sources shed light on the variability of reported data and the difficulty states may have to produce data types required for HPMS. As reported earlier, eight state highway agencies provided pavement management data to the research team, including Kansas, Minnesota, Montana, New Jersey, Ohio, South Dakota, Utah, and Virginia DOTs. The FHWA provided HPMS data for each of the volunteer states from the 2012 submittal packages. To protect the anonymity of state agencies, the names of the states are not provided when reporting on data comparisons. Instead, each of the states was randomly assigned a consecutive number so the information could be reported as State 1, State 2, State 3, and so on.

The analysis of the pavement management and HPMS data focused on the following areas:

- The availability of comparable information in the pavement management and HPMS data sets.
- The amount of processing required for comparing HPMS and pavement management data.
- Differences in pavement conditions reported using HPMS and pavement management data.
- The impact of the reporting length (e.g., segment or route) on pavement condition statistics.

The results in each of these areas are presented separately in the following subsections.

COMPARABILITY OF HPMS AND PAVEMENT MANAGEMENT DATA SETS

The HPMS data sets provided by FHWA contained all of the pavement-related information reported by the volunteer states as part of their 2012 data submittal for the state system. The same information was requested of the pavement management practitioners, only this information was requested in the format used by pavement management without requiring that HPMS submittal requirements be met. In addition, the pavement management practitioners were asked to provide the condition index values for their pavement management sections and a summary of the number of sections in Good, Fair, and Poor condition.

To compare pavement condition information, the research team focused on the following measures of pavement condition that are reported to HPMS:

- IRI
- Rutting
- Faulting
- Percent of fatigue cracking
- Length of transverse cracking

Table 3-6 summarizes the data items each volunteer state provided in its pavement management database. Since states were asked to provide data as it is currently stored in their pavement management database (so no manipulation of the data was required), the research team received pavement management data in a number of different formats, which impacted the suitability of the data for purposes of the analysis. For example, only three of the states (States 1, 6, and 7) were able to provide all of the information in a format that was directly comparable to the HPMS data set. Two states (States 2 and 3) provided some of the information in a format that was comparable to the HPMS data set, but some of the information was reported in terms of the agency's own condition index methodology. State 8 did not provide any raw data for direct comparison, but instead provided all index values for the different distress categories. Data that was not provided is indicated by a "No" in the table. In most cases, the agency's pavement management survey procedure exhibits differences from type of distress data requested for HPMS. For example, States 4 and 5 do not collect faulting information as part of their pavement management survey. Information identified by "Yes" in the table could be directly compared to the HPMS data set received from FHWA after the research team matched the data segments together.

As indicated by the information shown in the table, the majority of the states that participated as volunteer states (62.5%) have some differences in the way that pavement distress information on the state system is stored in their pavement management database and the way it is required for HPMS reporting. For example, State 3 reports distress information in terms of an index and the index containing transverse cracking also contains non-wheelpath

longitudinal cracking and block cracking, so it is not a direct comparison to the crack length required for HPMS. The index used by State 8 is similar in that it considers all non-load-related cracking observed in the field. This does not mean that the states cannot provide information for HPMS, but it illustrates that some amount of manipulation is required to respond to the HPMS reporting requirements and that a separate database must be established to store HPMS data in these states.

Table 3-6 Pavement Condition Information Provided by Volunteer States

State	IRI	Rutting	Faulting	Fatigue Cracking	Transverse Cracking
1	Yes	Yes	Yes	Yes	Yes
2	Yes	Yes	Index	Yes	Yes
3	Yes	Index	Index	Index	Index
4	Yes	Yes	No	Yes	Yes
5	Yes	No	No	No	No
6	Yes	Yes	Yes	Yes	Yes
7	Yes	Yes	Yes	Yes	Yes
8	Index	Index	Index	Index	Index

PROCESSING REQUIREMENTS TO COMPARE HPMS AND PAVEMENT MANAGEMENT DATA

Since states were asked to provide data directly from their pavement management databases, there were significant differences in the number of sections contained in the pavement management databases and those contained in the HPMS database. In every instance, the pavement management databases contained more sections than the HPMS database, most likely due to the fact that HPMS is based on a sample of data and the pavement management database contains information for the entire state network. Additionally, since some HPMS data elements (e.g., faulting) are only relevant to a certain subset of the pavement management database (e.g., concrete pavements) this impacted the number of samples that could be used when comparing pavement conditions in the HPMS and pavement management databases.

The differences in the data sets directly impacted the research team’s ability to compare some of the pavement condition data for this study. To facilitate the comparison of data, the research team was forced to manually manipulate the data provided so that data from the pavement management databases could be matched to the corresponding data in the HPMS database. The use of SHPE file formats (e.g., geospatial data such as used in a geographic information system [GIS]) was instrumental in allowing this transformation of the pavement management data to take place. Since HPMS data are reported using SHPE file formats, the research team requested the pavement management data from the volunteer states using the same format. This allowed the research team to utilize ArcGIS software to create new data tables linking the pavement management sections to those reported to HPMS. The process requires manual manipulation of the data in ArcGIS, which is very time consuming. For instance, the HPMS file contains an individual record for each distress segment by distress type so, for example, there is a separate record for IRI from 0.0 to 0.23 miles and another record for cracking from 0.0 to 0.56 miles, and so on. This is illustrated in Table 3-7. The pavement management files store data based on a

pavement management section rather than based on the way distress data is collected, as illustrated in Table 3-8. Therefore, for each type of distress considered (i.e., IRI, rutting, faulting, and cracking percentage), the linking and matching process had to be repeated.

