FY22 DATA COLLECTION FOR PAVEMENT MANAGEMENT

SCOPE OF WORK

The professional services to be provided by the Consultant under this Agreement shall be as necessary to furnish digital data collection for a pavement management system. General services to be provided by the Consultant shall include, but not be limited to, the following required deliverables for all mileage given, (Sections 1 through 6) as well as being able to follow WYDOT's existing Data Quality Management Plan (DQMP) found in, Supplemental Attachment A, with Consultant equivalent processes.

The Consultant shall provide pavement distress data and images for approximately 10,535 lane miles (lm) over a one-year period. The Consultant shall provide the equipment and personnel necessary to conduct the pavement video and data collection. The current WYDOT collection cycle is as follows; Interstate data is collected annually, Non-Interstate NHS data is collected biannually (on odd number years), and Non-NHS is collected biannually (on even number years).

The Consultant shall collect, process, verify and deliver an annual pavement condition data set for the Department's Pavement Management System (PMS).

1. Additional Detail on the General Services Listed Above

   a. Road Roughness (IRI)

      The Consultant shall gather and provide continuous roughness data for the roadway using laser sensors in each wheel path. The data shall be collected in accordance with ASTM E950 and provided in accordance with ASTM E1926-98.

      Left and Right wheel path quarter-car IRI, mean quarter-car IRI, and half-car IRI shall be reported.

      The Consultant shall provide software to allow the Department to average the data to whatever lengths desired and output in text/excel/.csv format.

   b. Rutting on Asphalt Pavement

      The Consultant shall use a 3-D system to detect and characterize pavement rutting across in each wheel path, using tightly spaced lateral and longitudinal measurements. The rutting shall be collected in conjunction with 3-D surface image and depth-enabled crack detection. The data shall be collected in accordance with AASHTO T 340 and ASTM E1703/E1703M.

      The Consultant shall provide software to allow the Department to average the data to whatever lengths desired and output in text/excel/.csv format.

   c. Faulting on Concrete Pavement

The Consultant shall gather and provide continuous faulting data for the roadway using laser sensors across the entire lane width. The average faulting value shall be collected and reported. The Consultant shall provide software to allow the Department to average the data to whatever lengths desired and output in text/excel/.csv format. The data shall be collected in accordance with AASHTO R 36.

d. Texture

The Consultant shall gather and provide texture data to identify areas of raveling and weathering using laser sensors in each wheel path. The Consultant shall provide software to allow the Department to average the data to whatever lengths desired and output in text/excel/.csv format.

e. Digital Images

The Consultant shall provide a high resolution camera system (~ 2500 X 2000 pixels, native) with forward and rear views utilizing a wide angle lens. Please provide cost options for full 360-degree images meeting the high resolution camera system. The images should be captured, compressed and stored in JPEG format at posted speed limits and synchronized in conjunction with sensor and location data to streamline playback and searching capabilities.

The images shall be displayed to provide a 180-degree field of view of the roadway ahead and behind. Each image shall resemble a windshield view of the roadway such that the pavement surface, and condition ahead and behind the survey vehicle, shall be captured. The images shall be synchronized with other sensors and location data.

The Consultant shall provide software to allow the user to zoom in on an image and measure distances using grid calibrations.

f. Image viewing and data manipulation/analysis software

The Consultant shall provide unlimited licenses for imaging viewing that shall allow viewing and manipulation of the roadway images and data. The software shall be able to work on the Department's Intranet server. The software shall allow for zooming within an image, estimating distances and dimensions on-screen and exporting coupled images and data, or images alone for third-party demonstration and use.

g. Data Hosting/Web Access

The Consultant shall host all files necessary to view, over the internet, the Department video/data collected since 2017 (previous 5 year) using Consultant supplied viewing software. The web link shall provide:

i. Multiple simultaneous users (free access)

ii. Digital images

iii. Condition data

iv. GPS information

v. Functionality, such as zooming, and other features available on the Department's current internet site

The software shall also have an open architecture, which enables it to connect to the Department's Agile Assets Pavement Management module. See the following link for the Department's current system available on the internet:

http://pathweb.pathwayservices.com/wyoming/

The State shall own all State data that may reside within the Consultant's hosting environment and/or equipment/media. Upon termination of the services, for any reason, the Consultant agrees to return all original State-owned data and any derivative work to WYDOT in a usable format. Delivery must be through a secured electronic transmission or by parcel service that utilizes tracking numbers.

Following WYDOT's verified receipt of the original State-owned data and any derivative work, the Consultant agrees to physically and/or electronically destroy or erase all residual State-owned data regardless of format from the entire Consultant's technology resources and any other storage media or areas. This includes, but is not limited to, all production copies, test copies, backup copies and/or printed copies of information created on any other servers or media and at all other Consultant sites. The Consultant will provide a record of data destruction to WYDOT for inspection and records retention no later than 30 days after destruction.

