

Managing the Quality of Pavement Condition Data

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Outline

- **Objective**
- **Background**
- **Data Quality Management**
- **Quality Control**
- **Quality Acceptance**
- **Findings**
- **Recommendations for Research**

Synthesis Objective

- **Document current quality management practices being employed by public agencies**
 - Clear definition of key terms
 - Importance of quality data to pavement management.
 - Quality management techniques
 - Tools available for quality control, quality acceptance, and independent assurance
 - techniques, and/or changes in data service provider
 - Gaps in knowledge and needed improvements
 - Specific research and development needs
- **Based on a Survey of Practice & Literature Review**

Acknowledgements

- The presentation is based on preliminary findings of NCHRP Project 20-5 Synthesis Topic 39-01 FY 2008
- The document is under review by the project panel
- Significant input has been provided by the following panel members:
 - Aramis Lopez
 - Eric Thibodeau
 - Ginger McGovern
 - Katie Zimmerman
 - Mike Murphy
 - Omar Smadi
 - Stephen Maher
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 - Tom Van
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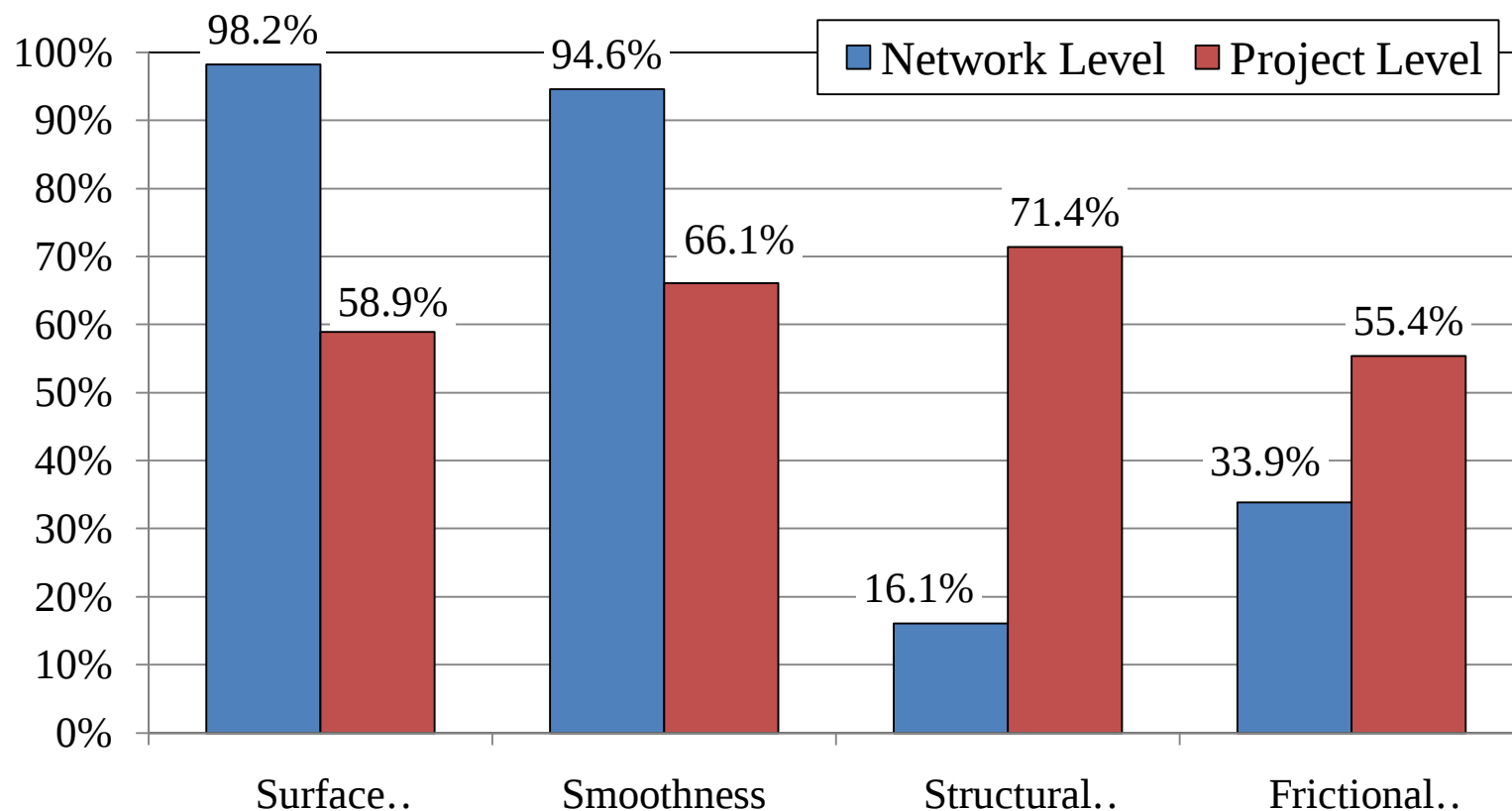
Background

Data Quality Management Framework

	Before Data Collection	During Production (Data Collection & Processing)	After Production
Quality Management	• Personnel training/certification • Equipment calibration/ certification/ inspections ...	Quality Control • On-vehicle real-time data checks • Periodic diagnostics/data checks • Incoming data and video check ...	• Distress rating data checks • Final database checks • Completeness checks ...
	• Initial Control Site Testing • Review qualifications or certifications ...	Quality Acceptance • Complete database checks • Control/ verification site testing • Sampling for quality acceptance ...	• Final database reviews • GIS-based quality checks • Time history comparisons ...
		Independent • Consistency checks • Sampling and re-analyzing ...	Assurance • Completeness checks • Time History Comparisons ...