Table 3-7 Example of HPMS Data Sample

A	D	E	F	G	H
YEAR	BEG_POINT	END_POINT	DATA_ITEM	SECTION_LENGTH	VALUE
2011	36.898	37.897	CRACKING_LENGTH	0.999	3168.00000
2011	36.898	37.897	IRI	0.999	121.00000
2011	37.897	38.898	CRACKING_LENGTH	1.001	2661.00000
2011	37.897	38.898	IRI	1.001	148.00000
2011	38.898	39.293	CRACKING_LENGTH	0.395	2281.00000
2011	38.898	39.293	IRI	0.395	133.00000
2011	39.293	39.900	IRI	0.607	85.00000
2011	39.293	40.679	FAULTING	1.386	0.00000
2011	39.900	40.679	IRI	0.779	67.00000
2011	40.679	41.901	CRACKING_LENGTH	1.222	2534.00000
2011	40.679	41.901	CRACKING_PERCENT	1.222	12.00000
2011	40.679	41.901	IRI	1.222	126.00000
2011	40.679	41.901	RUTTING	1.222	0.20000
2011	41.901	42.509	CRACKING_LENGTH	0.608	3802.00000
2011	41.901	42.509	CRACKING_PERCENT	0.608	2.00000
2011	41.901	42.509	IRI	0.608	183.00000
2011	41.901	43.524	RUTTING	1.623	0.10000
2011	42.509	43.003	CRACKING_LENGTH	0.494	1140.00000
2011	42.509	43.003	IRI	0.494	92.00000
2011	42.509	46.001	CRACKING_PERCENT	3.492	0.00000
2011	43.003	43.524	CRACKING_LENGTH	0.521	1267.00000
2011	43.003	43.524	IRI	0.521	100.00000
2011	43.524	44.001	IRI	0.477	124.00000
2011	43.524	45.000	CRACKING_LENGTH	1.476	1647.00000
2011	43.524	46.001	RUTTING	2.477	0.20000
2011	44.001	45.000	IRI	0.999	81.00000
2011	45.000	46.001	CRACKING_LENGTH	1.001	1394.00000
2011	45.000	46.001	IRI	1.001	112.00000

Linking the distress data for the state systems in the seven states that provided raw data required more than 60 hours of time. The exercise was worthwhile, however, because it illustrated the demands on state highway agencies to respond to the HPMS submittal requirements.

COMPARISONS IN REPORTING PAVEMENT CONDITIONS

A comparative analysis was conducted for each of the four different distress types required under HPMS: IRI, rutting, faulting, cracking percent (fatigue), and cracking length (transverse). In addition, a comparison of the pavement conditions reported by the volunteer states using their pavement management survey methodology and the conditions that would be reported nationally using HPMS data was performed. The results are presented for those sections where matches between pavement management and HPMS data sets could be created.

International Roughness Index

The IRI data were first evaluated on a route basis using the matched HPMS and pavement management data sets for six states. The data from one state was not used because the IRI data from the pavement management database was reported in terms of a Roughness Index rather than in in/mi (as is used in the HPMS). Data from another state was not used because the data was not provided in a GIS format, which prevented the linking of the HPMS and pavement management data sets.

Table 3-8 Example of Pavement Management Data Sample

B	I	J	K	N	AD	AE	AG	AH	AI	AJ
ID	Begin	End	Length	Date	IRI	PSR	Rutting	Faulting	Cracking_Percent	Cracking_Length
1	13.475	14.001	0.526	June-2011	92	3.2	0.12	N/A	0	1,774
2	14.001	15.000	0.999	June-2011	80	3.4	0.11	N/A	0	2,281
3	15.000	15.365	0.365	June-2011	88	3.2	0.10	N/A	0	2,154
4	15.365	16.002	0.637	June-2011	75	3.4	0.14	N/A	0	1,267
5	16.002	17.001	0.999	June-2011	77	3.4	0.14	N/A	0	887
6	17.001	17.419	0.418	June-2011	80	3.3	0.17	N/A	0	507
7	17.419	18.002	0.583	June-2011	86	3.3	0.12	N/A	0	1,774
8	18.002	19.001	0.999	June-2011	87	3.3	0.11	N/A	0	1,521
9	19.001	19.392	0.391	June-2011	87	3.3	0.13	N/A	0	2,154
10	19.392	20.004	0.612	June-2011	113	2.9	0.19	N/A	0	1,901
11	20.004	20.999	0.995	June-2011	109	3.0	0.14	N/A	0	1,647
12	20.999	22.000	1.001	June-2011	116	2.9	0.19	N/A	0	3,802
13	22.000	23.000	1.000	June-2011	115	2.9	0.20	N/A	0	2,154
14	23.000	24.000	1.000	June-2011	128	2.7	0.21	N/A	0	3,295
15	24.000	25.000	1.000	June-2011	111	2.9	0.17	N/A	0	2,408
16	25.000	25.997	0.997	June-2011	117	2.8	0.22	N/A	0	3,295
17	25.997	27.135	1.138	June-2011	108	3.0	0.19	N/A	0	2,408
18	27.135	28.002	0.867	June-2011	40	4.2	0.08	N/A	0	1,140
19	28.002	29.002	1.000	June-2011	38	4.2	0.08	N/A	0	1,014
20	29.002	30.003	1.001	June-2011	36	4.3	0.08	N/A	0	887
21	30.003	31.001	0.998	June-2011	38	4.2	0.08	N/A	0	760
22	31.001	32.001	1.000	June-2011	34	4.2	0.08	N/A	0	1,014
23	32.001	33.000	0.999	June-2011	39	4.1	0.10	N/A	0	760
24	33.000	34.001	1.001	June-2011	37	4.2	0.10	N/A	0	887
25	34.001	35.000	0.999	June-2011	49	3.9	0.11	N/A	0	887
26	35.000	35.906	0.906	June-2011	36	4.3	0.09	N/A	0	760
27	35.906	36.898	0.992	June-2011	106	3.0	0.18	N/A	0	2,154
28	36.898	37.897	0.999	June-2011	118	2.8	0.22	N/A	0	2,915
29	37.897	38.898	1.001	June-2011	145	2.5	0.23	N/A	5	2,028
30	38.898	39.293	0.395	June-2011	129	2.8	0.29	N/A	0	2,154
31	39.293	39.900	0.607	June-2011	138	2.7	0.15	N/A	0	2,534
32	39.900	40.900	1.000	June-2011	106	3.0	0.16	N/A	0	2,661
33	40.900	41.901	1.001	June-2011	116	2.9	0.20	N/A	0	1,901
34	41.901	42.509	0.608	June-2011	96	3.0	0.16	N/A	0	2,534
35	42.509	43.003	0.494	June-2011	193	2.1	0.29	N/A	0	1,394

The data were compared in two ways. First, average weighted IRI values were compared for all matched routes to determine a statewide average weighted IRI value. The results of this comparison are presented in Table 3-9. The exhibit shows strong correlations between the information reported in HPMS and the information stored in the pavement management database. The largest difference was observed in State 3 where the HPMS IRI value was 2.8% higher than the pavement management IRI value. The smallest difference was observed in State 6 where the HPMS IRI value was 0.25% higher than the pavement management IRI value. States 2 and 4 also had pavement management IRI values that were slightly larger than HPMS IRI values. None of the differences are considered to be significant.