If, for any reason, the State-owned data cannot be returned and/or destroyed upon termination of services, the Consultant agrees to notify the WYDOT with an explanation as to the conditions which make return and/or destruction impossible. Upon mutual agreement by both parties that the return and/or destruction of the data is not possible or feasible, the Consultant shall make the State-owned data

inaccessible to those purposes that make the return or proper destruction impossible. The Consultant shall provide to WYDOT a detail description as to the procedures and methods used to make the State-owned data inaccessible no later than 30 days after making the data inaccessible.

h. Automated 3-D Crack Detection

The Consultant's 3-D system shall capture both high-resolution images and transverse profiles of the road surface in real-time. The 3-D system shall provide analyzed full extent rutting, faulting and cracking data. The 3-D data shall be capable of determining rutting, faulting and percent cracking in the wheel paths based on the current requirements of the Federal Highway Administration (FHWA) HPMS.

i. Position and Orientation System, and Geometrics

The Consultant's system shall incorporate an inertial measuring unit, a Global Positioning System (GPS), and a Distance Measuring Instrument (DMI). The system shall be able to provide positioning (latitude, longitude, and elevation) continuously through GPS outages/blockages, velocity, acceleration, and elevation. The system shall also report curvature data including point of curvature, point of termination, length of curve, radius, grade, cross slope, and super elevation. Ground-truth post-processing shall be conducted by the Consultant using a Department-provided GPS-to-milepost conversion file to correct DMI errors and meet the required accuracy.

j. Quality Control/Technical Support

The Consultant shall estimate the number of vehicles, technicians, and time frame needed for data collection and post-processing. Provide estimated costs for technical support for all levels that are available. Provide a description of quality control measures that shall be performed during and after data collection.

The Consultant shall provide the equipment and personnel necessary to conduct the data collection. The Consultant shall allow Department personnel to observe the data collection process at any time. Under no circumstances will Department personnel drive or operate the Consultant's equipment. The cost of mobilization will be considered subsidiary to the Agreement.

2. Consultant Costs

The Consultant shall provide the following costs:

a. Cost per lane mile for full collection.

   i. See Table 1, below for collection mileage.

b. Data Hosting/Web Access cost for 2022.

Note: The Department is working under a fixed budget for 2022. The Consultant shall estimate the cost of the above items factoring in that the number of miles may be reduced to meet the defined budget.

Table 1. Data collection in lane miles (LM).[1]

Year	**Full Collection[2]**				**Partial Collection[3]**	**Total (LM)**
	Interstates (LM)[4]	Non-Interstate NHS (LM)	Non-NHS (LM)	County Roads (LM)	Service Roads[5] (LM)	
2022 State Highways	1,825	0	7,480	0	290	9,595
2022 County Highways				1,230		1,230
Total (State and County Highways)						**10,825**

[1] Additional system information will be provided by the Department prior to collection, including shape files of road locations, a spreadsheet detailing road section designations to be collected, along with a current Reference Marker Book and On-System Map. The Consultant shall work with the Department to prepare files for the Consultant's collection system.

[2] Full Collection – in the increasing and decreasing direction for all roadways driven.

[3] Partial Collection – in the increasing direction for all roadways driven.

[4] LM – Lane mile

[5] Service Roads – Please provide a cost estimate with this mileage separate.

3. Add-ons

Per the submitted Proposal, calculate the volume of material to fill ruts in the longitudinal direction using data from the 3-D system. The Proposal indicated this work would be subsidiary.

4. Quality Control (QC)

The Consultant shall perform the following QC tasks:

a. QC to Occur Upon Arrival

i. Collection databases containing detailed location reference information will be developed to provide field staff with necessary landmark and reference point designations (as indicated previously the Department shall supply preliminary system information detailing road section designations to be collected; this information will assist the Consultant in developing the collection databases).

ii. A preliminary kick-off meeting shall be conducted with the Department representatives to facilitate a detailed understanding of project objectives.

iii. Calibration procedure shall include test runs to compare results on different pavement types and conditions.

iv. Data from calibration sites shall be collected before network data collection begins.

1. Three calibration sites shall be tested: one smooth plant mix pavement, one medium smooth plant mix pavement, and one medium smooth concrete pavement.

2. The plant mix pavement sections will verify IRI, rutting, images, texture, geometrics, positioning, and 3-D crack detection.

3. The concrete pavement section will verify IRI, rutting, images, texture, faulting, geometrics, positioning, and 3-D crack detection.

v. Preliminary data from the calibration sites shall be compared to previous data collected on these sites.

vi. Images quality shall be verified by visual spot checks to ensure quality.

b. QC to Occur to Ensure Quality Data Collection During Collection Phase

i. Accelerometer sensors, laser height sensors and distance transducer sensor and other equipment shall be checked and calibrated on a daily or weekly basis as appropriate.

ii. The field staff shall maintain a log of equipment checks, calibration and maintenance as part of their daily routine. The log shall be provided to the Department upon request.

iii. Data shall be recollected from the calibration sites (before network collection begins, as described above) as well as mid-season and at the end of network collection and compared to previous data to evaluate accuracy and precision.

iv. The Consultant shall review video images and data collected each day and flag any irregularities, scan the health of all vehicle equipment, and document an overall summary of the collection process to-date. This documentation shall be made available to the Department upon request.

c. QC to Occur After Data Collection

i. Video images shall be screened for quality by the Consultant prior to delivery to WYDOT. The following is a summary list of images that will not be accepted by WYDOT and shall be re-driven by the Consultant.