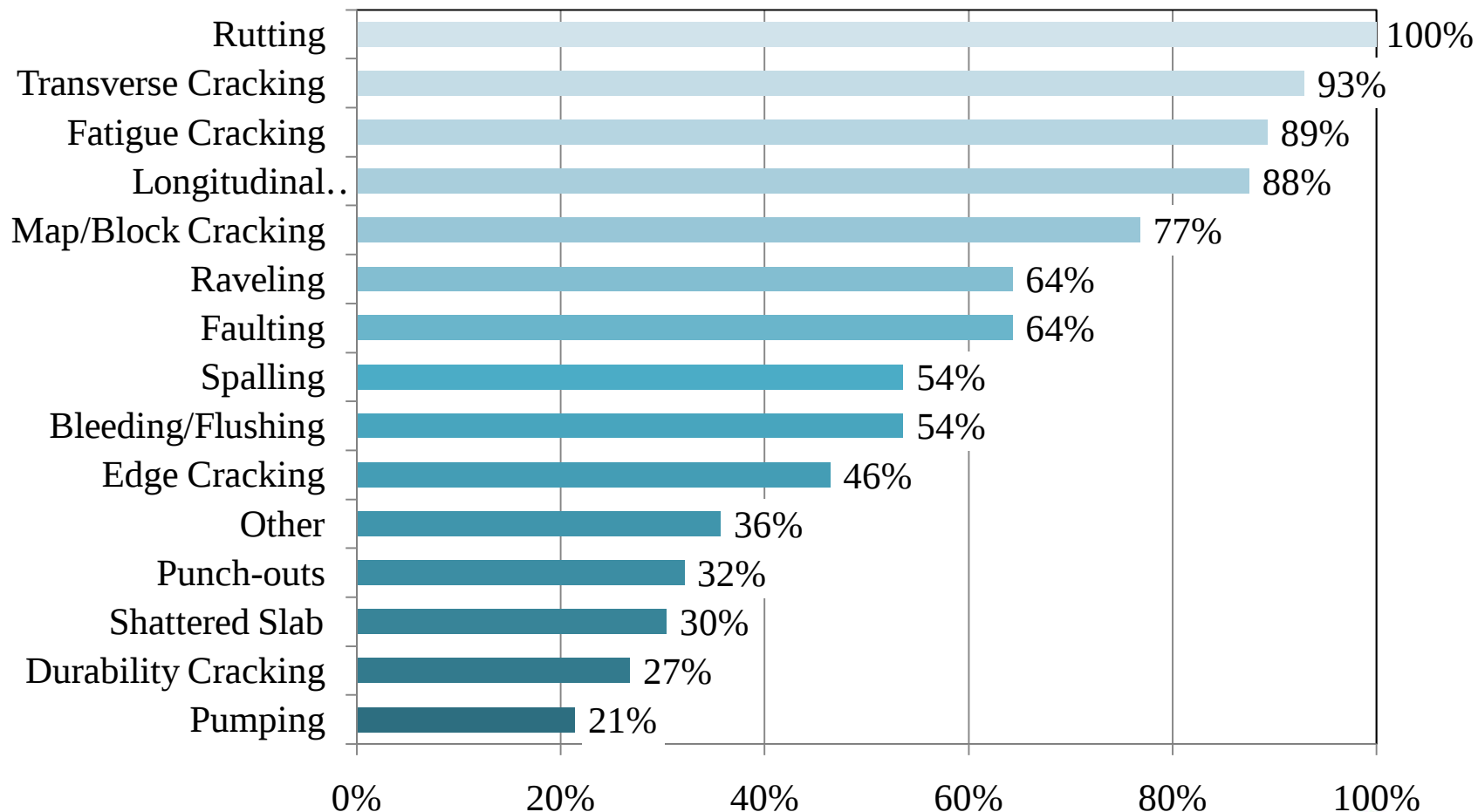
Pavement Condition Data Collected

Question: What pavement condition data does your agency collect?

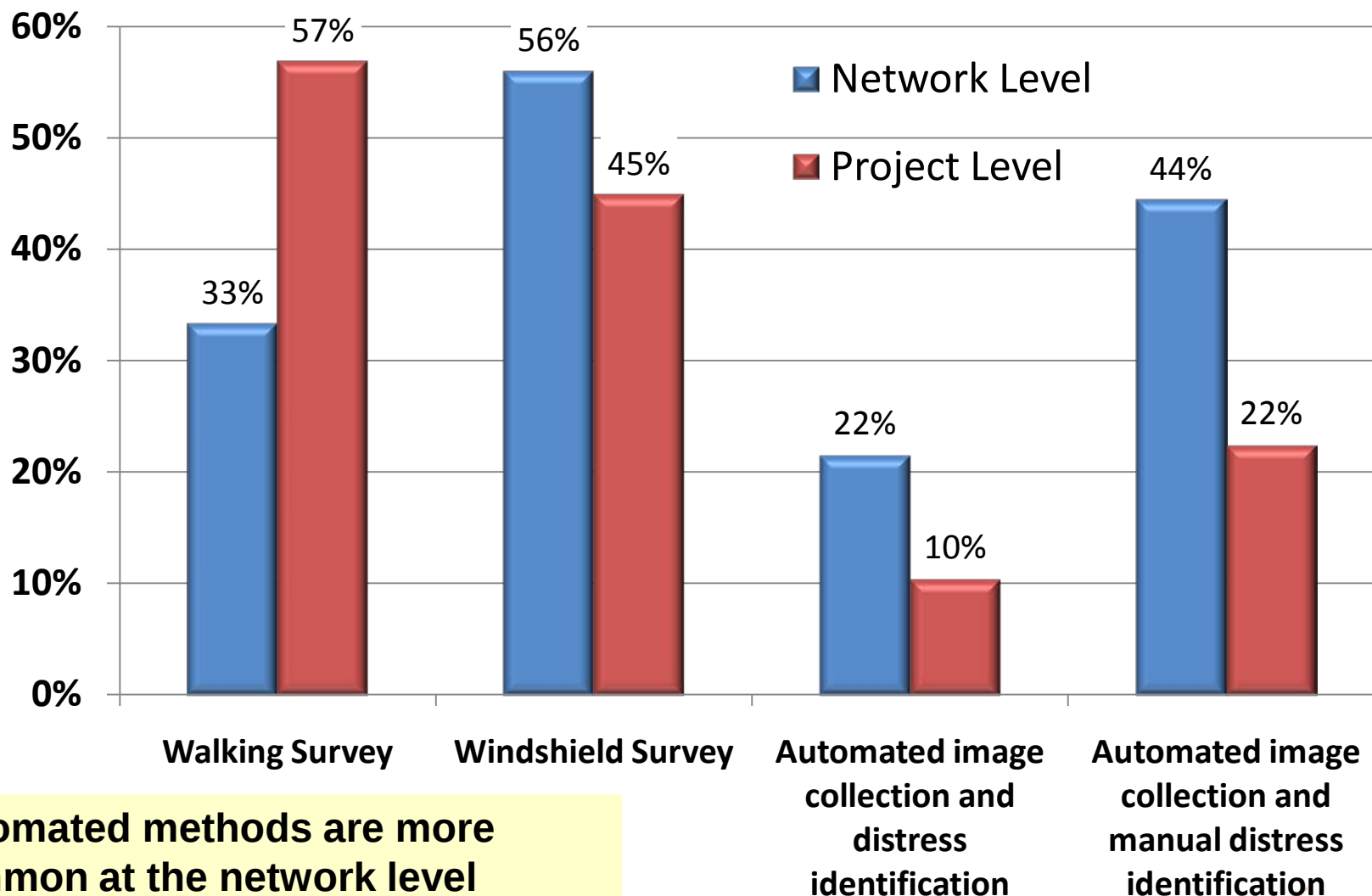


Distress Data Collected

Question: What pavement distress data does your agency collect?