Table 3-9. Statewide Average Weighted IRI Comparisons for Matched Routes

State	HPMS IRI Weighted-Average	Pavement Management IRI Weighted-Average
1	106.0	105.0
2	100.5	101.5
3	114.9	111.6
4	157.7	158.9
5	122.6	119.4
6	79.9	79.7

The second comparison on the route data involved classifying the HPMS and pavement management IRI data in terms of Good, Fair, or Poor condition to evaluate differences in using descriptive categories to report conditions. For this analysis, the following definitions were used: Good: IRI less than 95; Fair: IRI between 95 and 170; Poor: IRI greater than 170 (FHWA 2010b). The results of the analysis are presented in Figure 3-4. The results from States 4 and 6 showed no difference in the percent of the road network in Good, Fair, or Poor condition using the HPMS and pavement management data. However, for the four other states, the differences in weighted average condition begin to show more variability than is indicated by the IRI values reported in Table 3-9. As shown in Figure 3-4, State 2 showed the greatest variability in the results followed by States 1, 3, and 5. The level of variability shown in this analysis differs from the results calculated using average weighted IRI values. For instance, when comparing statewide average weighted IRI values, States 5 and 3 showed more variability than State 2.

The IRI information was also analyzed at the segment level for State 2 and the results are presented in Table 3-10 and Figure 3-5. Table 3-10 shows the difference in average weighted IRI values for all matched segments for State 2 using both HPMS and pavement management data. As the results show, there is good correlation between the average values. Figure 3-5 presents the results of the segment analysis in terms of the Good, Fair, and Poor definitions defined earlier. It is interesting to note that at the segment level, there is less variability in the reported results using the two data sources than there was for the same state at the route level. However, the resulting conditions that are reported based on segments are considerably different than what would have been reported if the summary had been done on a route basis. For example, on a segment basis, State 2 has 66% to 69% of the segments in Good condition but the route analysis shows between 28% and 42% of the network in Good condition. Similarly, the segment analysis shows 4% of the network in Poor condition using either HPMS or pavement management data. However, when a weighted average is calculated for each route, only 1 percent of the network is reported to be in Poor condition, regardless of the data source.

Table 3-10. Comparison of Average Weighted IRI Values for State 2 Segments

State	HPMS IRI Weighted-Average	Pavement Management IRI Weighted-Average
2	88.08	90.18

It should be noted that the statewide, route, and segment comparisons of average weighted IRI values evaluates data for each state individually; in other words, it does not provide a basis for comparing results across the states to evaluate the consistency in the survey methodologies used by the participating states. However, three of the eight volunteer states indicated in the survey of state practice that their pavement management IRI surveys do not match the HPMS requirements. Therefore, it can be assumed that there are differences in the way the IRI data are collected by the six states used in this analysis.

Figure 3-4. Comparison of Routes in Good, Fair, and Poor Condition Based on IRI

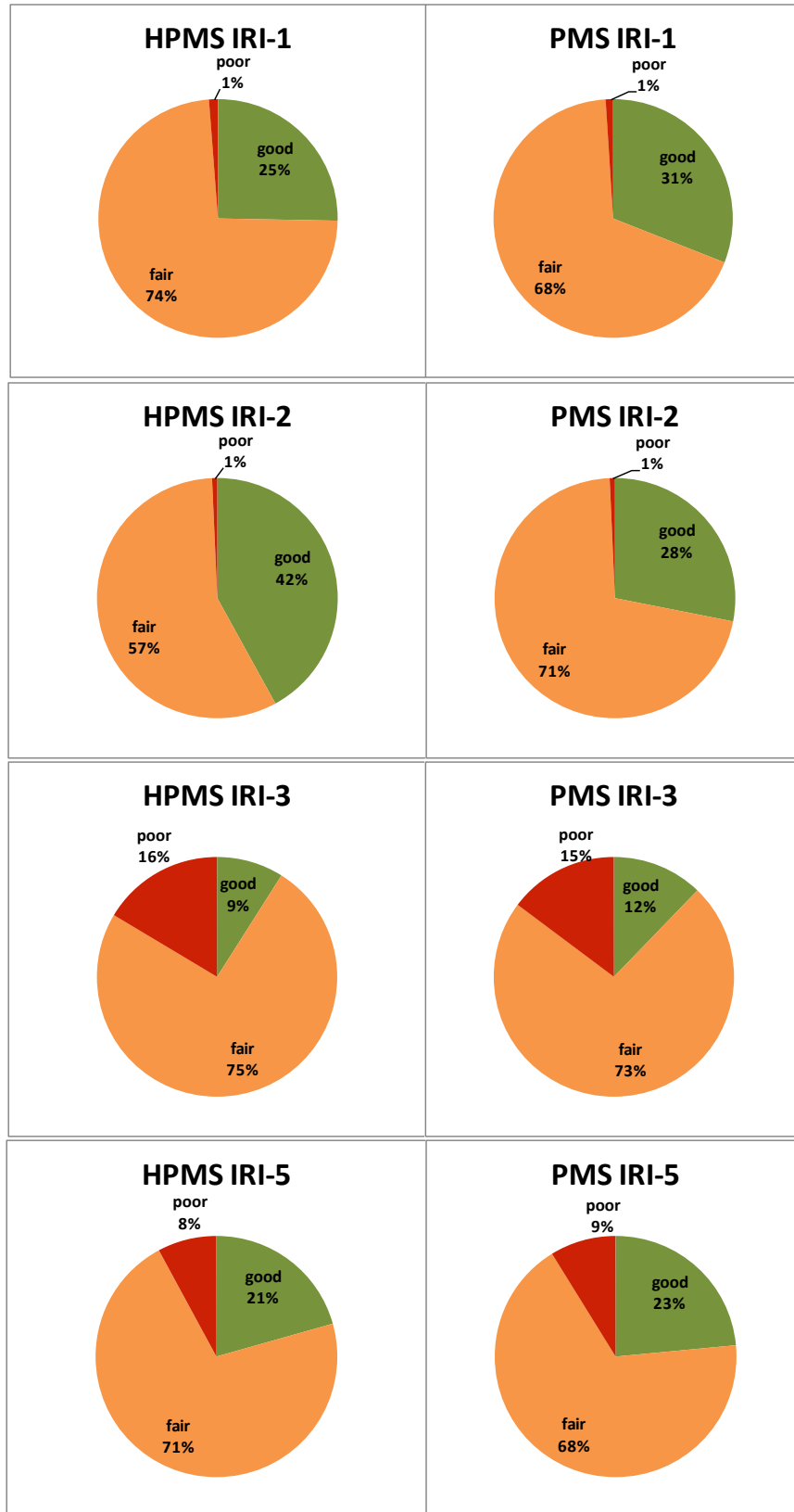
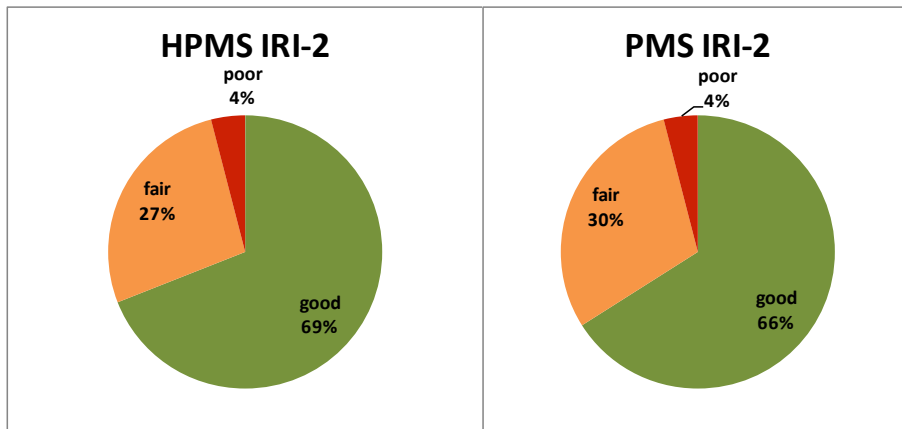