1. Blurry/Dark Images - an image should be clear enough to allow full zooming capabilities and distress verification. Images that make the viewer question what is being displayed are not acceptable.

2. Incorrect section represented - all images should correspond to the label given for the section. If upon review it is determined that the improper section or milepost listing was driven, the image is unacceptable. This review may be accomplished by comparing a milepost on the screen with the milepost in the database. Additionally, using provided shape files, highway markers and the current copy of the Wyoming Reference

Marker Book, a person should be able to ascertain whether the correct route is being driven.

3. Images without reference identification - images must all be tagged with reference identification.

4. On concrete pavement and bridge decks, review 3-D Automated Crack detection data to provide accurate information based on joints, tining, transverse cracks, longitudinal cracks, etc.

ii. Distress Data shall be reviewed by the Consultant prior to delivery to WYDOT. The following is a summary list of distress data or formats that will not be accepted by WYDOT and shall be re-driven or re-analyzed by the Consultant.

1. IRI values typically range from 30-200 in/mi for Wyoming roadways. Values lower than 20 in/mi or higher than 400 in/mi should be reason for concern. Values of zero will not be accepted, as this indicates sensor error. Upon delivery, the data shall already have been checked for zero values or null values, and those exceeding 400 in/mi. Additionally, the sum of the section lengths for all of the tables shall equal the total number of miles that were to have been driven for the year. Significant differences in length will prompt intense QA by the Department, and may result in the rejection of the initial submission of data.

2. Rutting values over 0.5 inches should trigger an investigation. Typically, the system contains less than two tenths of a percent of zero values for rutting. Any section of roadway showing zero inches of rutting for longer than four miles will trigger an investigate and possibly be re-driven, unless a logical reason for zero inches of rutting can be given, such as new construction.

3. 3-D Automated Crack Detection values for HPMS ranging from 0 to 100. Any pavement section for the HPMS Cracking Percent showing higher than 60 for longer than three miles will be re-evaluated, unless a logical reason can be given. Any concrete pavement section for the HPMS Cracking Percent showing higher than 70 percent for longer than two miles will be re-evaluated, unless a logical reason can be given.

iii. Distance Measuring Instrument (DMI) - The DMI shall be calibrated before the start of collection and once a week afterwards. The DMI shall be reset on all defined locations, such as bridge decks, to ensure any effects from cumulative errors are reduced. If during the review of images it is determined the DMI was off by more than 500', the Consultant shall either make adjustments if possible so the data and images match the actual location, or the Consultant shall re-drive the section(s).

iv. Flag or mark all Construction areas in reported data. Provide a continuous run of data through the construction zone with the beginning and ending limits notated so that the State may view the processed data, but choose to exclude from any or all reports.

v. GPS data shall be plotted by the Consultant in order to locate anomalies that may be present. GPS anomalies that occur for longer than 3 miles shall be re-driven.

5. Technical Support

Throughout the term of this Agreement, the Consultant shall be available to answer questions about data collection, the images, and any software support issues, by phone or e-mail. The Consultant shall provide contact information in the form of names, phone numbers, e-mail addresses and physical mailing addresses. The Department will list in-house contacts for technical support. The Materials Program will handle data integrity and use issues. The points of contact from the Department will contact the appropriate Consultant representative.

6. Hardware Requirements

A standard PC with Windows 7 or Windows 10 should not require any additional hardware or software for viewing the video and data. The Consultant shall provide to the Department for their ownership three hard drives: two sets with all the State highway including the County Road System images, data and software, and the third with only the County road images, data, and software. The initial delivery of hard drives will be one (or more if needed) hard drives with all images, data, and software. After internal verification of information and approval, changes regarding inaccurate data shall be made available on the secondary set of hard drives (Duplicate State highway and County Road System, and separate County Road System).

Supplemental Attachment A

Network-Level

Pavement Condition Data Collection

Quality Management Plan

Prepared By

Wyoming Department of Transportation

Cheyenne, Wyoming

March 2019

Document Change Control

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

Version No	Date of Issue	Author(s)	Brief Description of Change
5.15.2018			Initial Draft
3.25.2019			Revised Draft
3.31.2019			Finalized Version 1.0

Definitions

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

Term	Definition
AASHTO	American Association of State Highway and Transportation Officials
ASTM	American Society of Testing and Materials
DMI	Distance Measuring Instrument
GPS	Global Positioning Systems
HPMS	Highway Performance Monitoring System
IP	Inertial Profiler
IRI	International Roughness Index
LTPP	Long-Term Pavement Performance
PMS	Pavement Management System
QC	Quality Control
QM	Quality Management

Table of Contents

1. QUALITY MANAGEMENT APPROACH

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

The QM plan identifies key activities, processes, and procedures for ensuring quality data. Table 1.1 shows a brief explanation of each of the sections of the QM plan that follow.