Distress Data Collection Methods

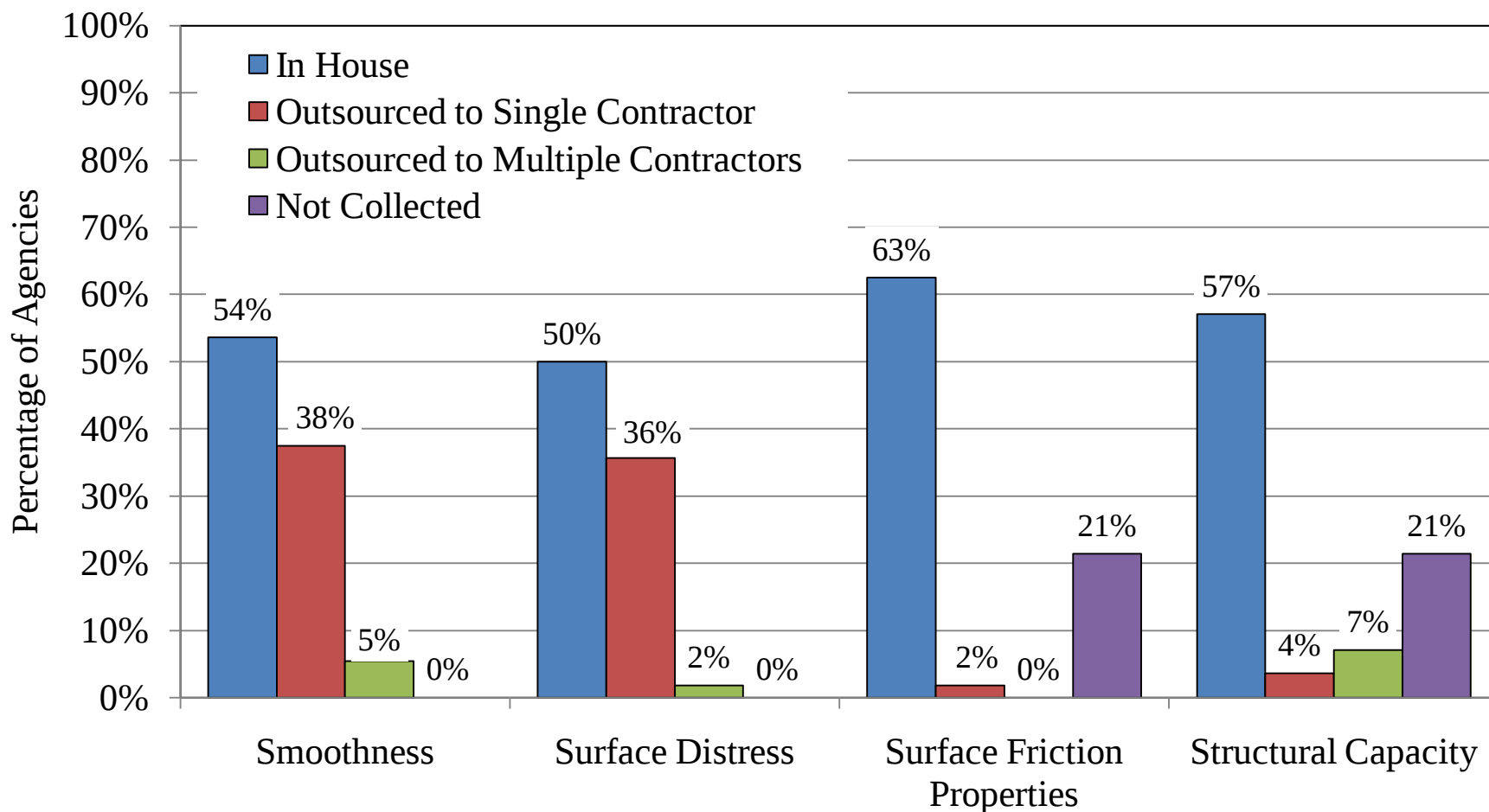


Automated methods are more common at the network level

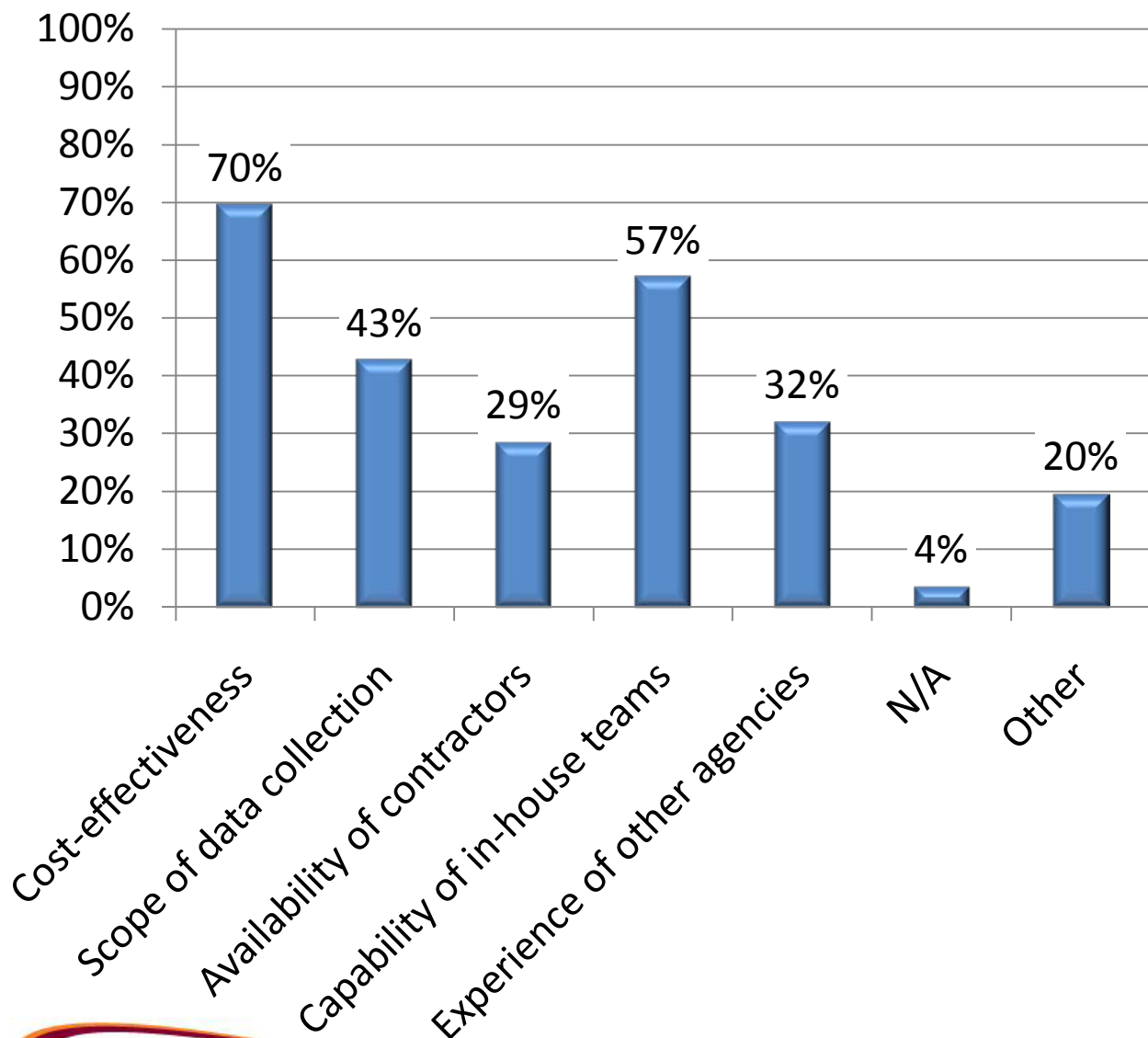
In-House vs. Service Providers

- **Trend towards the use of data collection service providers**
 - (1) Increase demand for timely quality data to support pavement management decisions;
 - (2) Reductions in the public sector staff that make it cumbersome to collect the data in house; and
 - (3) Availability of more sophisticated equipment that can collect large quantities of data quickly and efficiently but are often expensive and complex to operate.