Figure 3-5. Comparison of Segments for State 2 Using Average Weighted IRI Values



Rutting

Only four states were considered for the rutting comparison since two states reported a rutting index rather than a rut depth and one state did not provide their data in a GIS format to facilitate section matching. The analysis compared the average weighted rut depth reported in HPMS and in the pavement management database (in inches) on a statewide, route, and segment basis. The statewide comparisons are presented in Table 3-11. In three of the four states, the statewide weighted average rut depths were comparable; however, there was a significant difference in the averages for State 1.

Table 3-11. Statewide Average Weighted Rut Depth Comparisons

States	HPMS Rutting Weighted-Average (in)	State Rutting Weighted-Average (in)
1	0.29	0.14
2	0.13	0.15
4	0.20	0.19
6	0.13	0.13

A comparison of rut data at the route level was conducted on States 1 and 2. The impact of the variability is shown in Figure 3-6, which summarizes the results in terms of the percent of the routes in Good, Fair, and Poor condition. In this analysis, routes in Good condition were defined as having an average weighted rut depth of less than 0.25 inches, routes in Fair condition had an average weighted rut depth of between 0.25 and 0.5 inches, and routes in Poor condition had an average weighted rut depth of more than 0.5 inches. The results show a significant amount of variability for State 1, but equivalent results for the routes in State 2.

The differences in the results for State 1 are nothing less than astounding since the resulting conditions from the two data sets are in no way comparable. It is difficult to account for the variability in the data, except to say that the statewide weighted averages tend to mask the range of data that can be found when aggregating data into smaller subsets. This is further illustrated by the segment analysis that was performed on the data from State 2. While the resulting conditions from the route comparison showed no difference for this State, there were small differences in the reporting conditions when reported at the segment level, as shown in figure 3-7.

Figure 3-6. Average Weighted Rut Depth Comparisons by Route in States 1 and 2

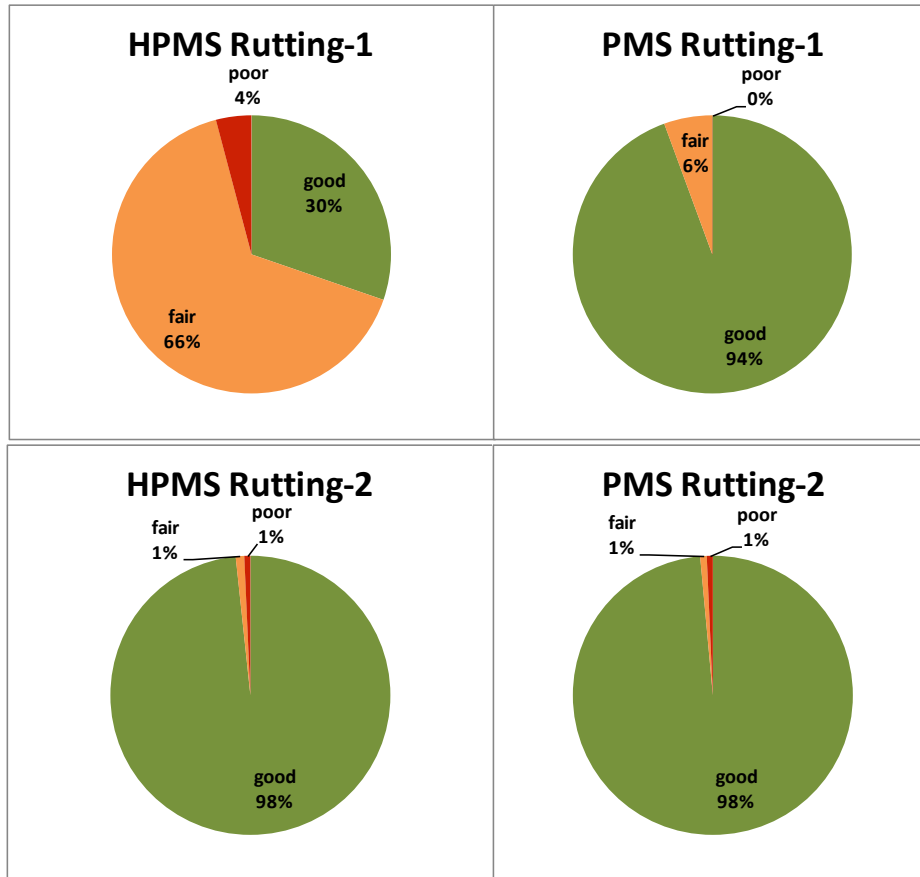
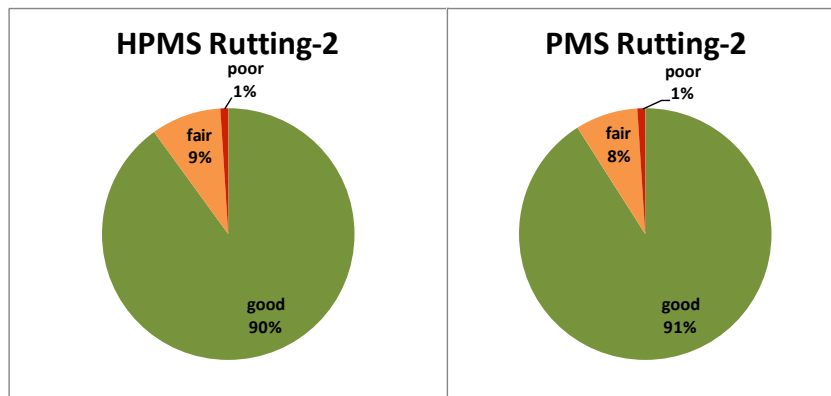


