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Guidelines for Development and Approval of State Data Quality Management Programs

Introduction

High-quality data is a critical part of performance-based management of highway pavements. Although many States use data quality practices, few have documented or formalized these into standard processes. Because of the importance of pavement performance data to decisions involving the Federal-aid program, the National Performance Management Measures: Assessing Pavement Condition for the National Highway Performance Program and Bridge Condition for the National Highway Performance Program (PM2) rule established ride (IRI), rutting, faulting, and cracking percent, or present serviceability rating (PSR) (can be used as an alternative to IRI, rutting, faulting, and cracking for NHS routes with speed limits less than 40 mph) as the pavement condition metrics, per 23 CFR 490.309[1] –"Data Requirements." States must collect and report these condition metrics to the Federal Highway Administration (FHWA) Highway Performance Monitoring System (HPMS) in accordance with the HPMS Field Manual[2] for the purpose of determining the condition of 0.1-mile sections and eventually calculating pavement measures in terms of good, fair, and poor per 23 CFR 490.309.

The PM2 rule also requires States to develop Data Quality Management Programs (DQMPs) appropriate for their agency, per 23 CFR 490.319. The DQMP requirement in the PM2 rule is intended to help States improve the accuracy of the pavement condition metrics noted above. A DQMP is a document that defines the acceptable level of data quality and describes how the data collection process will ensure this level of quality in its deliverables and processes.

An effective DQMP should address the critical areas where errors can occur. Even in the best of programs, errors often are made due to data collection equipment malfunction, unintended mistakes by operators, computer glitches, mechanical failures, and other issues that can result in poor data and the need for expensive recollection efforts.

Under 23 CFR 490.319(c), the State DOT must develop a DQMP that addresses the following minimum critical areas:

A. Data collection equipment calibration and certification;
B. Certification process for persons performing manual data collection;
C. Data quality control measures to be conducted before data collection begins and periodically during the data collection program;
D. Data sampling, review and checking processes; and
E. Error resolution procedures and data acceptance criteria.

DQMP Approval Process and Possible Outcomes

The FHWA Division Office is responsible for reviewing and approving the State DOT DQMP. This DQMP Guidance is a tool to help the FHWA Division Office assess the elements and completeness of a State DOT's DQMP. Per 23 CFR 490.319(c)(2), not later than one year after the effective date of the PM2 rule (May 20, 2017), each State

[1] National Performance Management Measures: Assessing Pavement Condition for the National Highway Performance Program and Bridge Condition for the National Highway Performance Program (PM2) rule under 23 CFR part 490: https://www.federalregister.gov/documents/2017/01/18/2017-00550/national-performance-management-measures-assessing-pavement-condition-for-the-national-highway

[2] Highway Performance Monitoring System (HPMS) Field Manual: https://www.fhwa.dot.gov/policyinformation/hpms/fieldmanual/ . The Field Manual is incorporated by reference in 23 CFR 490.111.

DOT must submit its DQMP to its respective FHWA Division Office for approval. Each FHWA Division Office will provide approval or comments to the State DOT within 30 days of the receipt of the DQMP.

In deciding whether the State DOT's DQMP submission is adequate, the FHWA Division Office will consider whether the submission describes the processes in enough detail and with sufficient clarity so that the Division Office can make a reasonable decision whether (1) each process meets the requirements in the regulation (23 CFR part 490) and will produce the information required by the PM2 rule; and (2) the submission addresses the minimum critical areas in 23 CFR 490.319(c).

Once FHWA approves a State DOT's DQMP, pursuant to 23 CFR 490.319, the State DOT must use the approved DQMP to collect and report data required by 23 CFR 490.309 and 490.311. State DOT also must submit any proposed significant change to the DQMP to FHWA for approval prior to implementing the change.

The DQMP review will lead to one of four outcomes:

- Compliance – The DQMP meets the requirements of 23 CFR 490.319(c).
- Substantial Compliance – The DQMP substantially meets the requirements of 23 CFR 490.319(c), except for minor deficiencies that require corrections.
    - The FHWA Division Office may approve the State DOT's DQMP as substantially compliant, but the State DOT should take actions to correct the minor deficiencies within 30 days after receipt of the notification of substantial compliance. The deficiencies must be addressed for State DOTs to meet the data collection requirements.
    - The State DOT must collect and report data per sections 23 CFR 490.309 and 490.311 and in compliance with a fully compliant, approved DQMP.
    - Minor deficiencies are deficiencies where a portion of the information or process is slightly incomplete, as compared to regulatory requirements. A determination of substantial compliance is not appropriate for a deficiency that is more than minor, including any case where the State DOT fails to address a required process.
    - Once the State DOT notifies FHWA in writing that the minor deficiencies have been addressed and the Division Office verifies that the corrections fully address the requirements of 23 CFR 490.319(c), the Division Office will issue a letter of full compliance.
- Conditional Compliance – The DQMP was found to have one or more items that did not meet the requirements of 23 CFR 490.319(c), but the State DOT is adhering to a FHWA-approved plan of corrective action (PCA) submitted in conjunction with the DQMP. For an example of PCAs, States and Divisions can find additional information on developing and monitoring PCAs developed for the National Bridge Inspection Standards.[3]
- Non-compliance – The DQMP does not meet the requirements of 23 CFR 490.319(c).

The FHWA will send the State DOT a written notice of non-compliance, including a listing of the specific deficiencies.

The State DOT is responsible for addressing deficiencies and resubmitting its DQMP to FHWA. Time is of the essence since pavement performance data must be collected per 23 CFR 490.309 and 490.311 and in compliance with a FHWA-approved DQMP.

FHWA Division Office Review Instructions/Framework

The following criteria should be used to evaluate the required DQMP critical elements in 23 CFR 490.319(c). For each criterion, the guidance provides protocols, required elements, examples of good practices, and considerations for the Division Office assessment.

[3] National Bridge Inspection Standards: https://www.fhwa.dot.gov/bridge/nbis/170103.pdf

- **Protocols:** Identifies standards, guidelines, processes, and references related to each DQMP critical element.
- **Required Elements:** Summarizes key elements for the specific DQMP critical area. A State DOT must use its DQMP to collect and report data satisfying each of the regulatory requirements in 23 CFR 490.309 and 490.311, including requirements contained in FHWA's HPMS Field Manual (https://www.fhwa.dot.gov/policyinformation/hpms/fieldmanual/). [23 CFR 490.319(c)(2)]
- **Examples of Good Practices:** Describes voluntary enhancements to the basic requirements. For example, State A, with a mature data quality management process, most likely has already developed a process for determining the level of accuracy and precision of the data that it collects as part of its pavement condition survey program whereas State B, which is at a lower maturity level with its DQMP, may need to develop a process and build upon it in the future. The FHWA encourages State DOTs to adopt more sophisticated approaches to their DQMPs, but if a State DOT's processes satisfy the required elements, FHWA will certify the processes. Further information on DQMP practices can be found in the FHWA Practical Guide for Quality Management of Pavement Condition Data Collection[4] or NCHRP Synthesis 401 -Quality Management of Pavement Condition Data Collection[5].
- **Division Office Assessment**: Indicates if the State DOT has met the requirements discussed in the Required Elements column, and how the State DOT has demonstrated compliance. Utilizing the Required Elements, the Division can document if the individual process has deficiencies, make recommendations, and point out notable practices.

Evaluation Criteria for each DQMP Critical Element

A. Data Collection Equipment Calibration and Certification

The DQMP must describe the method(s) in which the data collection equipment will be calibrated and certified.[6] At a minimum, the calibration process must describe how the equipment data collection devices are tested against a set testing method or standard and adjusted to reach an acceptable level of accuracy for each data element required in 23 CFR 490.309. Equipment calibration must be conducted before data collection and periodically thereafter to ensure that the equipment is functioning according to expectations per 23 CFR 490.309.