Question: How does your agency currently collect pavement condition data?



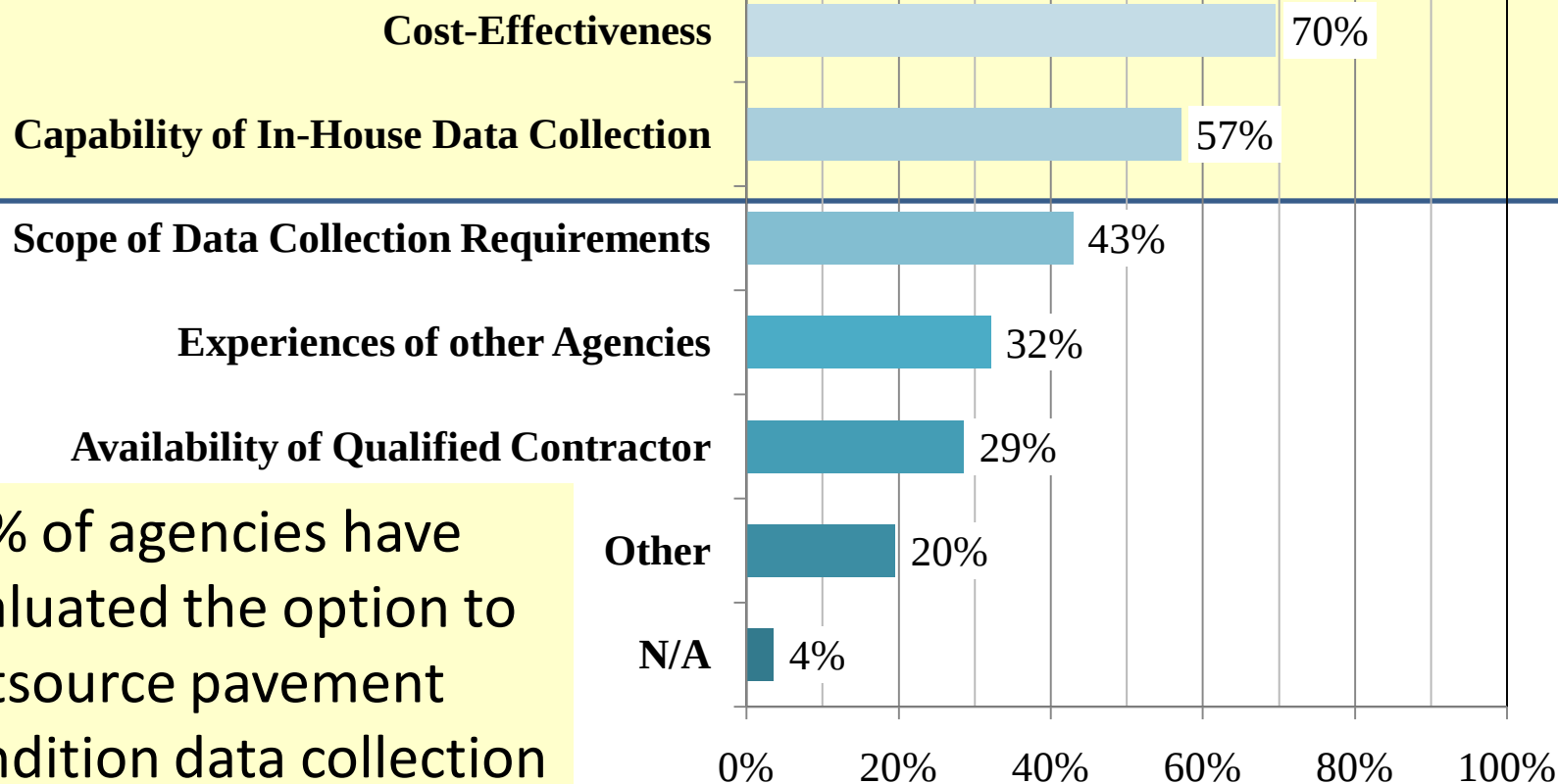
Factors Considered When Outsourcing



- 81% of agencies have evaluated the option to outsource pavement condition data collection
- Cost effectiveness and capabilities of the in-house team were the major factors when evaluating outsourcing

Data Collection Outsourcing Rationale

Question: What criteria did your agency use to determine whether or not to privatize pavement condition data collection?