Figure 3-7. Average Weighted Rut Depth Comparisons by Segment in State 2



Faulting

The research team was not able to compare HPMS and pavement management faulting data for several reasons. First, three of the states reported faulting in terms of an index rather than fault measurements and one state did not provide faulting information (it is not part of their pavement condition survey methodology). Two states reported faulting in terms of the number of slabs in a certain severity group, which did not compare to the average fault measurement reported in HPMS. These states use various approaches to convert the number of slabs to fault

measurements for HPMS reporting. It appears that one state uses a single default value for any sections with faulting present when reporting to HPMS and the other has developed a formula to convert the number of faulted slabs to a faulting measurement for HPMS purposes. Another state's HPMS data appeared questionable, with eight sections having average faults greater than 100 inches and another section with faulting of 254 inches.

Cracking

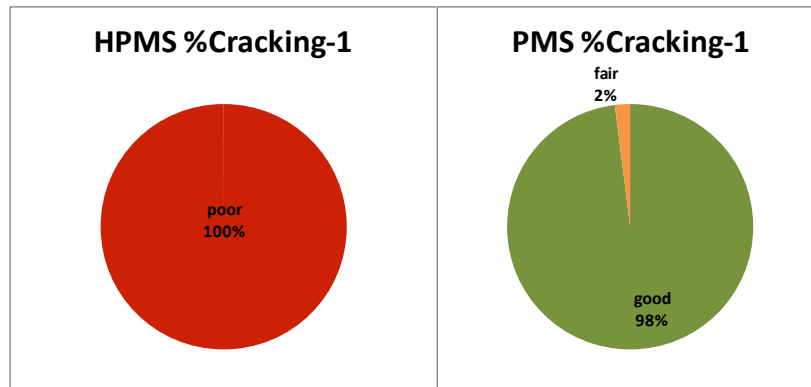
Cracking data was especially hard to compare due to the differences in data values between the HPMS databases and the pavement management databases. The HPMS database stores cracking data in two data items: Percent Cracking and Cracking Length. Percent Cracking is a record of longitudinal cracks formed on wheel-paths and other load related cracks found in both asphalt concrete and Portland concrete pavements. Cracking Length is a record of transverse cracks in asphalt pavements. Both of these data items are reported to HPMS without specifying crack severity. HPMS allows for estimation of these values based on collected cracking data.

The research team attempted to correlate the cracking data in the pavement management database to the HPMS Cracking Percent and Cracking Length data, but several issues impacted the team's ability to compare the cracking data directly, as summarized below.

- Several volunteer states did not report cracking information for concrete pavements. This could either be indicative of the lack of a survey methodology that collects cracking information on concrete pavements, the lack of cracking on concrete pavements, or the lack of concrete pavements in the state.
- At least one state's pavement management survey methodology rates alligator and non-alligator cracking. Another state's survey methodology does not measure the length of transverse cracking. Therefore, these states either do not have information on transverse cracking to submit to HPMS or have to convert data to provide crack length for HPMS.
- Several states did not submit raw distress data and only store the condition index in the pavement management database.

To illustrate the issues that arise when comparing cracking data, a route analysis was conducted on a randomly-selected route in State 1. Only 1 route was selected because the comparison required the research team to convert all of the pavement management crack data to percentages before the comparison could be conducted. The results of the analysis are provided in figure 3-8, which reflects drastically different results based on the data source. In the case of the HPMS data, it appears that a single value was submitted to HPMS to represent the percent of cracking along the route. Therefore, the entire route is reported to be in Poor condition. The pavement management database, however, contains cracking information for each pavement management segment along the route. The resulting conditions using pavement management information shows that most of the route is in Good condition, with only a small portion of the route in Fair condition. The example illustrates the possible impact of reporting default values in HPMS.

Figure 3-8. Percent Good, Fair, and Poor Conditions in State 2 Based on Percent Cracking