Table 1.1

Section 2. **Deliverables, Protocols, and Quality Standards**	The data collection deliverables are subject to quality review, protocols used to collect, and quality standard measures used to determine a successful outcome for a deliverable. The criteria to describe when each deliverable is considered complete and correct are defined by the Pavement Management Engineer. Deliverables are evaluated against these criteria before they are formally approved.
Section 3. **Quality Control (QC)**	The QC activities that monitor, provide feedback, and verify that the data collection deliverables meet the defined quality standards.
Section 4. **Acceptance**	The acceptance testing that will be used to determine if quality criteria are met and corrective actions that will be taken for any deliverables not meeting criteria.
Section 5. **Quality Team Roles and Responsibilities**	The quality-related responsibilities of the data collection team.
Section 6. **Quality Reporting Plan**	The documentation of all QM activities – including quality standards, QC, acceptance, and corrective actions – and the format of the final QM reports.
Section 7. **Acceptance of QM Plan**	Signature page for acceptance of the QM Plan.

2. DELIVERABLES, PROTOCOLS, AND QUALITY STANDARDS

2.1 The key deliverables, 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. See Section 4 for the Acceptance Testing Plan.

Table 2.1

Deliverable	Protocols	Resolution	Accuracy (compared to reference value)	Repeatability (for three repeat runs)
Longitudinal Profile	AASHTO M 328-10, AASHTO PP 70-14, AASHTO R 56-14, AASHTO R 57-14, ASTM E950	1 in/mile	+/- 5%	+/- 5%
IRI (left, right, and average)	AASHTO M 328-14, AASHTO R 43-13, AASHTO R 57-14, ASTM E1926	1 in/mile	+/- 5%	+/- 5%
Rut Depth (average and maximum)	AASHTO PP 69-10, AASHTO PP 69-14 (Automated), AASHTO PP 70-14 (Automated), AASHTO R 48-10	0.01 inch	+/- 0.02 inch	0.06 inch
Faulting (average)	AASHTO R 36-13	0.01 inch	0.06 inch	0.06 inch

Deliverable	Protocols	Resolution	Accuracy (compared to reference value)	Repeatability (for three repeat runs)
Distress Identification and Rating	AASHTO PP 67-10, AASHTO PP 67-14 (Automated), AASHTO PP 68-10, AASHTO PP 68-14 (Automated), AASHTO R 55-10 (Manual), ASTM E1656-11, LTPP Distress Identification Manual, NDDOT Distress Scoring Guide	Varies	+/- 20 percent	N/A

Table 2.1 (continued)

Deliverable	Protocols	Resolution	Accuracy (compared to reference value)	Repeatability (for three repeat runs)
GPS (latitude and longitude)	N/A	Submeter (static)	Submeter (static)	N/A
Perspective and ROW Images	N/A	2500 X 2000 per camera	Signs legible, proper exposure and color balance	N/A
Pavement Images	N/A	N/A	2 mm cracking visible and detected	N/A

2.2 In addition, a vendor hosts all of Wyoming DOT's data along with utilizing web access for end users. Custom reports are built through the end user vendor software that provides easy access for importing into a database or the FHWA HPMS system.

2.3 The University of Wyoming is able to contract with WYDOT and the vendor to collect data on county roads across Wyoming. This is paid for under a different project number and utilizes the same contract with the vendor. The vendor is required to submit a total of three hard drives per annual contract; two hard drives with all of the state and county data, and one hard drive with just the county data.

3. QUALITY CONTROL

3.1 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. 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.

Table 3.1

Deliverable	Quality Expectations	QC Activity	Frequency/Interval
IRI, DMI	95 Percent Compliance With Standards	Initial Equipment Configuration, Calibration, Verification	Pre-Collection (Annually)
		Daily Equipment Checks and Monitor Real-Time	Daily
		Control, Blind, or Verification Testing	Weekly
		Inspect Uploaded Data Samples	Weekly
		Inspect Processed Data	During Manual QC
		Final Data Review	Prior to RIMS Upload
Rut Depth, Faulting, GPS Coordinates, Longitudinal Grade	95 Percent Compliance With Standards	Initial Equipment Configuration, Calibration, Verification	Pre-Collection (Calibration at time of equipment purchase)
		Daily Equipment Checks and Monitor Real-Time	Daily
		Control, Blind, or Verification Testing	Weekly

Deliverable	Quality Expectations	QC Activity	Frequency/Interval
		Inspect Uploaded Data Samples	Weekly
		Inspect Processed Data	During Manual QC
		Final Data Review	Prior to RIMS Upload

Table 3.1 (continued)

Deliverable	Quality Expectations	QC Activity	Frequency/Interval
Distress Rating	80 Percent Match: Manual vs Automated	Initial Rater Training	Pre-Collection (as needed)
		Intra-rater Checks	During Manual QC
		Final Data Review	Prior to RIMS Upload
Perspective, ROW and Pavement Images	98 Percent Compliance With Standards of Each Control Section and Not More Than 5 Consecutive Images Failing to Meet Criteria	Startup Checks, Real-Time Monitoring, and Field Review	Daily
		Uploaded Samples Review	Weekly
		Final Review	Prior to Processing

3.2 WYDOT utilizes a vendor for data collection statewide, and the vendor is contracted for collection of IRI, Rutting, Faulting, and Cracking Percent, along with other minor collection items. [redacted]. Beginning in 2018, WYDOT will have annual data collected on Interstates, biennial data collected on Non-Interstate NHS, and a three year collection on Non-NHS routes.