- 81% of agencies have evaluated the option to outsource pavement condition data collection

Factors Impacting Quality Management

- ***Pavement data collection outsourcing***
 - Consistency with agency protocols/ requirements
- ***Quality of the location referencing data***
- ***Historical data consistency***
- ***Network spatial and temporal coverage***
- ***New demands imposed by changing business practices –***
 - E.g., the HPMS reassessment and the adoption by AASHTO of the MEPDG.

Data Quality Management

General Principles

- **Quality data is necessary for “good” pavement management decisions**
- **Most efficient way to achieve high quality services is to adopt a comprehensive quality management approach that includes methods, techniques, tools, and model problem solutions**
- **Costs and benefits of a quality “approach” are clear only after the quality processes have been tried out for a while and the organization starts to reap the benefits from the improved quality**

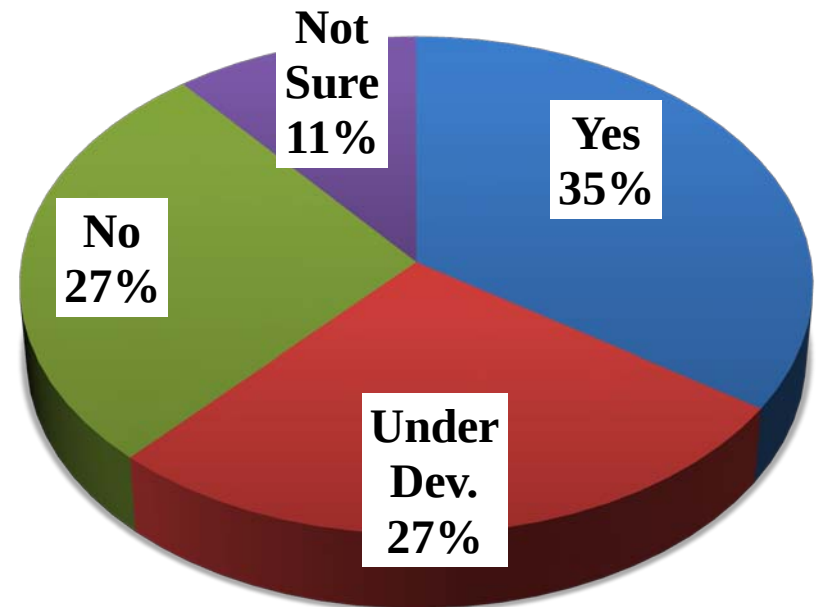
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Quality Management Plan

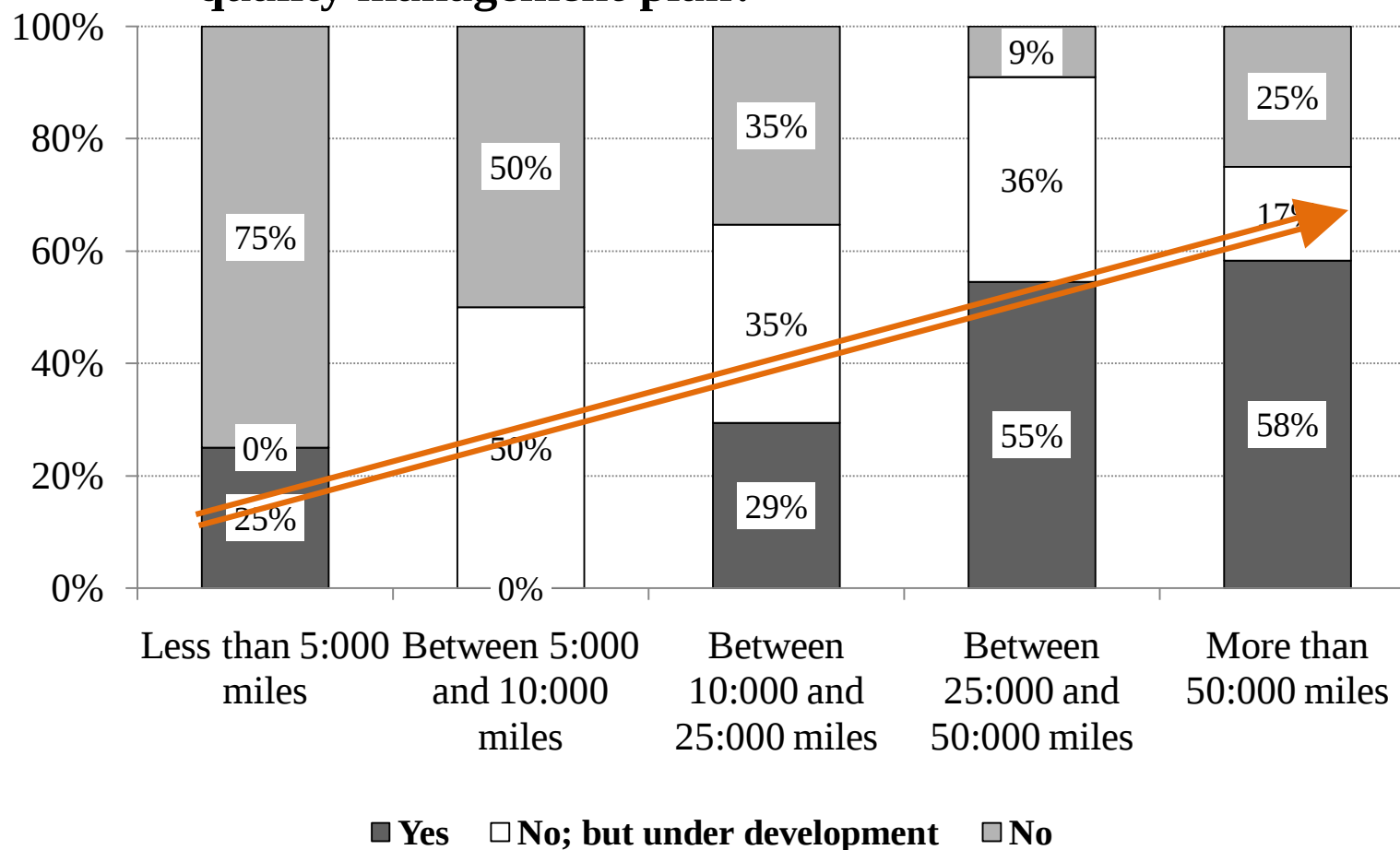
- Documents how the agency will plan, implement, and assess the effectiveness of its pavement data collection quality control and quality acceptance operations
- Agency performance and effectiveness appear to be affected by having a formal QM plan
- Almost two-thirds of agencies either have or are developing QM plans