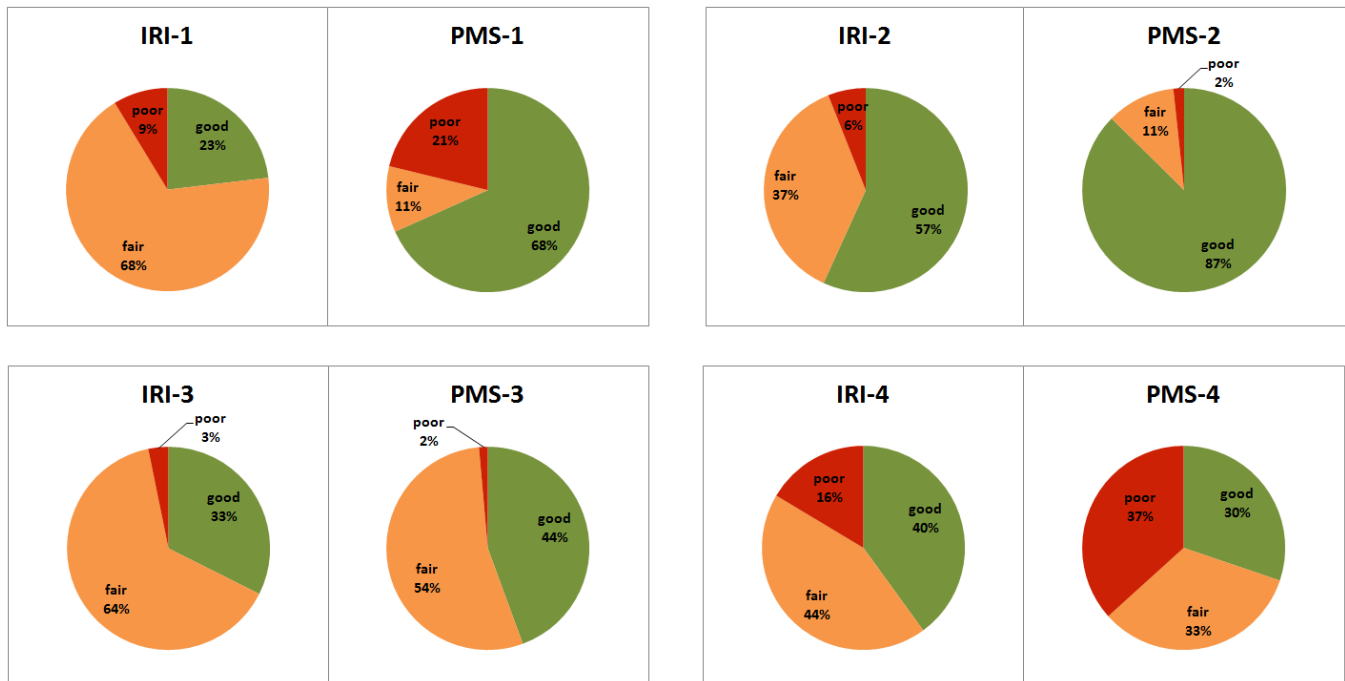
Good/Fair/Poor Comparison

One of the expected performance measures that may be used for reporting pavement conditions on a national basis is a summary of the percent of roads in Good, Fair, and Poor condition based on IRI. The use of IRI for this purpose is supported in the HPMS Field Manual, which states that IRI data will be used to estimate pavement deterioration, section deficiencies, and necessary improvements, as well as to conduct allocation studies (FHWA 2010a).

To investigate the differences in reporting pavement conditions using IRI and state pavement management results, the research team conducted a comparison of the percentage of the network reported to be in Good, Fair, and Poor condition using two different methods of evaluating pavement condition. For HPMS purposes, IRI values were used based on the definitions in the FHWA report. For pavement management purposes, each state’s individual rating methodology was used to define the percentage of the pavement sections that would be reported in Good, Fair, and Poor condition.

Four of the eight states provided a summary of their condition rating methodology that was used to determine the overall condition of the pavement management sections. The resulting comparison of road conditions in Good, Fair, and Poor condition is presented in figure 3-9. As can be seen, there are substantial differences in the results that are reported, especially in States 1, 2, and 4. These results are to be expected because of the large number of state highway agencies that do not rely exclusively on IRI to report pavement conditions or to recommend pavement preservation activities. However, the results illustrate the dramatic differences that can occur if the FHWA hopes to use IRI as a primary performance measurement on a national basis.

Figure 3-9. Percent of Sections Reported in Good, Fair, or Poor Condition



SUMMARY OF KEY FINDINGS AND OBSERVATIONS

The most significant findings and observations from the study are summarized below. These findings are based on the research team’s assessment of the HPMS Reassessment comments, the survey of state practice, and the analysis of the pavement management data.

1. There is a relatively high degree of confidence in the HPMS data on a state-by-state basis, but inconsistencies in how the information is collected nationwide result in a moderate to low degree of confidence in the ability to use the information to compare conditions across states. For example, on a statewide basis, the weighted average IRI data from pavement management and HPMS were very close. The same was true for rutting data, with only one exception. However, as smaller subsets of the data are evaluated, the variability in the data increases.
2. The HPMS pavement data requirements were implemented to populate new performance models based on the Mechanistic Empirical Pavement Design Guide (MEPDG). However, the information needed for the models, especially for roads off the state system, is not readily available in many states. Therefore, the states do not place a high degree of confidence in the reliability of the off-state system data. Other information, such as pavement cracking data, pavement structure information, and information on the last overlay and overlay thickness, was also rated as having a low degree of confidence by the participants in the survey of practice.
3. There are significant differences in the pavement condition information that states use to report network conditions. IRI is often a component of the overall condition, but ride is typically not a significant factor in selecting and prioritizing pavement preservation activities. Therefore, efforts by the FHWA to report pavement condition on a national basis using IRI alone will report substantially different conditions than what is being reported by the states to their constituents.

4. The variability in the reported pavement conditions varies based on the method of aggregating the data. The analysis showed significant differences in the percentage of pavements in Good, Fair, and Poor condition based on whether the data were summarized at the state, route, or segment levels.
5. Over three quarters of the states responding to the survey of practice indicate that the methodology used in their pavement management system for cracking differs from the HPMS requirements for reporting cracking information. As a result, some agencies have developed equations for converting their pavement management information for HPMS purposes and other states have developed other approaches for responding to the requirement. The analysis of the cracking data illustrates the potential impact of using default values to meet the HPMS submittal requirements.
6. The requirement to report faulting data is also problematic for some states since several states do not include faulting in their pavement management survey procedures. Where faulting is measured, it is not always measured consistently with HPMS requirements, which requires states to develop a process for converting data. In one instance, it appeared that a volunteer state reported a single default value to HPMS for any section in which faulting appeared.
7. The comparison of HPMS data and pavement management data required a lot of manipulation to match sections. This exercise illustrated the issues that would arise if the FHWA chose to develop a process for verifying the quality of the state data submitted to HPMS or if the pavement management personnel wanted to check the quality of the HPMS submittal before being sent to FHWA.
8. There was no evidence that the size of the agency or the method of collecting and processing the data influenced the results of the analysis or the likelihood of finding variability in the data.

PRIORITIZED RECOMMENDATIONS

Based on the findings and observations made during this study, several recommendations for changes to the HPMS data requirements can be made. The recommendations have been prioritized based on their potential impact on the states, and an agency to take responsibility for implementing the recommendation is suggested.