Protocols:

The DQMP should include a description of how the State DOT is collecting the pavement condition metrics to be reported in HPMS using the protocols shown in Table 1.

[4] [4]FHWA's Practical Guide for Quality Management of Pavement Condition Data Collection: https://www.fhwa.dot.gov/pavement/management/qm/data_qm_guide.pdf

[5] NCHRP's Synthesis 401 -Quality Management of Pavement Condition Data Collection: http://www.trb.org/Publications/Blurbs/Quality_Management_of_Pavement_Condition_Data_Coll_162632.aspx

[6] 23 CFR 490.319(c)(1)(i)

Table 1. PM2 rule pavement condition metrics testing protocols.

Pavement Condition Metric	Protocol
IRI[7]	• IRI collection device in accordance with AASHTO Standards M328-14.[8] • Collection of IRI data in accordance with AASHTO Standard R57-14.[9] • Quantification of IRI data in accordance with AASHTO Standard R43-13.[10] • Certification of IRI data in accordance with AASHTO Standard R56-14.[11]
Cracking percent[12]	• For asphalt, collection of pavement surface images in accordance with AASHTO Standard PP 68-14[13], with the modifications specified in the HPMS Field Manual. • Quantification of cracking from asphalt pavement surface images in accordance with AASHTO Standard PP 67-14.[14] • Quantification of cracking in asphalt pavement surfaces, both in wheelpath and non-wheelpath areas with AASHTO Standard R 55-10.[15] • Quantification of cracking from jointed and continuously reinforced concrete pavements in accordance with HPMS Field Manual.[16] • Computation of Cracking Percent for each pavement type in accordance with the HPMS Field Manual.
Rutting for asphalt pavements[17]	• Collection of Rut Depth values conforming to AASHTO Standard R48-10,[18] with the modifications specified in the HPMS Field Manual. OR: • Collection of transverse pavement profiles in accordance with AASHTO Standard PP 70-14[19] and • Quantification of Rut Depth values in accordance with AASHTO Standard PP 69-14[20], with the modifications specified in the HPMS Field Manual.
Faulting for jointed concrete pavements[21]	• Faulting computed based on AASHTO Standard R36-13[22], with the parameters specified in the HPMS Field Manual.

[7] 23 CFR 490.309; HPMS Field Manual, pp. 4-91.

[8] American Association of State Highway and Transportation Officials (AASHTO). 2014. Standard Specification for Inertial Profiler. AASHTO M 328-14. American Association of State Highway and Transportation Officials, Washington, DC.

[9] AASHTO. 2014. Standard Practice for Operating Inertial Profilers and Evaluating Pavement Profiles. AASHTO R 57-14.

[10] AASHTO. 2013. Standard Practice for Quantifying Roughness of Pavements. AASHTO R 43-13.

[11] AASHTO. 2014. Standard Practice for Certification of Inertial Profiling Systems. AASHTO R 56-14.

[12] 23 CFR 490.309; HPMS Field Manual, pp. 4-107- 4-109.

[13] AASHTO. 2014. Collecting Images of Pavement Surfaces for Distress Detection. AASHTO PP 68-14.

[14] AASHTO. 2014. Quantifying Cracks in Asphalt Pavement Surfaces from Collected Images Utilizing Automated Methods. AASHTO PP 67-14.

[15] AASHTO. 2010. Quantifying Cracks in Asphalt Pavement Surface. AASHTO R 55-10.

[16] 23 CFR 490.309; HPMS Field Manual, pp. 4-108 - 4-109.

[17] 23 CFR 490.309; HPMS Field Manual, pp. 4-99 - 4-100.

[18] AASHTO. 2010. Standard Practice for Determining Rut Depth in Pavements. AASHTO R 48-10.

[19] AASHTO. 2014. Collecting the Transverse Pavement Profile. AASHTO PP 70-14.

[20] AASHTO. 2014. Determining Pavement Deformation Parameters and Cross Slope from Collected Transverse Profile. AASHTO PP 69-14.

[21] 23 CFR 490.309; HPMS Field Manual, pp. 4-103 - 4-104.

[22] AASHTO. 2013. Standard Practice for Evaluating Faulting of Concrete Pavements. AASHTO R 36-13.

Required Elements[23]:

Calibration

The DQMP must document the Data Collector's equipment compliance with manufacturer's calibration protocols. 23 CFR 490.319(c)(1). The results of the routine calibration procedure should be documented and maintained by the State DOT and the Data Collector.

The DQMP should describe how each specific piece of pavement condition data collection device and its subsystems (e.g., DMI, GPS, or video images) will be tested, calibrated, and checked prior to initializing the pavement condition survey.

Control sites (also called certification, verification, or blind sites) with known length and condition values are typically used to calibrate the pavement condition data collection equipment. Certain subsystems, such as the DMI, can be calibrated in the field, if needed, while others, such as laser sensors, are typically calibrated when they are manufactured. However, the functionality of all the equipment sensors and components must be reviewed as part of the equipment certification process.

The State DOT must ensure that its methods and processes ensure that someone is responsible for calibrating the different data collection equipment devices (i.e., inertial profiler's accelerometer and height sensors, DMI, LCMS, global positioning system [GPS], inertial measurement unit [IMU], and right-of-way [ROW] cameras) in accordance with manufacturer recommendations and their own procedures. The responsible person must provide the State DOT with documentation of the proposed calibration processes and proof of the successfully calibrated equipment prior to certification testing. The State DOT is responsible for reviewing and approving the equipment calibration documentation.

Certification

Currently there are certification procedures for Inertial Profiling Systems (AASHTO R56-14), but there are no certification procedures for rutting, faulting, and cracking data collection devices. Therefore, the State DOTs are responsible for establishing and conducting equipment certification to ensure that the rutting, cracking, and faulting data collected and reported meet the requirements in the HPMS Field Manual, per 23 CFR 490.309. It is recommended that the certification process include validation testing to evaluate the accuracy, repeatability, and precision of the data reported in the field under conditions representative to the ones anticipated during actual data collection.

The State DOT can use an independent data collector not related to the regular pavement data collector to oversee the certification testing on the equipment, and those results will be used by the State DOT in consideration of their certification of the data collector's equipment. The DQMP should stipulate that equipment certification will be performed before production data collection can start.

Certification References for Each Pavement Condition Metric

Ride (IRI): Using Inertial Profilers – Certification guidance can be found in AASHTO R 56-14 "Certification of Inertial Profiling Systems" Standard.

Cracking, Rutting and Faulting

The DQMP must describe the methods that pavement condition collector uses to certify the equipment that collects cracking, faulting and rutting data. Certification testing should be conducted at a site approved by the State DOT and involve test sections, reference condition data (ground truth), and established variability or range of expected values. The State DOT must include processes in its DQMP to require documentation of data collection equipment calibration and certification, including documentation demonstrating that the equipment

[23] 23 CFR 490.319(c)(1)(i).

successfully performs tests with results that meet the established minimum requirements for accuracy, repeatability, and precision set forth by the State DOT.

The DQMP should include a description of how a State DOT establishes control sites that include the typical range of values for the pavement condition metrics that the equipment will be certified against. The State DOT should determine the reference condition data (ground truth) for each certification site. As part of the DQMP's equipment calibration and certification process, it should include processes for comparing results from data collection on the certification sites with the minimum requirements for accuracy and repeatability or precision set forth by standards defined in the HPMS Field Manual and required by 23 CFR 490.309. It is expected that the DQMP will document the acceptable level of tolerance when comparing collected results versus the reference condition data.

Example(s) of Good Practices:

Calibration of Equipment

State A requires the Data Collector to conduct inertial profile equipment calibration per AASHTO R56-14 specification, which calls for longitudinal verification of laser sensors plus a block test for vertical verification to be performed at least monthly, and the bounce test for vertical verification to be performed daily. In addition to requiring the Data Collector to maintain the vehicle according to the manufacturer's recommendations, the calibration procedures require that the Data Collector check the cold tire air pressure of the vehicle at least daily. Per the calibration procedures, the Data Collector is also required to rerun short sections of pavement that were measured on the previous day for comparison of IRI. The State sets a bias limit for the calibration IRI values to differ by no more than 6 percent from the previous day's IRI value.