Question: Does your agency have a formal pavement data collection quality management plan?

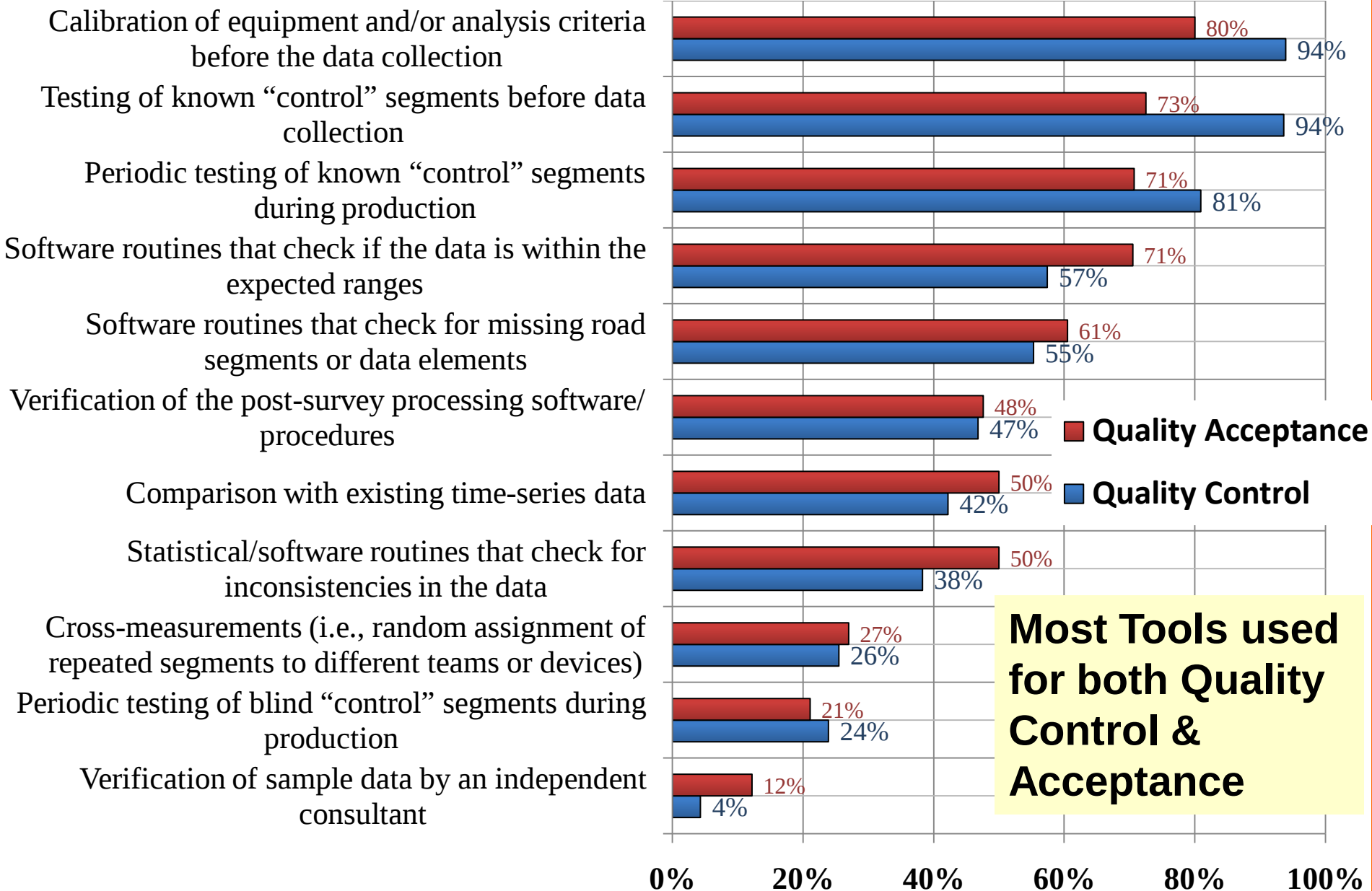


Effect of Network Size

Question: Does your agency have a formal pavement data collection quality management plan?