1. Determine the appropriateness of the models being used for national performance management and the need for the level of detail currently required. It is evident from the comparison of Good/Fair/Poor that metrics other than IRI are needed to report pavement conditions on a national basis; however, the current level of detail required and the annual reporting frequency for IRI on the entire system has created a burden on the states without evidence of any benefit to the states. Recommended lead: FHWA
 - a. If the current models continue to be used, conduct a sensitivity analysis on the models to determine the impact of using unreliable information for pavement cracking, pavement structure, date of last overlay, and overlay thickness. Based on the findings, provide guidance to the states on the level of detail required and/or modify the models to place less emphasis on these data elements. Recommended lead: FHWA
 - b. If new models are developed, identify pavement condition metrics that more closely match the information normally collected as part of network-level pavement management surveys to report network conditions and to trigger pavement preservation activities. For instance, the survey procedures for non-load related cracking in the volunteer states typically was not limited to transverse cracking, and often included other types of cracking (such as block cracking) that make it difficult to report Cracking Length for only transverse cracks. A more simplistic approach at capturing all wheelpath and non-wheelpath cracking might be an acceptable substitute to the

States. Alternatively, consider other methods of collecting consistent distress information on a national basis (e.g., a national data collection contract). Recommended lead: FHWA

2. Address the inconsistencies in the pavement management data collection activities that are impacting the ability to use HPMS data to compare pavement conditions across states. Begin by improving the consistency in the way IRI data is collected for HPMS purposes by strongly enforcing the existing HPMS section length recommendation and communicating the impact of inconsistent section lengths among practitioners. Recommended lead: FHWA with assistance from AASHTO to develop correlating data collection standards if they do not exist.
3. For pavement-related data only, require states to submit HPMS data using a consistent section length. Future research is needed to determine the appropriate length to minimize variability and processing time for reporting purposes. Recommended lead: FHWA
4. Demonstrate to the states the benefits associated with the availability and use of HPMS data. Based on the comments made during the HPMS Reassessment, many states do not see the return for the level of investment they are making in HPMS activities. Recommended lead: FHWA
5. Develop a strategy for obtaining the information necessary for evaluating or estimating the performance of the off-state system in a cost-effective manner. Recommended lead: States

CHAPTER 4 CONCLUSIONS AND SUGGESTED RESEARCH

The recent highway authorization, Moving Ahead for Progress in the 21st Century (MAP-21) promotes a performance-based approach for managing highways on the federal-aid system. The FHWA is responsible for developing the policies, guidance, tools, and training necessary to support this program. In the past, the FHWA has relied on HPMS data as the primary source for preparing the pavement-related information for the Condition and Performance Reports provided to Congress every other year. HPMS is populated using data provided by state transportation agencies on the condition, performance, use, and operating characteristics of the Nation's highways in accordance with reporting requirements specified by FHWA.

As part of its responsibilities under MAP-21, the FHWA would like to use HPMS data to report highway conditions on a national basis. However, states have raised concerns that HPMS data is not sufficient to be used at the national level for policy decisions and target setting due to perceived inconsistencies in the data across states. States have also raised concerns about differences between overall conditions reported in HPMS and the conditions reported for a state's pavement management program. This study investigated the differences between HPMS and pavement management data and conducted an objective assessment of the consistency of HPMS data with pavement management data.

The findings show that while most practitioners indicate they have confidence in the HPMS reports submitted by their state, they do not have confidence that the information can be used to compare pavement performance across states. The study found a significant impact on reported pavement conditions based on the reporting length and significant differences between the pavement conditions that would be reported using HPMS data (i.e., IRI) and what is reported by the states using their pavement management data.

Therefore, if the FHWA intends to use HPMS data to report national highway conditions, to predict future highway conditions, and to estimate the impacts of different investment levels on national highway conditions, additional efforts are needed to improve the consistency in the HPMS data. To overcome the issues raised in this study, research is recommended in the following areas:

- An assessment of the models needed by FHWA to satisfy its requirements under MAP-21 and the data required to populate the models.
- The sensitivity of predicted conditions to the variables required under HPMS to better determine the impact of inaccurate or default data.
- The enforcement of a consistent HPMS reporting length that minimizes variability and reporting time.
- A suitable pavement condition metric that more closely matches state conditions reported for pavement management.

REFERENCES

American Association of State Highway and Transportation Officials (AASHTO). 2007. *Standard Practice for Quantifying Roughness of Pavements*. American Association of State Highway and Transportation Officials, Washington, DC.

Federal Highway Administration. 2008. *HPMS Reassessment 2010+ Final Report*. Federal Highway Administration, Washington, DC.

Federal Highway Administration. 2010a. *Highway Performance Monitoring System Field Manual for the Continuing Analytical and Statistical Database*. Federal Highway Administration, Washington, DC.

Federal Highway Administration. 2010b. *Evaluation of Highway Performance Measures for a Multi-State Corridor – A Pilot Study*. Federal Highway Administration, Washington, DC.

Federal Highway Administration. 2012. *Moving Ahead for Progress in the 21st Century Act (MAP-21): A Summary of Highway Provisions*. Federal Highway Administration, Washington, DC

APPENDIX A: STATE OF PRACTICE SURVEY

NCHRP 20-24(82) Increasing Consistency in the Highway Performance Monitoring System for Pavement Reporting

Parsons Brinckerhoff is managing a team of individuals working on NCHRP Project 20-24(82), which is focused on improving the consistency between Highway Performance Monitoring System (HPMS) data and pavement management data. As part of this project, the research team is surveying the pavement management and the HPMS personnel in each State and would like to obtain your feedback.

The goal of the survey is to determine the magnitude and extent of the issues that are impacting the quality of HPMS data and/or causing differences in the data reported to HPMS and the information reported by pavement management. Therefore, it is important that when you complete the survey, you provide answers that represent **your perspective of the process** rather than trying to answer from the DOT's perspective. In other words, if you are the HPMS coordinator, please focus only on the tasks you complete in preparing your submittal to the FHWA. Similarly, the pavement management personnel should only consider their part of the process to collect and report the data.

Please help us better understand these differences by completing this survey. **It should take no more than 15 minutes of your time.**

The survey is set up so that you can complete part of the survey at one time and if needed, you can come back and complete the survey at a different time. Further, if you do not know an answer to a question, you can leave it blank.

We would like all surveys to be completed by close of business on Friday, September 7, 2012.

If needed, you can find the Highway Statistics tables with the data reported to FHWA at <http://www.fhwa.dot.gov/policyinformation/statistics.cfm>.

To begin the survey, please select "Next".