Certification of Equipment

- State A selects certification sites and collects reference transverse profile data at selected points in each certification site that cover a range of "low" and "high" rutting. These locations are marked with reflective tape so they can be located by the Data Collector. The Data Collector collects and reports the rutting data for the certification site in accordance with the procedure specified in the AASHTO PP 69-14 standard. The State DOT compares the rutting calculated from the individual transvers profiles reported by the Data Collector with those from the pre-selected points that cover a range of "low" and "high" rutting.

  The Data Collector Alpha visits a nationally recognized test facility and has their equipment tested against R56-14. State B contracts with Vendor Alpha to collect pavement distress data. As part of the contract, State B specifies that the equipment used to collect data in the state must run five test strips of pavement, varying in surface type and distress quantity and severity. The variance of these sites was based on an analysis of those items in State B's inventory. State B has rated these five sections per appropriate AASHTO standards and State protocols. The results of the test track as well as the five State B established sites, compared to the criteria in the DQMP, serve as the basis for State B to certify Data Collector Alpha's equipment.

- For pavement distress, State C's certification process is usually done by evaluating control sites where the pavement condition is closely monitored by a group of experts. These experts determine the condition of the control site, usually through careful evaluation and consensus ratings before equipment certification, or in the case of manual data collection, personnel training. The expert ratings are considered the reference ratings of the control site. Statistical confidence intervals are often calculated to determine the requirements for equipment and personnel criteria certification. For example, a 95 percent confidence interval with respect to the reference rating has been used for evaluating distress data collection equipment. Certification of rutting measurements is typically conducted at the profiler calibration/certification centers. State C uses eight control sites (for asphalt concrete and four PCC

sections) for the initial verification of the data collection equipment and methodology. The Data Collector tests these sections before starting the production data collection. The sections have a variety of distress conditions and serve as a sample of the state and local roads in the state. The reference distress measurements are determined by experienced staff and State equipment is used to collect ride and rutting information. The Data Collector measures the site three times, and the data are compared with the benchmark data collected by State C. The final data delivery requirements are set based on this comparison. The control sites are also measured monthly by experts during production or whenever there is a change in equipment or subsystems on that same equipment.

- State D owns its own equipment for pavement distress data collection. State D establishes its own test sites for both conducting the R56-14 certification as well as cracking, rutting, and faulting. Sites are selected in a manner similar to State C in the above example. To assure independence, personnel from another office within State D are used to establish the baseline measures of the certification sites. State D uses the results from these certification sites and the criteria in the DQMP to certify the equipment that will be used to collect pavement distress data to be submitted to FHWA.
- State E also contracts with Data Collector Alpha. State E has established a similar certification methodology to State B. Data Collector Alpha submits a value engineering proposal to use their test results and certification from State B to meet State E's requirements. State E decides to reduce the testing to only one site to ensure that cracking is being collected per their protocols rather than the original planned six sites. Testing at the one State E site, along with the testing and certification from State B, serve as the basis for State E's certification.
- State F establishes certification requirements with minimum accuracy, resolution, and repeatability standards for each data element as shown on Table 2.

Table 2. State F Pavement Condition Data Collection Equipment Certification Requirements.

Data Element	Required Minimum Accuracy	Required Resolution (Measure to the Nearest)	Required Minimum Repeatability
International Roughness Index	± 5 percent compared to a reference profiler	1 in/mi (0.02 m/km)	± 5 percent run to run for three repeat runs
Rut Depth	± 0.08 in (2.0 mm) compared to manual survey	0.01 in (0.25 mm)	± 0.08 in (2.0 mm) run to run for three repeat runs
Faulting	± 0.08 in (2.0 mm) compared to manual survey	0.01 in (0.25 mm)	± 0.08 in (2.0 mm) run to run for three repeat runs
Distress Ratings	± 10 percent compared to agency ratings	N/A	N/A
GPS Coordinates	0.00005 degrees compared to agency provided coordinates	0.000001 degree	N/A

Division Office Assessment for Data Collection Equipment Calibration and Certification:

Approval Status	Action	Comments
Compliance – This element meets the requirements of 23 CFR 490.319(c)(1)(i).	☐	
Substantial Compliance – The DQMP substantially meets the requirements of 23 CFR 490.319(c)(1)(i) except for minor deficiencies that require corrections.	☐	
Conditional Compliance – The DQMP was found to have one or more items that did not meet the requirements of 23 CFR 490.319(c)(1)(i) but is adhering to a FHWA approved plan of corrective action (PCA) submitted in conjunction with the DQMP.	☐	
Non-compliance – The DQMP do not meet the requirements of 23 CFR 490.319(c)(1)(i).	☐	

B. Certification Process for Persons Performing Manual Data Collection

If the State DOT will be using manual pavement condition data collection in either its pavement performance submission or as part of the certification process, the DQMP must explain how the State will certify that data collection personnel are capable of collecting data meeting requirements of 23 CFR 490.309. The certification methodology must be defined based on who (State, Data Collector, or Local Agency personnel) will be conducting the manual condition data collection. The certification processes may include training, testing, observing activities, regular checks, comparison with known values, and other approaches.

Protocols:

- State DOT Pavement Condition Survey Procedures and raters' certification process.
- HPMS Field Manual.
- Distress Identification Manual for Long Term Pavement Performance Program.[24]

Required Elements:[25]

- The DQMP must explain the methodology used by the State DOT to certify the raters performing manual data collection.
- The certification process must be specific to the State's pavement condition rating methodology.
- The manual data collectors must be familiar with the definitions of pavement condition metrics identified in the HPMS Field Manual.
- The DQMP must identify who will be responsible for certifying individuals conducting the manual ratings.
- If the State DOT intends to collect and report Present Serviceability Rating (PSR) as an alternative to IRI, cracking, rutting, and faulting per 23 CFR 490.309 on the National Highway System (NHS) routes with speed limits less than 40 mph, then the State has the option of certifying that manual data collectors follow the PSR manual condition rating method described in the HPMS Field Manual. If a State DOT elects to use an alternative pavement condition method (e.g. PCI, PSI, etc.) to PSR, the manual data collectors must be certified for that methodology and the State DOT must have an acceptable method of

[24] Distress Identification Manual for Long Term Pavement Performance Program https://www.fhwa.dot.gov/publications/research/infrastructure/pavements/ltpp/reports/03031/03031.pdf.
[25] 23 CFR 490.319(c)(1)(ii).

converting its manual pavement condition method (e.g. PCI, PSI, PCR, etc.) to PSR as defined in the HPMS Field Manual.

Example(s) of Good Practices:

The State DOT's certification process for persons performing manual data collection includes the following elements or methods:

- A pavement condition survey manual that describes its pavement condition rating methodology.
- Manual Data Collectors attend an annual visual pavement condition rating training. The intention is to teach all the proper methods for identifying and quantifying all tracked distresses on the road surface, and is based on the State DOT's Pavement Condition Survey Manual and the proper methods for recording distresses documented in the State DOT Pavement Condition Survey Manual.
- After significant classroom instruction, the students conduct manual condition surveys on roadways with known distress ratings. Through an iterative process of rating and discussing results, students learn to calibrate their distress rating skills on pavements with different types of distresses.
- Students pass a written exam demonstrating overall understanding of the visual rating process, procedures, categorization, quantification, and data input of distresses according to the State DOT Pavement Condition Survey Manual.
- State DOT issues a certification to students that meet their manual data collection requirements.
- Manual Data Collectors are recertified annually.