Quality Management Tools



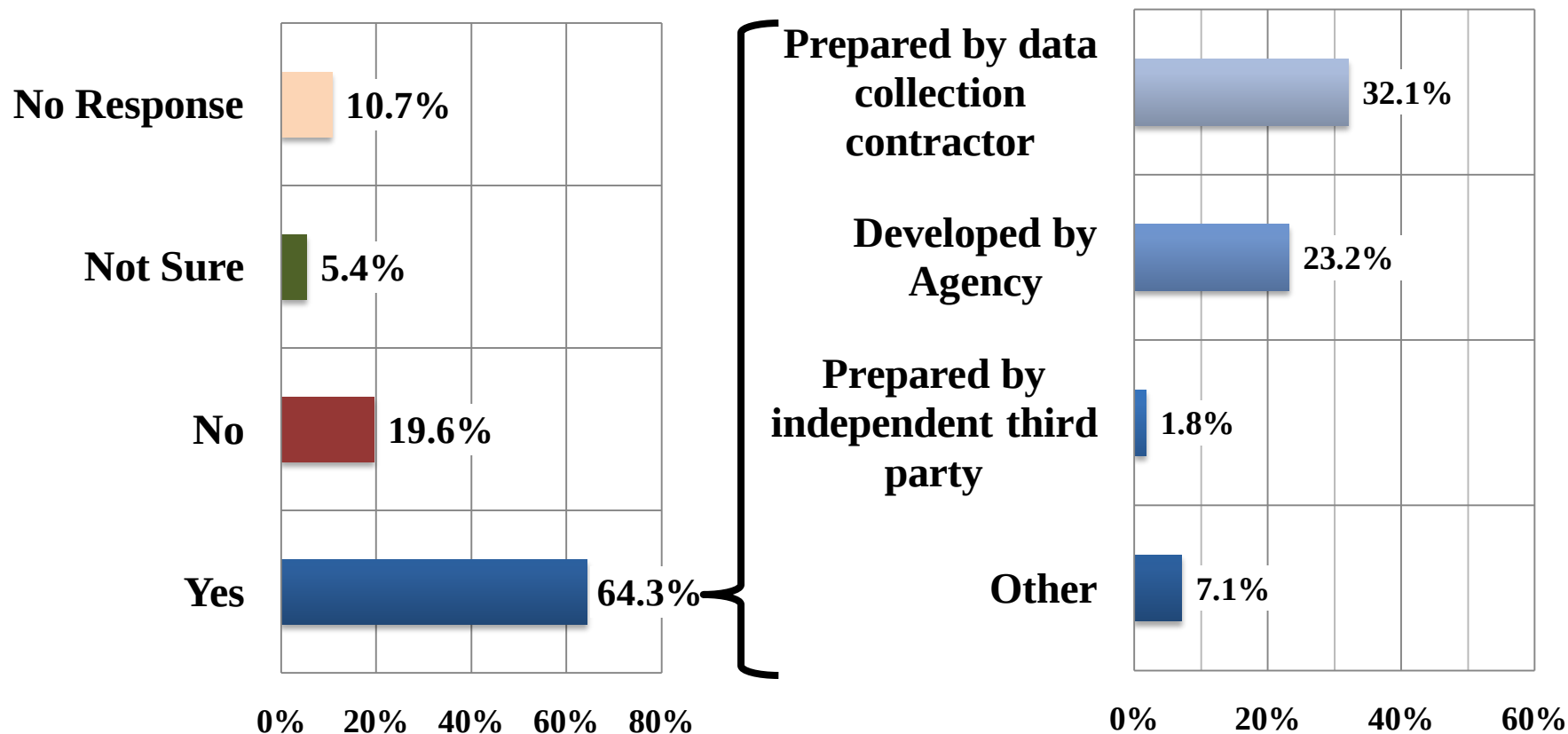
- **Personnel Training and Certification**
- **Equipment/Method Calibration, Certification, and Verification**
- **Data Verification Procedures by Testing of Control or Verification Sites**
 - known or
 - unknown (blind) to the data collection crews.
- **Software Data Checks**
- **Other Tools**
 - Time-history comparisons,
 - GIS-based analysis,
 - Verification of sample data by independent third parties.

Quality Control

Quality Control

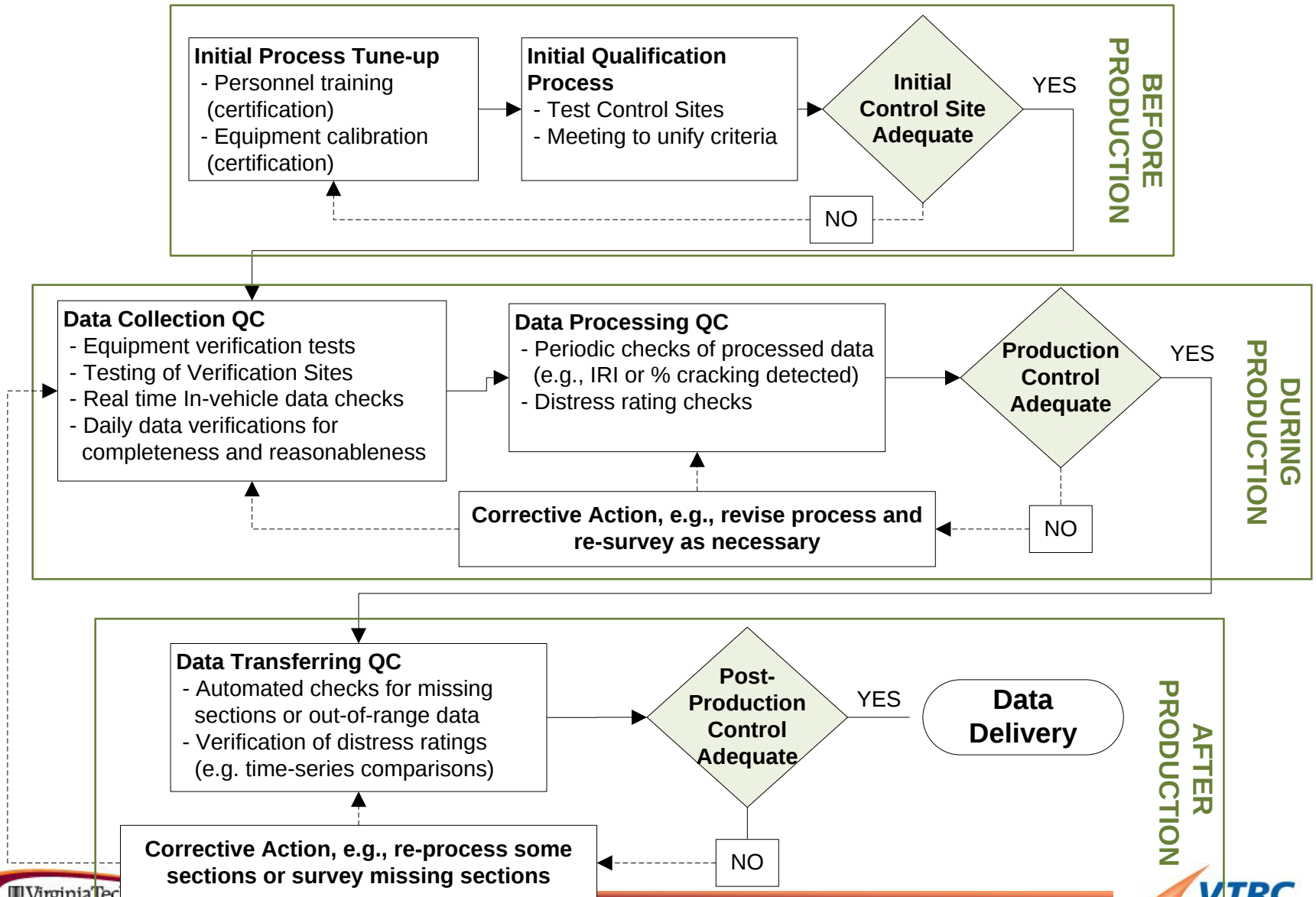
- Purpose: to quantify the variability in the process, maintain it within acceptable limits, identify source of variability that can be controlled, and take the necessary production adjustments to minimize the “controllable” variability.
- **Contents of a Quality Control Plan**
 - Clear delineation of the responsibilities
 - Documented (and available) manuals and procedures
 - Training of survey personnel
 - Equipment calibration, certification, and inspection procedures
 - Equipment and/or process quality verification procedures (e.g., testing of control sections) before starting and during production testing
 - Checks for data reasonableness, consistency, and completeness