3.3 The vendor has its own set of training and calibration requirements:

3.3.1 Vehicle and equipment

Prior to starting a project with the [redacted] vehicle, it goes through rigorous testing to ensure that the vehicle is as accurate and precise as possible. The vendor's internal testing procedures and calibration tolerances exceed all AASHTO standards and guidelines. Despite these high standards, daily inspections and periodic validation and verification are required to ensure the data provided by the vehicle is as accurate and precise as possible.

Before a project is started, the vendor verifies all equipment is working properly. This includes verifying computer operation, accelerometer sensors, lasers height sensors, 3-D lasers and camera calibration, and distance measuring instruments (DMI or encoder) are calibrated according to the corresponding ranges and limits of operation. The following steps are followed to ensure vehicle accuracy, precision, and consistency:

- Vehicle calibration procedures include:
    - A "bounce" and block test are AASHTO standards for profiler verification (refer to manual for actual procedures)
        - Block test tolerances are +/- .01"
        - Bounce test
            - Visual inspection of laser and accelerometer synchronization
            - Featuring 528 feet of lead in, 528 feet of bouncing, and 528 feet of lead out generating less than 3 in/mi, 10 in/mi, and 3 in/mi IRI, respectively
    - 3D laser calibration and camera focus (refer to the manual for visual data verification that can be done by operators, but actual calibration and focus should only be done by a [redacted] engineer)
    - Roadway camera image quality
        - Ensure camera housing is clean of cobwebs and dust and the internal glass has not developed a film. If cameras are moved, the cameras will need to be recalibrated with a new camera calibration file created for asset measuring
        - Sealed camera enclosures contain dry nitrogen to eliminate fog on lenses and improve image quality and efficiency during data collection.
    - GPS, pitch, roll, and heading verification
        - Technology has improved to where the IMUs have error reporting built in and only the need to verify the data needs to be done in order to ensure quality data
- Calibration sites are setup and collected
    - The vendor utilizes at least two sites:
        - 1 – 1/10th to 1/5th of a mile that is straight and level that will be collected weekly or bi-weekly – This is often referred to as a "10-run"

- A baseline measurement should be taken by an external group or by the use of precision equipment such as a SURPRO
- If a baseline measurement is not practical, repeated runs with the [redacted] to develop a baseline can be used to verify consistency, but accuracy is limited
- AASHTO standards state there should be no more than 30 mils bias in the precision and +/- 6 IRI from the reference IRI (we use a maximum of 20 mils precision +/-3 IRI for our internal standards are higher for preseason collection standards, if we feel we can get better results we try)
    - **NOTE: DRIVING IS ONE OF THE BIGGEST FACTORS TO BIAS CALCULATIONS, SO IF THE DRIVER IS NOT PRECISE IN THEIR DRIVING, THE BIAS WILL INDICATE THAT THE EQUIPMENT IS OUT OF TOLERANCES WHEN IN REALITY IT WAS JUST POOR DRIVING**

▪ 1 – Larger loop that covers various pavement types and conditions; it is not important that loop has a specific length, but rather a selection of various pavement types and conditions representative of the overall project
- This should be collected several times immediately after the vehicle is calibrated to develop a baseline
- Heading, Grade, and Cross-slope should align consistently with reference data
- IRI and rutting should deviate no more than 10% from section to section due to increased error with driving
    - **NOTE: BE AWARE OF DEVIATIONS DUE TO POOR DRIVING, CONSTRUCTION, AND IMPROPER LANE COLLECTION AS THESE WILL CAUSE VARIED AND INVALID RESULTS**

- After the sites have been set up and a baseline has been developed, data collected by the vehicle is processed and verified to ensure quality standards and archived to track calibrations
    - After a calibration site has been collected and data has been verified, the vendor uses an Excel file to archive and track the results

- Test runs compare results with roughness from different pavement types and conditions. Preliminary data is processed and charted with industry protocols and previous calibrations from DOT collections.

3.3.2 Field Collection QA/QC

The MOST CRITICAL COMPONENT to ensuring a successful project is the field QA/QC conducted by the vendor's drive teams. It is extremely important to re-iterate the importance of this process over and over and ensure that vendor's teams are conducting these QA/QC processes to prevent extended durations of poor data and imagery.

The vendor utilizes checklists built specifically for items and tasks highlighted in areas they feel should be emphasized during training and periodically inspected/checked throughout the collection period.

3.3.3 Daily pre-collection QA/QC

- Check that removable drives are recognized and there is enough room for the daily collection
- Check basic operation of all equipment and that it is reporting to the profiler computer
- Allow proper warm-up time for GPS system (5 minutes static) and provide adequate find alignment calibration [redacted]
- Verify imagery and settings on roadway camera for daily sky conditions
- 3D system lasers and cameras are working properly
- Macro system is reading and reporting correctly
- Speed is being generated by the encoder on the profiler

3.3.4 Set QA/QC

The following section is expanded because proper QA/QC conducted during this phase can eliminate nearly 100% of all project challenges up-front. There are a couple of items that cannot be foreseen, but a good operator that is actively looking for problems will catch these problems almost immediately.

Prior to the collection of each set, drive teams should:

- Check that there is enough room on the designated drive and the programs are pointing/collecting to the correct drive and folder

- Verify that the correct database is loaded and the set has not been previously collected
- Check that all equipment is operating and reporting to the profiler computer
- Visual inspection of 3D system and laser data
- Visual inspection of roadway camera settings and focus
- DMI is in run mode and the encoder is secure
- IRI laser lenses are clean

During collection, drive teams should:

- Listen to voice animation alerting operators of any potential problems discovered by self-governing equipment and software.
- Profiler:
    - Check speed, GPS, laser, and accelerometer data are reporting
    - All computers are connected to the profiler
    - Distances collected do not vary from the expected distance by more than 300 ft (without known reason).
        - **EXCEPTION: Newly constructed or modified roads may be shorter/longer than previously reported and a comment should be placed in the database to check the reported polyline**
- Cycle through the subsystem computers to verify:
    - Roadway cameras:
        - Camera software is "Connected to the profiler"
        - Image quality and exposure
        - Number of dropped images do not exceed 1.5% of the overall number of images
    - 3D System:
        - Data visually looks correct through 3D collection program
        - Data is saving
        - Lasers are On and the image represents both lasers are firing
    - Macro data (if utilized) is reporting

At the end of each set, the drive team should:

- Profiler
    - Verify that as many .prft files exist as listed in the "FinU" column of the last record collected

    - Log the starting and ending time codes of each set to help verify complete data on other subsystems
    - Verify that all collected records have the set number assigned and log route completions on both their paper and digital (iPAD) databases.
- Roadway camera subsystem
    - There are minute folders for each subsystem for the total number of minutes collected
    - All roadway cameras saved images into the first minute folder, last minute folder, and that the images (particularly the last minute folder images) checked do not have bugs, glares, or other impediments.
- 3D System
    - There are minute folders for each subsystem for the total number of minutes collected
    - Utilize the 3DC viewer to check a few images in the first minute folder, last minute folder, and a couple of randomly selected folders throughout the set
- Macro System
    - Ensure that Texture files exist for the set. There should be at least as many files as records collected in the set.

3.3.5 End of day QA/QC

The end of day QA/QC is just a double check to verify that something wasn't missed during the Set QA/QC. More than once, the [redacted] drive team has discovered something at the end of the day that they missed during the Set QA/QC and helped decrease potential down-time.

- Profiler
    - Verify that as many .prft files exist as listed in the "FinU" column of the last record collected
    - Run end of day report and review it for error messages. This will flag any irregularities, scan the health of all vehicle equipment, monitor daily production and document an overall summary of the collection process to date. After review, save it to the profiler USB drive as these reports are sent to home office project managers for quick and effective quality control.

    - Backup the .sec file and COMPLETED set folders from that day to a USB drive
- Roadway camera subsystem
    - There are minute folders for each subsystem for the total number of minutes collected
    - All roadway cameras saved images into the first minute folder, last minute folder, and that the images (particularly the last minute folder images) checked do not have bugs, glares, or other impediments.
- 3D System
    - There are minute folders for each subsystem for the total number of minutes collected
    - Utilize the 3DC viewer to check a few images in the first minute folder, last minute folder, and a couple of randomly selected folders throughout the set
- Macro System
    - Ensure that Texture files exist for the set. You should have at least as many files as records collected in the set.
- Field teams should maintain detailed logs and conduct data backup as part of their daily routine.
    - While time consuming, it is good routine to create data backups to a secondary drive (second internal drive). These backups can be deleted once drives have been received, copied, and verified by the office.
        - End of week QA/QC (collection period prior to shipping drives – the vendor does this weekly)
- Check that all profiler data has been copied to the USB drive
    - Check that all set folders are loaded and that for each folder has a .pft file for the number of minutes in the set present
    - Utilize a folder naming convention to identify current data versus archived or older data
    - Verify/Copy daily reports to the USB drive for verification purposes
- Check each drive to ensure all sets collected that week are on the removable drive
- Label each drive with a dry erase marker on the label
    - A process identifying collection vehicle, collection dates, and collected set numbers should be followed

- Field staff verify collected data as often as desired using the built-in data query and logic with onboard workstation software to ensure data completeness and quality

3.3.6 Weekly/Bi-weekly/As needed

The following checks are recommended to be made weekly if practical or bi-weekly at a minimum. There may also be a need for some of these checks to be conducted when data looks suspect from the vehicle or home office.