Survey Questions (possible answers are in parenthesis after the question)

- 1) Please select the state where your agency is located (List all 50 states, DC, and Puerto Rico)
- 2) Please indicate whether you are the HPMS coordinator or a representative from pavement management (HPMS, Pavement Management)
- 3) Are HPMS and pavement management located in the same division? (Yes or no)
- 4) Please indicate the extent to which you agree with the following statements:
 - The HPMS data reported by our state closely matches the information reported by pavement management. (Strongly Agree, Agree, Disagree, Strongly Disagree, Do Not Know)

- The HPMS information reported to the FHWA is representative of the information used to recommend projects in our pavement management system. (Strongly Agree, Agree, Disagree, Strongly Disagree, Do Not Know)
- 5) What degree of confidence do you have in the HPMS data reported (or posted on FHWA Highway Statistics Tables) being an accurate representation of your State's pavement conditions? (High, Moderate, Low)
 - 6) What degree of confidence do you have in the HPMS data reported (or posted on FHWA Highway Statistics Tables) being used across states to provide a consistent representation of pavement condition? In other words, what degree of confidence do you have in using HPMS data to compare state performance and to assess national system performance? (High, Moderate, Low)
 - 7) Do you collect any pavement-related data specifically for HPMS or do you use a conversion of your own PMS data? (Collect pavement-related data specifically for HPMS, Use a conversion of pavement management data, Use pavement management data without a conversion, Use a combination of approaches.)
 - a) If you indicated that you collect pavement-related data specifically for HPMS or use a combination of approaches, please list the items that are only collected to satisfy HPMS requirements.
 - b) Do you use HPMS pavement data internally? (Yes or no) If yes, list the pavement data you use internally. If no, list the reason why.
 - 8) Based on comments provided to the FHWA during the 2010 HPMS Reassessment, the following items represent the biggest challenges agencies face in responding to the HPMS requirements. Please indicate the significance of this issue in your State and the extent to which it impacts the quality of the data your State reports.
 - a) How significant a challenge is the **number of data items** agencies are required to report in the HPMS submittal? (A major challenge, somewhat of a challenge, a minor challenge, not a challenge)

How does the number of data items required impact the quality of the data reported? (A major impact, somewhat of an impact, a minor impact, no impact)
 - b) How significant a challenge is the **amount of IRI data** required in the HPMS submittal? (A major challenge, somewhat of a challenge, a minor challenge, not a challenge)

How does the amount of IRI data required impact the quality of the data reported? (A major impact, somewhat of an impact, a minor impact, no impact)
 - c) How significant a challenge is **the frequency with which IRI data must be collected** (i.e., annually on the NHS)? (A major challenge, somewhat of a challenge, a minor challenge, not a challenge)

How does the frequency with which the IRI data must be collected impact the quality of the data reported? (A major impact, somewhat of an impact, a minor impact, no impact)
 - d) How significant a challenge is the **type and extent of pavement distress data** required? (A major challenge, somewhat of a challenge, a minor challenge, not a challenge)

How does the type and extent of pavement distress data required impact the quality of the data reported? (A major impact, somewhat of an impact, a minor impact, no impact)

- e) How significant a challenge is the **type and extent of pavement structure information** required? (A major challenge, somewhat of a challenge, a minor challenge, not a challenge)

How does the type and extent of pavement structure data required impact the quality of the data reported? (A major impact, somewhat of an impact, a minor impact, no impact)

- f) How significant a challenge is the **type and extent of inventory information** required? (A major challenge, somewhat of a challenge, a minor challenge, not a challenge)

How does the type and extent of inventory data required impact the quality of the data reported? (A major impact, somewhat of an impact, a minor impact, no impact)

- g) How significant a challenge is your **effort to convert data to the format required by HPMS**? (A major challenge, somewhat of a challenge, a minor challenge, not a challenge)

How do your efforts to convert data to the format required by HPMS impact the quality of the data reported? (A major impact, somewhat of an impact, a minor impact, no impact)

- h) How significant a challenge is the **availability of required information on non-state owned roads**? (A major challenge, somewhat of a challenge, a minor challenge, not a challenge)

How do the issues with data availability on non-state owned roads impact the quality of the data reported? (A major impact, somewhat of an impact, a minor impact, no impact)

- i) How significant a challenge is the **appropriateness of your data collection approach** (e.g., manual or automated surveys) to the HPMS requirements? (A major challenge, somewhat of a challenge, a minor challenge, not a challenge)

How does your data collection approach impact the quality of the data reported? (A major impact, somewhat of an impact, a minor impact, no impact)

- j) How significant a challenge are **data variations caused by changes in data collection equipment**? (A major challenge, somewhat of a challenge, a minor challenge, not a challenge)

How do data variations caused by changes in equipment impact the quality of the data reported? (A major impact, somewhat of an impact, a minor impact, no impact)

- 9) Do you have steps in place to check HPMS data before submittal? (Yes or no)

- 10) Do you have steps in place to check the quality of the pavement management data collected? (Yes or no)

- 11) Indicate if the majority of the PMS data is measured, estimated, or default data for the following highway networks:
 - a) NHS data (Measured, estimated, or default)
 - b) State owned non-NHS data (Measured, estimated, or default)
 - c) Off-system route data (Measured, estimated, or default)
- 12) Indicate if the majority of the HPMS data is measured, estimated, or default data for the following highway networks:
 - a) NHS data (Measured, estimated, or default)
 - b) State owned non-NHS data (Measured, estimated, or default)
 - c) Off-system route data (Measured, estimated, or default)
- 13) Indicate whether the reporting requirements for HPMS match your pavement management condition survey methodology for the following data elements. (If there are differences, please explain in the comment feature).
 - a) IRI Data (Match, don't match, or don't know: Comments: _____)
 - b) Cracking Data (Match, don't match, or don't know: Comments: _____)
 - c) Pavement Structure Data (Match, don't match, or don't know: Comments: _____)
- 14) Does your State use different segments to report to HPMS than those used for pavement management purposes? (Yes or no)
- 15) Does your State collect IRI data using a sampling approach or is 100 percent of the area surveyed? (Sampling or 100 percent surveyed)
- 16) Does your State collect pavement distress data using a sampling approach or is 100 percent of the area surveyed? (Sampling or 100 percent surveyed)
- 17) When collecting IRI data for your own use, do you include bridge and railroad crossings with the pavement as part of your normal operations? (Yes or no)
- 18) IRI data reported for HPMS is supposed to include bridge and railroad crossings. How does this differ from the IRI data used and reported by the Agency for pavement management purposes? (Data must be collected twice to satisfy this requirement, data must be processed twice to satisfy this requirement, data in both systems matches)
- 19) We will be looking for a few states to provide pavement management information that we can compare to HPMS data to further investigate data issues. Would you be interested in participating in this part of the study? (Yes or no)
 - a) Thank you for your interest in participating in this future part of our study. Please enter your name, position title, and email address below and we will be in touch in the near future. (name, position title, and email address)

Thank you for your help. We appreciate you taking the time to complete this survey.

- 20) If you have any other comments, please share them here:

