Organization

• Condition surveys
  ‒ Data collection
• Automated surveys
• Highway agency trends with automated data collection
• Data quality
Condition Surveys

- Assess existing condition
- Predict future condition
- Estimate budget needs
- Evaluate budget impacts
- Support asset management
- Project selection
- Treatment selection
Data Collection

- Manual Walking & Windshield
- Semi-Automated
- Fully Automated
What Do We Collect

Data Collection

AASHTO / ASTM Standards

Rutting

Faulting

- Cross slope
- Radius of curvature
- Grade

Roughness
What Do We Collect (continued)

LTPP

DISTRESS IDENTIFICATION MANUAL for the Long-Term Pavement Performance Program

ASTM

Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys

NWPMA/WSDOT

Pavement Surface Condition RATING MANUAL

Northwest Pavement Management Systems Users Group
Sponsored by:
WSDOT, FHWA, Washington State University,
Washington DOT, University of Washington, University of Idaho, Oregon DOT, others

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Automated Data Collection

The chart shows the number of agencies reporting data over different years:

- **IRI**: 49 in 1986, 51 in 1991, 2 in 2004
- **Faulting**: 23 in 1986, 23 in 1991, 33 in 2004
- **Distress**: 10 in 1986, 20 in 1991, 33 in 2004
2D Systems

- Area or **line-scan** camera
  - Captures laser beam reflection
  - Software generates surface image
- Surface distress determined by:
  - Human rater viewing images or
  - Analysis software

~13 ft  ~6 ft
3D Systems

- High resolution 2D and 3D continuous profile
- Software & algorithms to detect:
  - Cracking (>1mm)
  - Raveling
  - Potholes
3D Systems (continued)

Source: Pavemetrics Systems, Inc.
2D Intensity Data (reflected light)

3D Range Data (height)

Source: F. Li (Georgia Tech)
3D Systems (continued)

3D Laser Image

Automated Crack Detection

Source: Dynatest, Inc.
How good is 3D?

• Need precise and clear distress definitions
• Algorithm accuracy is critical
• Compare to manual surveys
  – Laurent et al. (2014) evaluated 6,200 mi, 96% good agreement in crack type, multiple runs very repeatable
  – TxDOT (2014) evaluated 20 different sections, similar distress values
Example of Results
Advantages/Disadvantages

**Advantages**
- Safety
- Accuracy for certain distresses
- Faster data collection and processing
- Track distress over time
- Asset data collection

**Disadvantages**
- Link to historical manual distress data
- Changing technology
- Higher cost
- Potential vendor variability
- May required modification to distress manual, decision trees, models, etc.
Trends in Automated Data Collection (2018 survey)
Collection/Analysis Methods

- Full and Semi-Automated: 21 agencies
- Fully Automated: 16 agencies
- Combo of All: 8 agencies
- Manual: 6 agencies
Who does what?

- Vendor Collects/Analysis: 16 agencies
- Agency Collect/Analysis: 16 agencies
- Both: 6 agencies
- Vendor Collects - Agency Analysis: 5 agencies
- Vendor Collects - Both Analysis: 3 agencies
- Both Collect - Agency Analysis: 2 agencies

No. of Agencies
## What’s collected?

### Asphalt Pavements

<table>
<thead>
<tr>
<th>Condition</th>
<th>Fully Automated</th>
<th>Semi-Automated</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRI</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>Rutting</td>
<td>53</td>
<td></td>
</tr>
<tr>
<td>Longitudinal cracking</td>
<td>33</td>
<td>9</td>
</tr>
<tr>
<td>Transverse cracking</td>
<td>32</td>
<td>13</td>
</tr>
<tr>
<td>Cross slope</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Alligator cracking</td>
<td>29</td>
<td>15</td>
</tr>
<tr>
<td>Texture</td>
<td>19</td>
<td>1</td>
</tr>
<tr>
<td>Edge cracking</td>
<td>19</td>
<td>10</td>
</tr>
<tr>
<td>Reflection cracking</td>
<td>16</td>
<td>7</td>
</tr>
<tr>
<td>Block cracking</td>
<td>16</td>
<td>11</td>
</tr>
<tr>
<td>Raveling</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>Potholes</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>Bleeding</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Patching</td>
<td>15</td>
<td>10</td>
</tr>
</tbody>
</table>

No. of Agencies
Jointed Plain Concrete Pavements

What's collected (continued)?

<table>
<thead>
<tr>
<th>Condition</th>
<th>Fully Automated</th>
<th>Semi-Automated</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRI</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>Faulting</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Long. Crack</td>
<td>13</td>
<td>20</td>
</tr>
<tr>
<td>Cross slope</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Tran. Crack</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>Texture</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Patching</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td>Spalling</td>
<td>15</td>
<td>7</td>
</tr>
<tr>
<td>Corner Crack</td>
<td>16</td>
<td>7</td>
</tr>
</tbody>
</table>

No. of Agencies
Data Quality

- DOTs required to have data quality management plan (FAST Act)
  - Equipment calibration & certification
  - Certification process for manual data collection
  - Quality control
  - Sample, review & check processes
  - Error resolution procedures
  - Data acceptance criteria
Process Overview

Standards
- Equipment
- Rater

Control Site
- Ground truth
- Automated
- Compare for accuracy & repeatability

Production
- Verification sites
- Quality control (collection team)

Data Processing
- Acceptance (collection team)

Independent Verification
- Sampling
- Data checks
- Image quality

Agency Acceptance
- Data checks
- Image quality
- Compare to previous results

PMS
- Data load
- Additional functional checks
Standards

**Distress**
- Agency
- ASTM D6433
- LTPP

**Profile (equipment)**
- AASHTO M 328
- AASHTO R 56
- AASHTO R 57

**Profile (measure)**
- AASHTO PP 70
- ASTM E950
- ASTM E1656
- ASTM E2133

**Roughness**
- AASHTO R 43
- AASHTO PP 37
- ASTM E1926
- ASTM E1489

**Faulting**
- AASHTO R 36

**Rutting / Deformation**
- AASHTO PP 38
- AASHTO PP 69
- AASHTO R 48
- ASTM E1703

**Asphalt Cracking**
- AASHTO PP 67
- AASHTO R 55

**Images**
- AASHTO PP 68

**Macrotexture**
- ASTM E1845

**Precision & Bias**
- ASTM C670
- ASTM C802
Monitoring Sites

- **Control**
  - Conducted by agency
  - Establish ground truth
  - Certify, calibrate, verify equipment
  - Rater training and certification
  - Located proximity to central office

- **Verification**
  - Conducted by agency
  - Spread across network
  - Location known by collection team
  - Can be traversed multiple times during collection

- **Blind**
  - Same as verification
  - Location unknown to collection team
Rater Certification

• Agency-specific distress definitions

• Training
  - Conducted by agency or vendor
  - Identify and recognize agency distress

• Certification
  - Must be done by agency
Quality Control (examples)

• Equipment calibration & certification
  - Profiler
  - Distance measuring instrument
  - Linear referencing system

• Location
  - Match agency

• Data completeness
  - Length
  - Number of sections
  - Blank or null values

• Distress/condition
  - Expected range
  - Pavement type

• Images
  - Quality
  - Confirm distress
QC Detail Examples

- **Profiler**
  - Repeatability ± 5% (three runs)
  - Accuracy ± 10% of agency value
  - Bound test ≤ 8in/mi
  - Block check ± 0.1in

- **Imagery focus, color, luminance quality**

- **Location** ≤ 30 ft

- **IRI (3 runs):**
  - Std ≤ 0.06 in/mi and
  - ± 0.06 in. agency

- **Rut (3 runs):**
  - Std ≤ 0.06 in. and
  - ± 0.06 in agency

- **Fault (multiple runs and historical avg):**
  - Std ≤ 15%
### Example of Control, Verification, and Blind Site Requirements

<table>
<thead>
<tr>
<th>Condition</th>
<th>Criteria (3 runs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRI</td>
<td>Std ± 5% Class 1 profiler</td>
</tr>
<tr>
<td>Rutting</td>
<td>Std ± 0.06 in Class 1 profiler</td>
</tr>
<tr>
<td>Faulting</td>
<td>Std ± 0.06 in manual survey</td>
</tr>
<tr>
<td>Distress</td>
<td>± 10% manual survey</td>
</tr>
</tbody>
</table>
| Images     | • Displayable and clear, continuous, correctly stitched with no missing or overlapping images, synchronized with geographic locations and associated attributes  
• ≤ 10 images/mi or ≤ 2 consecutive images/mi with poor quality  
• 1/8 in. wide cracks are visible |
Example of Acceptance Requirements

• 100% data & image completeness
• Conduct field verification (5-10% sample)
  - Verify images & results
  - IRI: >95% ± 10% agency value
  - Rut: >95% ± 0.06 in. agency value
  - Fault: >95% ± 0.06 in. agency value
  - Cracking >85% ± 10% agency value
Example of Acceptance Requirements (continued)

• Location: >95% ± 30 ft
• Downward and ROW images > 95% meet criteria
• Confirm 100% data upload to PMS
• Major rehabilitation segment > 85% of segments ± 10% area agency value
• Year-to-year consistency checks
## Example of Corrective Action

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Acceptance</th>
<th>Testing</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data completeness</td>
<td>&gt; 98%</td>
<td>Total network miles</td>
<td>Re-collect</td>
</tr>
<tr>
<td></td>
<td>100%</td>
<td>Delivered data accurately populated</td>
<td>Correct</td>
</tr>
<tr>
<td></td>
<td>&gt; 98%</td>
<td>Accurately populated with required data elements</td>
<td>Correct</td>
</tr>
<tr>
<td></td>
<td>&gt; 98%</td>
<td>Delivered data &lt; 10 consecutive fixed missing segments</td>
<td>Correct</td>
</tr>
<tr>
<td>IRI, rut depth, &amp; faulting</td>
<td>&gt; 95%</td>
<td>Compliant with the verification testing requirements</td>
<td>Re-collect</td>
</tr>
<tr>
<td>Distress ratings</td>
<td>&gt; 95%</td>
<td>Compliant with the verification testing requirements</td>
<td>Re-collect</td>
</tr>
<tr>
<td>Location Information</td>
<td>100%</td>
<td>Database check of accuracy and completeness</td>
<td>Correct</td>
</tr>
<tr>
<td>Photolog &amp; pavement images</td>
<td>100%</td>
<td>20% random sample compliant with verification requirements</td>
<td>Re-collect</td>
</tr>
</tbody>
</table>
National Research

- NCHRP Synthesis (Spring 2019)
- NCHRP 1-57A (July 2019)
  - Standard definitions for automated cracking data
- NCHRP 1-60 (December 2021)
  - Calibration, certification, and verification of imaging systems
National Research (continued)

- FHWA Pooled Fund
  - Improving quality of distress and profile data collection and analysis
    - Standard data format
    - Transverse profile verif/valid/calib protocols
    - Cracking assessment protocols
    - Faulting collection and analysis standards
    - Quality management guide

https://www.pooledfund.org/Details/Study/543
Summary

Data Collection

Data Quality

Pavement Management
Questions?

Linda Pierce
lpierce@ncenet.com
(505) 603-7993