- Vehicle maintenance needs
- Bounce test
  - This check is to verify synchronization of accelerometer and laser signals as well as provide a validation of static IRI quality
- 10-run/Calibration site (not loop)
  - This provides validation of precision and bias throughout the process
- 3D system visual verification

This check should be done daily however, it is highlighted here to show the importance of the check and should be included in the weekly validation check

3.3.7 Rater Consistency/Reliability

Both inter-rater (comparing two raters) and intra-rater (comparing one rater over time) are conducted throughout the project to diagnose potential data disagreement. The automated nature of the vendor's system also helps mitigate these issues due to the highly-objective and repeatable nature of the software. Human QC is also done on 100% of all rated roads by the vendor.

- Daily report software preprocesses data collected each day and flags any irregularities, scans the health of all vehicle equipment, monitors daily production and documents an overall summary of the collection process to date. The reports are sent to the vendor's home office project managers for quick and effective quality control on a regular basis.
- Incoming data is scanned and pre-process checks are undertaken to quickly assess data completeness and accuracy.
- WYDOT-specific [redacted] software automatically checks for any data that does not meet quality expectations. Any sections flagged for resurvey are quickly diagnosed and scheduled.

- Preliminary reports are created and compared to previous collections for historic reference. Custom software also scans sensor data and digital images to verify completeness and quality expectation.
- A meticulous distress rater QC program ensures that all distress ratings undergo daily random sampling and consistency tests.
- Inter and Intra-rater studies can be conducted with provided software to ensure survey is conducted consistently both by the same rater and between raters throughout the survey process.
- Image and sensor data is verified both by software and manual spot checks to ensure quality display.
- Logic check software verifies pavement types, associated distresses, lane designations and event information.
- An accuracy target of automated crack detection will be 80% on concrete pavements and bridge decks, with 90% or better expected after manual QC is performed.
- All data undergoes vigorous completeness and consistency testing before it is delivered to WYDOT.
- Spatial checks and logic checking applications are customized to the reporting data dictionaries of each project.
- [redacted] image viewer gets image and location data into the hands of Wyoming DOT personnel within days of collection to allow for easy access and quick data verification without the need to ship hard drives and copy data physically.

3.4 WYDOT Equipment Calibration and Certification

The vendor is required to run WYDOT's calibration locations before data collection, mid-way through data collection, and a final calibration after all data has been collected. This calibration data is compared to other Profile Data gathered during the annual April Profiler Calibration Course for verification along with verifying that the vendor's vehicle is precise and accurate for all collected data. The items that are verified are:

- Verification of WYDOT's certification course includes calculation of faulting, texture, rutting, and IRI in the left wheel path, right wheel path and average in inches per mile
- Features like real-time graphs in the data collection vehicle allow the operator to make sure that the hardware is working correctly
- Visual display of the images being collected allows the operator to make sure proper quality standards are met

- Bounce tests and equipment tests are completed on a weekly basis in the field to ensure continued data reliability and are readily available for viewing
- The 64-bit, native Windows collection program allows for simultaneous playback of robust GPS mapping for greater efficiency and accuracy
- All imaging is easily viewed in real-time from a single location by vehicle operators to ensure cameras are providing crisp, clear images free of insects and water on the outer lens.
- Drivers and operator checklists are employed daily to maintain a high level of consistency and provide steps and procedures to follow for the proper operation of the data collection system and readily available
- Daily report software preprocesses data collected each day and flags any irregularities, scans the health of all vehicle equipment, monitors daily production and documents an overall summary of the collection process to-date. The reports are sent to the vendor's home office project managers for quick and effective quality control

3.5 WYDOT Manual Data Collection Certification

Manual data collection is only done on low volume routes for the purpose of gathering Present Serviceability Rating (PSR) values, which includes a visual survey of the route. The HPMS field manual states that these values may be reported for any route with a posted speed limit less than 40 mph. Table 3.2 below shows the value descriptions.

Table 3.2: Present Serviceability Rating

PSR	Description
4.0 – 5.0	Only new (or nearly new) superior pavements are likely to be smooth enough and distress free (sufficiently free of cracks and patches) to qualify for this category. Most pavements constructed or resurfaced during the data year would normally be rated in this category.
3.0 – 4.0	Pavements in this category, although not quite as smooth as those described above, give a first class ride and exhibit few, if any, visible signs of surface deterioration. Flexible pavements may be beginning to show evidence of rutting and fine random cracks. Rigid pavements may be beginning to show evidence of slight surface deterioration, such as minor cracks and spalling.

2.0 – 3.0	The riding qualities of pavements in this category are noticeably inferior to those of new pavements, and may be barely tolerable for high-speed traffic. Surface defects of flexible pavements may include rutting, map cracking, and extensive patching. Rigid pavements in this group may have a few joint failures, faulting and/or cracking, and some pumping.
1.0 – 2.0	Pavements in this category have deteriorated to such an Extent that they affect the speed of free-flow traffic. Flexible pavement may have large potholes and deep cracks. Distress includes raveling, cracking, rutting and occurs over 50 percent of the surface. Rigid pavement distress includes joint spalling, patching, cracking, scaling, and may include pumping and faulting.
0.1 – 1.0	Pavements in this category are in an extremely deteriorated condition. The facility is passable only at reduced speeds, and with considerable ride discomfort. Large potholes and deep cracks exist. Distress occurs over 75 percent or more of the surface.