Division Office Assessment for Certification Process for Persons Collecting Data:

Approval Status	Action	Comments
Compliance – This element meets the requirements of 23 CFR 490.319(c)(1)(ii).	☐	
Substantial Compliance – The DQMP substantially meets the requirements of 23 CFR 490.319(c)(1)(ii) except for minor deficiencies that require corrections.	☐	
Conditional Compliance – The DQMP was found to have one or more items that did not meet the requirements of 23 CFR 490.319(c)(1)(ii) but is adhering to a FHWA approved plan of corrective action (PCA) submitted in conjunction with the DQMP.	☐	
Non-compliance – The DQMP do not meet the requirements of 23 CFR 490.319(c)(1)(ii).	☐	

C. Data Quality Control (QC) Measures to Be Conducted Both Before Data Collection Begins and Periodically During the Data Collection Program

QC is the system used by the Data Collector to monitor, assess, and adjust its production processes to ensure that the final product will meet the specified level of quality. QC includes sampling, testing, inspection and corrective action (where required) to maintain continuous control of a production process. QC can be part of the calibration, certification, validation, or verification review. The DQMP must include methods and processes for QC measures developed by the Data Collector that show how the Data Collector will ensure that the collected pavement condition data meet or exceed quality standards. In addition, the acceptance criteria should be met prior to the pavement condition data being accepted for use. The QC should establish the timeframe or recurring frequency for performing specific data checks prior to, during, and after data collection. In general, data inspection checks are performed during production for QC when the data are submitted. Testing of control

sites are used for QC before and during production. Other validation techniques include oversampling or cross-measurements and reanalyzing or resurveying a sample of the sections.

Protocols:

- 23 CFR part 490
- HPMS Field Manual
- Practical Guide for Quality Management of Pavement Condition Data Collection.
- NCHRP's Synthesis 401 Quality Management of Pavement Condition Data Collection.

Required Elements:[26]

The DQMP must include methods and processes for written quality control measures for the person responsible for data collection. These measures should reflect any routine calibration procedure that will be conducted during the data collection phase including frequency and extent of the calibration procedure. The DQMP must outline the minimum requirements of the quality control measures.

Example(s) of Good Practices:

QC measures may include the following:

- Training automated distress collection crews and distress raters.
- Equipment setup and calibration.
- Field testing control sites.
- Real-time data checks.
- Internal validity checks.
- Random sample audits, inter-rater reproducibility, and repeat test checks.
- Quality checks during data reduction.
- Corrective action.
- Periodic reports covering:
    - Equipment and key personnel used during data collection.
    - Documentation of initial and continuing calibration/checks/maintenance for field equipment, any equipment problems, and corrective actions taken.
    - Schedule adherence and the reasons for any changes.
    - Documentation of collection procedures and protocols used.
    - Reporting of any variances in standard operating procedures or changes in collection methods made in the field.
    - Applicable guidance documents.
    - Reporting of all control, verification, and blind site testing and results.
    - Documentation of all QC activities.
        - Analysis of all rater checks and intra- or inter-rater comparisons.
        - Log of all quality issues identified through QC activities and corrective actions taken.
        - Copies of all correspondences.

[26] 23 CFR 490.319(c)(1)(iii).

Table 3. Example Pavement Condition Data Collection Quality Control Measures.

Deliverable	Quality Expectations	Activity	Frequency
Vehicle Configuration	• Meet profiler, crack measurement system, orientation system, and camera criteria	Check and certify	Pre-deployment
	• Inspect and clean laser apertures, windshield, and cameras • Inspect hardware and mountings • Check tire pressure • Bounce and block test, crack measurement system height check, and photo imagery review • Collect small sample route	Check	Pre-collection
	• GPS accuracy ≤ 3 meters • Image quality and lane placement • Monitor collection system errors • Data completeness • Crack measurement system height comparable to previous day.	Check	During collection/ Daily
Profiler	• Bounce test ≤ 8 inch/mile • Block check ± 0.01 inch of appropriate height	Calibration	Daily check/ Pre-deployment
DMI Pulse Counts	• ≤ 0.1 difference (five runs)	Validation	Pre-deployment
Location of Segment	• Mileage - 100% compliance with Standards	Validation	Daily
IRI	• Std. dev. ≤ 5% (ten 0.1 mile runs) • Std. dev. ≤ 10% (historical average) • Symmetrical appearance of multiple runs • Power Spectral Density peaks ~10ft/cycle	Validation	Pre-deployment
	• ≥ 30 inch/mile IRI ≤ 400 inch/mile • Left and right IRI values differ ≤ 50 inch/mile	Check	Daily
Rutting	• Std. dev. ≤ 0.40 inch (ten 0.1 mile runs) • Std. dev. ≤ 0.40 inch (historical average)	Validation	Pre-deployment
	• Values ≤ 0.35 inch • Left and right rutting values differ ≤ 0.25 inch	Check	Daily
Percent Cracking	• Std. dev. ≤ 15% total length (ten 0.1 mile runs) • Std. dev. ≤ 15% (historical average)	Validation	Pre-deployment
	• AC pavement values ≤ 50% • JPCP pavement values ≤ 100% • CRCP pavement values ≤ 100%	Check	Daily
Faulting	• Values ≤ 1.0 inch • Faulting values > 0 when joints are present	Check	Daily
Imagery	• 98 % compliance with standards • Focus, color, luminance quality	Check Uploaded Images	Weekly
		Validation	Prior to delivery

Division Office Assessment for Data Quality Control:

Approval Status	Action	Comments
Compliance – This element meets the requirements of 23 CFR 490.319(c)(1)(iii).	☐	
Substantial Compliance – The DQMP substantially meets the requirements of 23 CFR 490.319(c)(1)(iii) except for minor deficiencies that require corrections.	☐	
Conditional Compliance – The DQMP was found to have one or more items that did not meet the requirements of 23 CFR 490.319(c)(1)(iii) but is adhering to a FHWA approved plan of corrective action (PCA) submitted in conjunction with the DQMP.	☐	
Non-compliance – The DQMP do not meet the requirements of 23 CFR 490.319(c)(1)(iii).	☐	

D. Data Sampling, Review, and Checking Processes

Data sampling, review, and checks during the data collection process and data analysis process help identify the reliability of the data by identifying out of range data, detecting missing segments or data elements, and data inconsistencies.

Most network-level pavement condition survey programs typically generate a large quantity of data (e.g., longitudinal and transverse profile data, video images, condition data). Checking all collected data (and images) is generally not practical due to level of effort, time constraints, and costs. Sampling of data, particularly distress ratings, for QC and/or acceptance testing is a common quality management procedure adopted by many agencies. Therefore, many agencies use statistical analysis to help identify a data sampling size that can be evaluated to determine validity of data range, consistency, precision, and accuracy. Detailed examination of random samples of a portion of the data also enables the agency to make an estimation of the likelihood of errors in the whole database.

Protocols:

- 23 CFR part 490.
- HPMS Field Manual.
- Practical Guide for Quality Management of Pavement Condition Data Collection.
- NCHRP's Synthesis 401 Quality Management of Pavement Condition Data Collection.

Required Elements[27]:

The DQMP must document a data sampling, review, and checking processes that the State DOT will use to conduct checks of the pavement condition data that typically include verifying proper data format, checking for missing data, and screening the entire dataset for data completeness, consistency, and range.

Statistical analysis should be able to determine the quality of the entire batch of data from which the sample was taken. Data sampling can be random, systematic, stratified, clustered, or some combination of those, all of which can be used in QM procedures. When conducting sampled checks, a key consideration that must be addressed is the size of the sample for adequate representation of the population and verification of required measurement accuracy. For network-level pavement condition data collection, sample size typically ranges from 2 to 20 percent. Factors that could influence this are the sampling rate:

[27] 23 CFR 490.319(c)(1)(iv).