4. ACCEPTANCE

4.1 The focus of acceptance is to validate that deliverables meet the established quality standards. Table 4.1 is a description of acceptance testing, the frequency to be performed, and corrective actions for items that fail to meet criteria.

Table 4.1

Deliverable	Acceptance (Percent Within Limits)	Acceptance Testing & Frequency	Action if Criteria Not Met
IRI, Rut Depth, Faulting, GPS Coordinates, Longitudinal Grade	95 Percent Compliance With Standards	Weekly verification testing. Global database check for range, consistency, logic, and completeness and inspection of all suspect data. Daily monitoring of data completeness during collection.	Recalibration and possible recollection
Distress Rating	80 Percent Match: Manual vs Automated	At end of annual collection, check accuracy of automated crack detection and QC pre-set percentage of automated distress scores compared to manual distress score.	Contact Vendor to discuss correction of crack detection software.
Perspective, ROW and Pavement Images	98 Percent Compliance With Standards of Each Control Section and Not More Than 5 Consecutive Images Failing to Meet Criteria	Weekly verification testing. Daily monitoring for clarity, brightness and no bugs or raindrops during collection.	Clean camera, contact vendor if issues with clarity or brightness can't be resolved by data collection team. Possible recollection.

4.2 Error Resolution and Data Acceptance

WYDOT has a very good working relationship with the vendor. If during WYDOT's routine checks any errors are found, WYDOT can either manually go into the vendor's software to make minor changes, or WYDOT will contact the vendor to make any significant changes. If the road section proves to be "bad data," the vendor will collect the data a second time in order to make sure everything is accurate. The vendor has never had to come back to Wyoming to fix "bad data" due to the multiple checks that are associated on a regular basis. Once the routine checks are completed, WYDOT proceeds with the acceptance of the data for use in the Pavement Management System and reporting for FHWA HPMS.

5. QUALITY TEAM ROLES AND RESPONSIBILITIES

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

Table 5.1

Team Role	Assigned Resource	Quality Management Responsibilities
Pavement Management Section	Pavement Management Engineer, Assistant Pavement Management Engineer, and Pavement Management Technician	• Set quality standards, acceptance criteria and corrective actions • Assess effectiveness of QM procedures • Recommend improvements to quality processes • Assure practice of QC measures in QM Plan • Assure proper protocols used • Assure training for all personnel skill levels • Issue certification upon completion of training • Assure correction of all quality issues and changes in procedures as needed • Document all QC activities • Perform all QA checks on the automated crack detection and analysis. • Perform all QA checks on image data, IRI, rutting, faulting, etc. • Conduct calibration site testing

Table 5.1 (continued)

Vendor - Data Collection Contractor	Project Manager	• Assure deliverables meet broad set of data quality requirements • Assure proper protocols used • Configure and ensure vehicle configuration meets specified criteria • Upon request, provide most relevant and current accuracy validation and calibration results to Wyoming DOT prior to mobilization • Assure training plan addresses all personnel skill levels • Conduct data reduction checks and resolve and troubleshoot any identified issues • Assure practice of QC measures in QM plan • Assure quality issue resolution and report results to Wyoming DOT • Communicate periodically with Wyoming DOT to provide status and schedule updates • Assure annual equipment configuration, calibration, certification and verification • Perform daily and/or periodic equipment start-up checks, tests, inspections and calibrations • Assure real-time monitoring of data and video quality • Perform daily review of data logs and video samples • Perform verification at test site; beginning, middle, and end of collection • Assure complete uploading and processing of all pavement condition data. This includes uploading to backup drives. • Perform initial rater training and assure raters adequately trained in protocols (perform retraining as needed) • Perform all QC checks on the automated crack detection and analysis.

6. QUALITY REPORTING PLAN

6.1 Before Pavement Data Collection

The Data Collection Contractor provides proof of all equipment calibration and personnel certification to the Wyoming DOT before calibration site testing begins.

6.2 During Pavement Data Collection

The vendor monitors quality through QC activities and report data quality exceptions as part regular status reports, or more frequently if conditions warrant. Quality is monitored through acceptance testing, and quality issues are reported to the vendor as soon as issues are discovered. Manual QC records are available by vendor when checks are need by WYDOT.

In addition, WYDOT retains the calibration site data for all runs for each collection year. During a typical year, there will be a minimum of three separate calibration site runs.

The vendor submits the pavement condition collection results (data and images) to the Wyoming DOT at the end of collection and regular QC checks.

7. AGENCY AND DATA COLLECTOR QM PLAN ACCEPTANCE

Quality Management Plan accepted by the Pavement Management Engineer:

_____ Date: _____

Sarah Rickgauer, P.E.
WYDOT Pavement Management Engineer