- Size of the network
- Experience with the data collector
- Risk tolerance
- Variability of surface types and distresses
- Cost

Example(s) of Good Practice:

State F contracts for the collection of condition data on approximately 27,000 mi (43,452 km) of roadway annually. Ride (IRI), faulting, rut depth, percent cracking, surface type, GPS, and pavement section length are all collected concurrently by the data collector. As part of the acceptance process, State F performs data sampling, review, and checks as shown on Table 4:

Table 4. State F Data Sampling, Review, and Checking Processes

Data Element	Sampling	Expected Range	Annual Variability	Checking Process
Ride (IRI)	100 percent	< 250 in/mile	-5 and +10 in/mile	Automated data check
Rut Depth	100 percent	0 to 1 in. Rutting should not be reported in Rigid Pavements.	-0.05 and +0.1 in	Automated data check
Faulting	100 percent	0 to 1 in. Faulting shall not be reported in Flexible Pavements.	-0.04 and +0.08 in	Automated data check
Percent of Cracking	10 percent of network	0 to 60 percent for Flexible Pavements. 0 to 100 percent for Rigid Pavements.	-5 and +10 percent	Automated data check
Surface Type	10 percent Network	No unpaved surfaces.		Visual
GPS	100 percent	Mileage review Comparison w/ master route file.		Visual
Missing Pavement Data	10 percent of network	Pavement data shall not be missing in more than 10 consecutive 0.1-mile long pavement sections, or no more than 2 percent of the extent of a certain route.		Visual
Pavement Images	10 percent of uploaded images per batch	No more than 5 consecutive images failing to meet criteria		Visual or image analyzing software.

State F reviews each data batch received for completeness and validity and flags the observations not meeting the acceptable criteria. Flagged data is subject to further review by State F staff to identify systemic problems with the collection, if any. Missing data will be flagged and reviewed by State F staff to investigate the cause and decide whether data are to be recollected.

Division Office Assessment for Data Sampling, Review, and Checking Processes:

Approval Status	Action	Comments
Compliance – This element meets the requirements of 23 CFR 490.319(c)(1)(iv).	☐	
Substantial Compliance – The DQMP substantially meets the requirements of 23 CFR 490.319(c)(1)(iv) except for minor deficiencies that require corrections.	☐	
Conditional Compliance – The DQMP was found to have one or more items that did not meet the requirements of 23 CFR 490.319(c)(1)(iv) but is adhering to a FHWA approved plan of corrective action (PCA) submitted in conjunction with the DQMP.	☐	
Non-compliance – The DQMP do not meet the requirements of 23 CFR 490.319(c)(1)(iv).	☐	

E. Error Resolution Procedures and Data Acceptance Criteria

During data collection, it is important that pavement condition data be continuously monitored by a variety of possible methods to ensure equipment calibration and data accuracy and precision during the collection effort. This monitoring allows for errors to be detected and corrected before submission of large batches of unsatisfactory data. After data collection is complete, the data may be validated before acceptance. However, errors may occur during the data collection efforts. Therefore, the DQMP must specify an error resolution procedure and data acceptance criteria that include corrective action(s) to be taken if data do not meet established quality requirements and defined data acceptance criteria. (23 CFR 490.319(c)(1)(v))

Data errors may be caused by:

- Procedural errors – such as the use of the wrong method to calculate pavement condition metrics such as IRI, Rutting, etc. This type of error typically occurs during the post-processing procedure used on the raw data to summarize the test results.
- Data quality and omission error – may be caused by poor image quality, poor accuracy due to equipment failures or lack of calibration.
- Data correctness error – such as collecting the wrong condition metric or using an incorrect standard for data collection.

The error resolution process may require the person responsible for data collection to maintain error logs and conduct corrective actions that may include re-collect, re-calibrate equipment, re-analyze the raw data, or re-train the staff responsible for data collection or data analysis. It is important that the agency and the person responsible for data collection (when applicable) discuss and agree upon the error resolution actions upfront rather than waiting until a problem is discovered.

The DQMP must specify the data acceptance criteria. These criteria describe quality standards that the pavement condition survey deliverables (e.g. IRI, distress rating, route number, pavement images, etc.) must meet (23 CFR 490.319(c)(1)(v)). The acceptable criteria for each data item should be interpreted so that when variability limits are exceeded, proper corrective action(s) are taken before erroneous data collection or data analysis procedures can proceed.

Protocols:

- 23 CFR part 490
- HPMS Field Manual.
- Practical Guide for Quality Management of Pavement Condition Data Collection.
- NCHRP's Synthesis 401 -Quality Management of Pavement Condition Data Collection.

Required Elements[28]:

State DOT's DQMP details error resolution procedures and data acceptance criteria.

Example(s) of Good Practices:

State G receives data from the Data Collector at the end of each week of data collection, and field technicians back up data and review data files to look for irregularities. Log files keep track of all error messages and section averages may be calculated. These, as well as samples of video, are reviewed for any issues that need corrective action. The field crew fills out a daily log of activities, including QC performed. Reports are uploaded and reviewed by QC personnel.

On a monthly basis, State G conducts a review of the submitted data and reports any inconsistences to the Data Collection Project Manager for action (i.e., correction, re-collection). State G reviews images representing 2 to 10 percent of the annual mileage collected during the automated condition survey. The State G staff manually identifies and automatically quantifies distress type and severity based on the pavement surface images. Images are used to perform independent analysis checks and other data quality checks. These checks are performed on 0.10 to 1-mile pavement segments that are randomly selected by the State G.

State G acceptance criteria, testing requirements, and corrective action (error resolution) for each deliverable of the pavement condition data collection process are shown in Table 5.

[28] 23 CFR 490.319(c)(1)(v)

Table 5. State G Error Resolution and Acceptance Procedures.

Deliverable	Acceptance	Testing	Action if Criteria Not Met
Data completeness	98 percent	Total network miles (excludes areas closed to construction)	Return deliverable for re-collection
	100 percent	Delivered data accurately populated with description information (system, route, direction, and begin and end latitude/longitude	Return deliverable for correction
	98 percent	Delivered data accurately populated with required data elements. Excludes areas with expected limitations (e.g., IRI in low-speed areas)	Return deliverable for correction
	98 percent	Delivered data with no more than ten consecutive fixed missing segments (500 feet total)	Return deliverable for correction
IRI, rut depth, and faulting	95 percent	Must be compliant with the verification testing requirements	Return deliverable for re-collection
Distress ratings	95 percent	Must be compliant with the verification testing requirements	Return deliverable for re-collection
Route number, direction, begin mile, end mile, GPS coordinates, District, and date collected	100 percent	Database check of accuracy and completeness	Return deliverable for correction
Photolog and pavement images	100 percent	Review of 20 percent random sample. Must be compliant with the verification testing requirements	Return deliverable for re-collection

Division Office Assessment for Error Resolution Procedures and Data Acceptance Criteria:

Approval Status	Action	Comments
Compliance – This element meets the requirements of 23 CFR 490.319(c)(1)(v).	☐	
Substantial Compliance – The DQMP substantially meets the requirements of 23 CFR 490.319(c)(1)(v) except for minor deficiencies that require corrections.	☐	
Conditional Compliance – The DQMP was found to have one or more items that did not meet the requirements of 23 CFR 490.319(c)(1)(v) but is adhering to a FHWA approved plan of corrective action (PCA) submitted in conjunction with the DQMP.	☐	
Non-compliance – The DQMP do not meet the requirements of 23 CFR 490.319(c)(1)(v).	☐	

F. FHWA Division Office DQMP Approval Decision and Notice to the State DOT

DQMP Criteria	Compliance	Substantial Compliance	Conditional Compliance	Non-compliance
A. Data collection equipment calibration and certification.				
B. Certification process for persons performing manual data collection.				
C. Data quality control measures to be conducted before data collection begins and periodically during the data collection program.				
D. Data sampling, review, and checking processes.				
E. Error resolution procedures and data acceptance criteria.				

General Comments

FHWA Division Office Pavement Engineer Recommend Approval of State DQMP:

_____ Date: _____

DO Pavement Engineer: Name

DQMP accepted by FHWA Division Administrator:

_____ Date: _____

FHWA Division Administrator: Name

Acronyms & Abbreviations

AASHTO – American Association of State Highway and Transportation Officials

ASTM – American Society for Testing and Materials

CFR – Code of Federal Regulations

DQMP – Data Quality Management Program

DMI - Distance Measuring Instrument

FHWA – Federal Highway Administration

GPS - Global Positioning System

HPMS – Highway Performance Monitoring System

ICO - International Commission for Optics

IRI - International Roughness Index

NBIS - National Bridge Inspection Standards

NCHRP – National Cooperative Highway Research Program

PCI - Pavement Condition Index

PM2 - National Performance Management Measures: Assessing Pavement Condition for the National Highway Performance Program and Bridge Condition for the National Highway Performance Program Final Rule.

PSI - Present Serviceability Index

PSR - Present Serviceability Rating

QC - Quality Control

QM - Quality Management

State DOT – State Transportation Agency

Definitions

Acceptance – The process or set of criteria used by the agency (i.e., sampling, testing, and inspection) to determine if the results of the data collection and processing meets the level of accuracy set by the agency. Also referred to as verification when used to validate the collected data.[29]

Accuracy – The degree to which a measurement, or the mean of a distribution of measurements, tends to coincide with the true population mean. When the true population mean is not known, as is the case with pavement data collection, the degree of agreement between the observed measurements and an accepted reference standard (ground truth) is typically used to quantify the accuracy of the measurements.[30]

Bias – An error, constant in direction, that causes a measurement, or the mean of a distribution of measurements, to be offset from the true population mean.[31]

Calibration – Process used to standardize (something, such as a measuring instrument) by determining the deviation from a standard to ascertain the proper correction factors. Calibrating a measuring equipment or person assure that a piece of equipment or person is producing measurements or observations as intended. The processes may include adjustments to the device and rechecking outcomes where necessary. Calibration is normally done by qualified persons at qualified facilities on a periodic basis.[32]

Certification – The process of assuring that persons understand and equipment involved in the data collection and processing use the correct methods to collect, process and analyze data.[33]

Data – Numerical outcomes from the collection and processing of measurements of pavement conditions or conditions of other assets. The term usually refers to electronic records of these outcomes although it could include manually recorded paper copies of measurements.[34]

Data Collection – Measurement of some characteristics of pavement condition, converting the measurements into numerical values, and electronically storing the values.[35]

Data Collector – Vendor or state staff responsible for collecting pavement condition data.[36]

Data Processing – Extracting, manipulating, and recording results of data collection using a defined process or algorithm. This could include processes that analyze data such as derivation of International Roughness Index from pavement profile and accelerometer measurements.[37]

Error Resolution – Activities taken if the outcomes from the data collection and processing do not meet the acceptance criteria.[38]

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[29] Practical Guide for Quality Management of Pavement Condition Data Collection, February 2013 (FHWA-HIF-14-006): https://www.fhwa.dot.gov/pavement/management/qm/data_qm_guide.pdf

[30] Ibid.

[31] Ibid.

[32] Developed based on standard industry practice and regulations in 23 CFR part 490.

[33] Developed based on standard industry practice and regulations in 23 CFR part 490.

[34] Practical Guide for Quality Management of Pavement Condition Data Collection, February 2013 (FHWA-HIF-14-006): https://www.fhwa.dot.gov/pavement/management/qm/data_qm_guide.pdf

[35] Developed based on standard industry practice and regulations in 23 CFR part 490.

[36] Ibid.

[37] Ibid.

[38] Ibid.

Precision – The degree of agreement among a randomly selected series of measurements; or the degree to which tests or measurements on identical samples tend to produce the same results.[39]

Quality – The degree of excellence of a product or service; the degree to which a product or service satisfies the needs of a specific customer; or the degree to which a product or service conforms with a given requirement.[40]

Quality control (QC) – The system used by the Data Collector to monitor, assess, and adjust its production or placement processes to ensure that the final product will meet the specified level of quality. Quality control includes sampling, testing, inspection and corrective action (where required) to maintain continuous control of a production or placement process.[41]

Repeatability – Degree of variation among the results obtained by the same operator repeating a test on the same material. The term repeatability is therefore used to designate test precision under a single operator.[42]

Reproducibility – Degree of variation among the test results obtained by different operators performing the same test on the same material.[43]

Resolution – The smallest change in a quantity being measured that causes a perceptible change in the corresponding indication.[44]

Sample – A portion of the data used for reviewing and examining the quality of the data collection and processing process. This is usually done with a statistically significant sample size that corresponds to a defined level of confidence and confidence interval.[45]

Validation – The mathematical comparison of two independently obtained sets of data (e.g., agency acceptance data vs. contractor data) to determine whether it can be assumed they came from the same population.[46]

[39] Practical Guide for Quality Management of Pavement Condition Data Collection, February 2013 (FHWA-HIF-14-006): https://www.fhwa.dot.gov/pavement/management/qm/data_qm_guide.pdf

[40] Ibid.

[41] Ibid.

[42] Ibid.

[43] Ibid.

[44] Ibid.

[45] Developed based on standard industry practice and regulations in 23 CFR part 490.

[46] Practical Guide for Quality Management of Pavement Condition Data Collection, February 2013 (FHWA-HIF-14-006): https://www.fhwa.dot.gov/pavement/management/qm/data_qm_guide.pdf

APPENDIX

DATA QUALITY MANAGEMENT PROGRAM TEMPLATE

The following template includes statements and values included for illustration purposes only.

June 15, 2018

Network-Level Pavement Condition Data Quality Management Program

Agency Name: _____

Prepared By: _____
Date: _____
Version No: _____

Document Change Control

The following is the document control for revisions to this document.

Version Number	Date of Issue	Author(s)	Brief Description of Change

Definitions

The following are definitions of terms, abbreviations, and acronyms used in this document.

Term	Definition
AASHTO	American Association of State Highway and Transportation Official
ASTM	ASTM International formerly known as the American Society for Testing and Materials
FHWA	Federal Highway Administration
HPMS	Highway Performance Monitoring System
PM2	Performance Measures for Pavements and Bridges Rule
PSR	Pavement Serviceability Rating
QC	Quality Control
QM	Quality Management

TABLE OF CONTENTS

1. QUALITY MANAGEMENT APPROACH

The purpose of managing quality is to validate that the deliverables are completed with an acceptable level of quality. Quality management (QM) assures the quality of the data collection deliverables and describes the processes and procedures to be used for ensuring quality.

The QM Program identifies key activities, processes, and procedures for ensuring quality. Below is a brief explanation of each of the sections of the QM plan that follow.

Section 2. Data collection equipment calibration and certification	This section describes the methods in which the data collection equipment will be calibrated and certified to collect the data required by the PM2 Rule (Roughness, Rutting, Faulting, and Percent of Cracking). Each specific piece of pavement condition data collection equipment and its subsystems (e.g., DMI, GPS, or video images) shall be tested, calibrated and checked prior to initializing the pavement condition survey. Equipment certification will be based on the ability to meet existing AASHTO or ASTM standards.
Section 3. Certification process for persons performing manual data collection	State will certify that persons collecting data using a manual collection process have acceptable knowledge of their manual data collection survey procedures.
Section 4. Quality Control (QC)	The QC activities that monitor, provide feedback, and verify that the data collection deliverables meet the defined quality standards.
Section 5. Data sampling, review and checking processes	Typical data checks during the data collection process that includes network-level checks for ratings that are out of expected ranges, checks for detecting missing segments or data elements, and statistical analysis to check for data inconsistencies.
Section 6. Error Resolution Procedures and Acceptance	The State specifies the corrective action to be taken if data are not found to meet quality requirements. The corrective actions specified in the QM plan should improve data collection procedures and data quality that results in acceptance of deliverables.
Section 7. Quality Team Roles and Responsibilities	The quality-related responsibilities of the data collection team.
Section 8. Quality Reporting Plan	The documentation of all QM activities—including quality standards, QC, acceptance, and corrective actions—and the format of the final QM report.
Section 9. Acceptance of QM Program	Signature page for acceptance of the QM Plan.

2. DATA COLLECTION EQUIPMENT CALIBRATION AND CERTIFICATION

The protocols used for collection, and associated quality standards are described below. Quality standards define, when applicable, the resolution, accuracy, and repeatability or other standards that will be used to determine the quality of each deliverable.

Pavement Metric Collection Protocols

Deliverable	Protocols	Resolution	Accuracy (compared to reference value)	Repeatability (for three repeat runs)	Certification
Ride (Average of left and right wheel-paths IRI)	AASHTO	1 in/mi	± 5 percent	± 5 percent	Equipment meets calibration, accuracy and repeatability requirements
Rut depth (average and maximum)	AASHTO	0.01 in	± 0.06 in	± 0.06 in	
Faulting (absolute average of faults)	AASHTO	0.01 in	± 0.06 in	± 0.06 in	
Cracking Percentage (per HPMS Field Manual 2016 Edition for AC, PCC, and CRCP)	HPMS Field Manual	N/A	± 10 percent	N/A	
GPS (latitude and longitude)	N/A	0.00001 degree	± 0.00005 degree	± 0.00005 degree	
Cross slope	N/A	0.1 percent	± 0.5 percent	± 0.5 percent	
Longitudinal grade	N/A	0.1 percent	± 0.5 percent	± 0.5 percent	
Radius of curvature	N/A	1 ft	± 10 percent	± 10 percent	
Location of segment	N/A	N/A	All assigned segments surveyed & assigned correct location	N/A	
Segment begin point	N/A	0.01 mi	± 0.05 mi	N/A	
Panoramic images	N/A	N/A	Signs legible, proper exposure and color balance	N/A	
Pavement images	N/A	N/A	1/8 in wide cracking visible on asphalt and concrete pavements	N/A	

Pavement Metrics Standards and Calculations

Deliverable	Standard
Ride (Average of left and right wheel-paths IRI)	• IRI collection device in accordance with AASHTO Standards M328-14. • Collection of IRI data in accordance with AASHTO Standard R57-14. • Quantification of IRI data in accordance with AASHTO Standard R43-13. • Certification of IRI data in accordance with AASHTO Standard R56-14.
Rut depth (average and maximum)	• Collection of Rut Depth values conforming to AASHTO Standard R48-10 with the modifications specified in the HPMS Field Manual. • Collection of transverse pavement profiles in accordance with AASHTO Standard PP 70-14. • Quantification of Rut Depth values in accordance with AASHTO Standard PP 69-14, with the modifications specified in the HPMS Field Manual.
Faulting (absolute average of faults)	• Faulting computed based on AASHTO Standard R36-13 with the parameters specified in the HPMS Field Manual.
Cracking Percentage	• Collection of pavement surface images in accordance with AASHTO Standard PP 68-14. • Quantification of cracking from pavement surface images in accordance with AASHTO Standard PP 67-16. • Quantification of cracking in asphalt pavement surfaces, both in wheelpath and non-wheelpath areas with AASHTO Standard R 55-10. • Computation of Cracking Percent for each pavement type in accordance with the HPMS Field Manual.

3. CERTIFICATION PROCESS FOR PERSONS PERFORMING MANUAL DATA COLLECTION

This section is to document the certification processes in-place to secure that persons performing manual data collection demonstrate basic knowledge of State manual data collection process and FHWA's Highway Performance Monitoring System (HPMS) Field Manual procedures.

Manual Data Collection Protocols

Deliverable	Protocols	Performance Matrix	Certification
Data Collector Staff Certification	State Manual Pavement Condition Survey Procedures and Highway Performance Monitoring System Field Manual	Cracking	State certifies that raters are familiar with the agency pavement condition survey procedures and distress identification manual based on raters attending distress identification training and passing a rater certification exam.
		Rutting	
		Faulting	
		Pavement Serviceability Rating (PSR)	
		Inspect processed data	
		Final data review	
		Inter-rater checks	

4. QUALITY CONTROL

The focus of QC is on data collection deliverables and processes. QC monitors the deliverables to verify that they are of acceptable quality and are complete and correct. A written QC plan will be submitted and signed by the data collector.

The following table identifies:

- The major deliverables that will be tested for satisfactory quality level.
- The quality expectations for the deliverables.
- The QC activities that will be executed to control and monitor the quality of the deliverables.
- How often or when the QC activities will be performed.

Quality Control Deliverables and Processes

Deliverable	Quality Expectations	Activity	Frequency
Vehicle Configuration	• Meet profiler, crack measurement system, orientation system, and camera criteria	Check and certify	Pre-deployment
	• Inspect and clean laser apertures, windshield, and cameras • Inspect hardware and mountings • Check tire pressure • Bounce and block test, crack measurement system height check, and photo imagery review • Collect small sample route	Check	Pre-collection
	• GPS accuracy ≤ 3 meters • Image quality and lane placement • Monitor collection system errors • Data completeness • Crack measurement system height comparable to previous day.	Check	During collection/ Daily
Profiler	• Bounce test ≤ 8 inch/mile • Block check ± 0.01 inch of appropriate height	Calibration	Daily check/ Pre-deployment
DMI Pulse Counts	• ≤ 0.1 difference (five runs)	Validation	Pre-deployment
Location of Segment	• Mileage - 100% compliance with Standards	Validation	Daily
IRI	• Std. dev. ≤ 5% (ten 0.1 mile runs) • Std. dev. ≤ 10% (historical average) • Symmetrical appearance of multiple runs • Power Spectral Density peaks ~10ft/cycle	Validation	Pre-deployment
	• ≥ 30 inch/mile IRI ≤ 400 inch/mile • Left and right IRI values differ ≤ 50 inch/mile	Check	Daily
Rutting	• Std. dev. ≤ 0.40 inch (ten 0.1 mile runs) • Std. dev. ≤ 0.40 inch (historical average)	Validation	Pre-deployment
	• Values ≤ 0.35 inch • Left and right rutting values differ ≤ 0.25 inch	Check	Daily
Percent Cracking	• Std. dev. ≤ 15% total length (ten 0.1 mile runs) • Std. dev. ≤ 15% (historical average)	Validation	Pre-deployment
	• AC pavement values ≤ 50% • JPCP pavement values ≤ 100% • CRCP pavement values ≤ 100%	Check	Daily
Faulting	• Values ≤ 1.0 inch • Faulting values > 0 when joints are present	Check	Daily
Imagery	• 98 % compliance with standards • Focus, color, luminance quality	Check Uploaded Images	Weekly
		Validation	Prior to delivery

5. DATA SAMPLING, REVIEW, AND CHECKING PROCESS

This section should focus on describing the level of data sampling, review, and checking process at the network-level that the State will use to access the reliability of the data. This section includes checks for ratings that are out of expected ranges, checks for detecting missing segments or data elements, and statistical analysis to check for data inconsistencies.

Data Sampling Checks

Data Element	Sampling	Expected Range	Annual Variability	Checking Process
Ride (IRI)	100 percent	< 250 in/mile	-5 and +10 in/mile	Automated data check
Rut Depth	100 percent	• 0 to 1 in. • Rutting should not be reported in Rigid Pavements.	-0.05 and +0.1 in	Automated data check
Faulting	100 percent	• 0 to 1 in. • Faulting shall not be reported in Flexible Pavements.	-0.04 and +0.08 in	Automated data check
Percent of Cracking	10 percent of network	• 0 to 60 percent for Flexible Pavements. • 0 to 100 percent for Rigid Pavements.	-5 and +10 percent	Automated data check
Surface Type	10 percent Network	No unpaved surfaces.		Visual
GPS	100 percent	• Mileage review • Comparison w/ master route file.		Visual
Missing Pavement Data	10 percent of network	Pavement data shall not be missing in more than 10 consecutive 0.1-mile long pavement sections, or no more than 2 percent of the extent of a certain route.		Visual
Pavement Images	10 percent of uploaded images per batch	No more than 5 consecutive images failing to meet criteria		Visual or image analyzing software.

6. ERROR RESOLUTION PROCEDURES AND ACCEPTANCE

The focus of acceptance is to validate that deliverables meet the established quality standards. The following table describes acceptance testing, the frequency to be performed, and corrective actions for items that fail to meet criteria.

Acceptance Testing Procedures

Deliverable	Acceptance	Acceptance Testing & Frequency	Action if Criteria Not Met
Data completeness	98 percent	Total network miles (excludes areas closed to construction)	Return deliverable for re-collection
	100 percent	Delivered data accurately populated with description information (system, route, direction, and begin and end latitude/longitude	Return deliverable for correction
	98 percent	Delivered data accurately populated with required data elements. Excludes areas with expected limitations (e.g., IRI in low-speed areas)	Return deliverable for correction
	98 percent	Delivered data with no more than ten consecutive fixed missing segments (500 feet total)	Return deliverable for correction
Ride (IRI), rut depth, and faulting	95 percent	Weekly control, verification, and blind site testing. Global database check for range, consistency, logic, and completeness and inspection of all suspect data. 5 to 10 percent sample inspection upon delivery. Use of GIS for further inspection.	Reject deliverable; data must be re-collected.
Cracking Percentage	90 percent	Global database check for consistency, logic, completeness. 5 to 10 percent sample inspection upon delivery.	Return deliverable for correction.
GPS coordinates	100 percent	Weekly control, verification, and blind site testing. Plot on base map using GIS upon delivery.	Return deliverable for correction.
Location of segment and segment begin point	100 percent	Plot on base map using GIS. Global database check of accuracy and completeness.	Return deliverable for correction.

Deliverable	Acceptance	Acceptance Testing & Frequency	Action if Criteria Not Met
Panoramic and pavement images	98 percent of each control section and not more than 5 consecutive images failing to meet criteria	Weekly inspection of control, blind, or verification site video. 5 to 10 percent sample inspection upon delivery.	Reject deliverable; images must be re-collected.

7. QUALITY TEAM ROLES & RESPONSIBILITIES

The following identifies the quality-related responsibilities of the data collection team and lists specific quality responsibilities.

Team Roles and Responsibilities

Team Role	Assigned Resource	Quality Management Responsibilities
State Manager	J. R. Smith – Pavement Mgt. Engineer	• Set quality standards, acceptance criteria, and corrective actions. • Approve each deliverable per quality standards. • Oversees and Approves certification of data collection equipment and personnel. • Approve resolution of quality issues. • Assess effectiveness of QM procedures. • Recommend improvements to quality processes.
State Assistant Manager	A. T. Bell – Transportation Specialist	• Communicate weekly with data collection manager. • Submit acceptance exceptions log to data collection team. • Supervise manual measurement of control sites. • Establish reference values with data collection team. • Monitor schedule adherence. • Supervise acceptance checks. • Monitor resolution of quality exceptions reported to data collection team. • Prepare QM report.
Operations and Training Coordinator	T. Cooper – Pavement Specialist	• Oversee proper training, functional testing, and certification of automated equipment operators • Oversee the calibration, certification, and correlation of automated equipment
State Staff	B. Wilson, S. Davis - Transportation Technicians	• Observe and maintain records of control, verification, bind site testing. Analyze and document results. • Perform data and video acceptance checks and document results. • Perform GIS checks and document results. • Maintain acceptance log and submit quality exceptions to agency assistant manager.

Team Role	Assigned Resource	Quality Management Responsibilities
Data Collection Manager	D. L. Jones	• Assure deliverables meet broad set of data quality requirements. • Communicate weekly with agency assistant manager. • Assure quality issue resolution and report results to agency assistant manager.
Quality Manager	R. M. Williams	• Assure practice of QC measures in QM plan. • Assure proper protocols used. • Assure training plan addresses all personnel skill levels. • Assure reviews by Distress Rating Lead, Data Reduction Lead, and Video Lead. • Assure performance of all quality audits and reporting of all data quality exceptions using QC log. • Assure correction of all quality issues and changes in procedures as needed. • Perform and document final deliverables quality review. • Compile documentation of all QC activities.
Equipment Manager	J. C. Adams	• Assure and document initial equipment configuration, calibration, and verification.
Field Crew Lead	M. B. Jones	• Perform daily and/or periodic equipment start-up checks, tests, inspections, and calibrations. • Perform daily review of data logs and video samples. • Assure real-time monitoring of data and video quality. • Assure performance of weekly control, verification, or blind site testing. • Assure documentation of all field QM activities and reporting of any problems using QC log.
Distress Rating Lead	C. D. McGee	• Perform and document initial rater training and assure raters adequately trained in protocols. • Document testing of raters on initial control site calibration. • Perform and document quality audits, including intra- and inter-rater checks. Report any problems using QC log. • Perform retraining as needed.

Team Role	Assigned Resource	Quality Management Responsibilities
Data Reduction Lead	F. V. Ross	• Perform and document checks of total mileage, segment lengths, and comparison with master route file. • Assure and document GIS checks of segment location and completeness. • Document quality audits of uploaded and processed data. Report any problems using QC log.

8. QUALITY REPORTING PLAN

The data collection manager will monitor quality through QC activities and report data quality exceptions as part of weekly status reporting, or more frequently if conditions warrant. Quality is monitored through acceptance testing, and quality issues are reported to the data collection team as soon as issues are discovered.

The QC log is used by the data collection team to itemize, document, and track to closure items reported through QC process.

Quality Control Log

QC Log						
ID Number	**Review Date**	**Deliverable Reviewed**	**Location Information**	**Findings**	**Resolution**	**Resolution Date**
QC-1						
QC-2						
QC-3						
QC-4						

The acceptance log is used by the pavement management engineer or independent assurer to itemize, document, and track to closure items reported through the acceptance process.

Acceptance Log

Acceptance Log						
ID Number	**Review Date**	**Deliverable Reviewed**	**Location Information**	**Findings**	**Resolution**	**Resolution Date**
Accept-1						
Accept-2						

Final QM Reporting

Data Collection Team – Upon delivery of the final database and other deliverables, the data collection team provides: a copy of the QC logs; a summary of scope and schedule (including any deviations from the planned schedule); a list of the collection vehicles and personnel used on the project; documentation of equipment calibration and maintenance; results of all control site testing; and documentation of other problems encountered (not listed on the QC log) and corrective actions taken.

Pavement Management Engineer – Upon acceptance of the final database and all other deliverables, the Pavement Management Engineer prepares a draft Quality Management Report and when applicable, provides a copy to the service provider (who reviews and provides feedback). This report will include: a summary of scope and schedule; description of control site testing (including reference values and analysis of results); description of all global and sampling tests performed and the results; and recommendations for improvement.

9. AGENCY & DATA COLLECTOR QM PROGRAM ACCEPTANCE

Quality Management Program accepted by the State Manager:

_____ Date: _____
State Manager Name & Title

Quality Management Program accepted by the Data Collection Manager:

_____ Date: _____
Data Collection Manager Name & Title

10. FHWA QM PROGRAM APPROVAL

FHWA Division Office Pavement Engineer Recommend Approval of State DQMP:

_____ Date: _____
DO Pavement Engineer: Name

DQMP accepted by FHWA Division Administrator:

_____ Date: _____
FHWA Division Administrator: Name

NOTES