Quality Control Plan



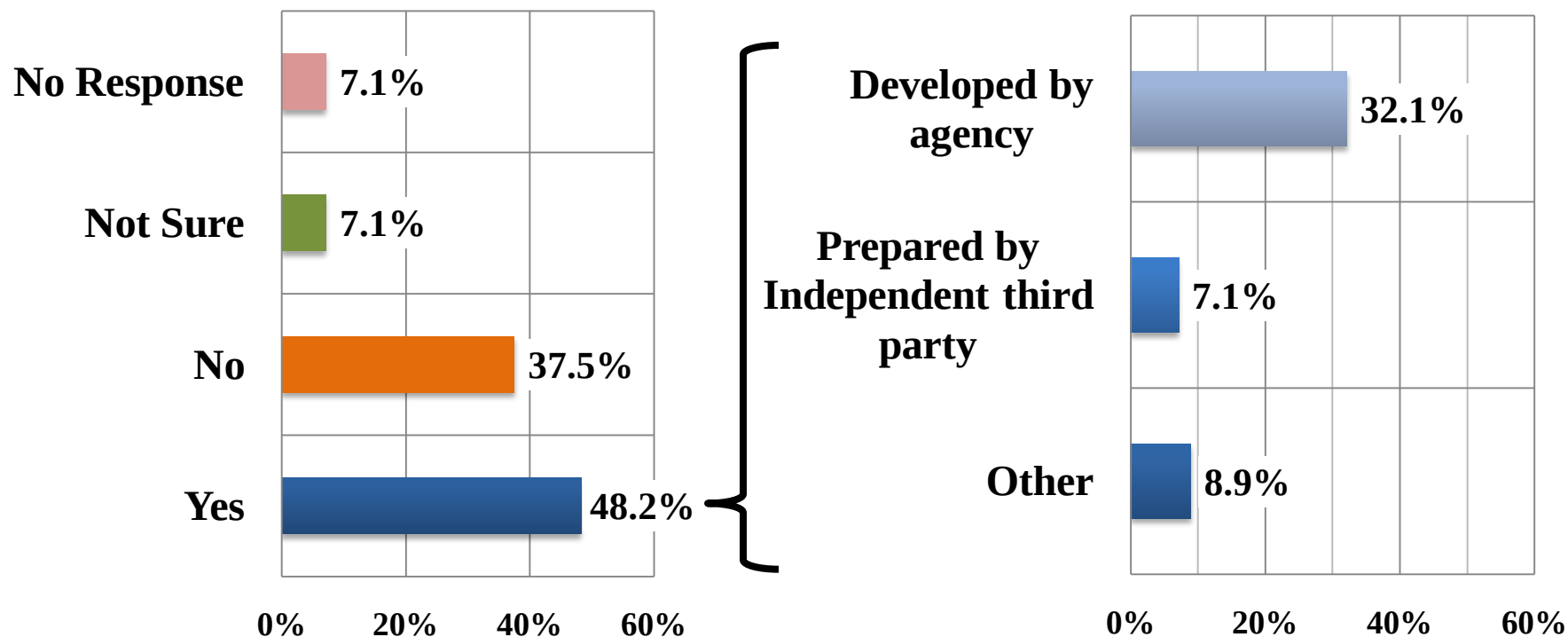
- **Most common methods/ tools:** (in order of decreasing frequency, the percentage of agencies citing each method/tool is provided between brackets):
 - Calibration of equipment and/or analysis criteria before the data collection (94%),
 - Testing of known “control” segments before data collection (94%),
 - Periodic testing of known “control” segments during production (81%),
 - Software routines that check if the data are within the expected ranges (57%), and
 - Software routines that check for missing road segments or data elements (55%).

Example



Quality Acceptance

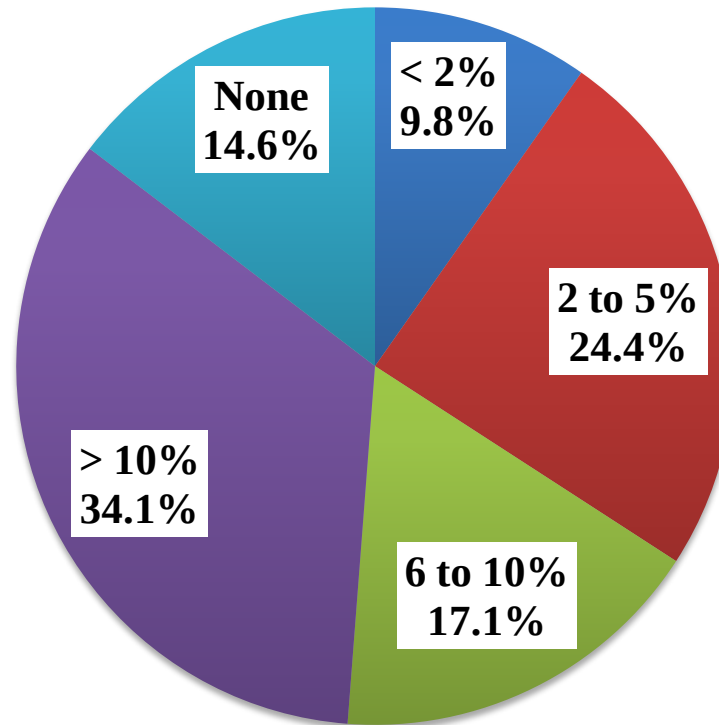
Quality Acceptance Plan



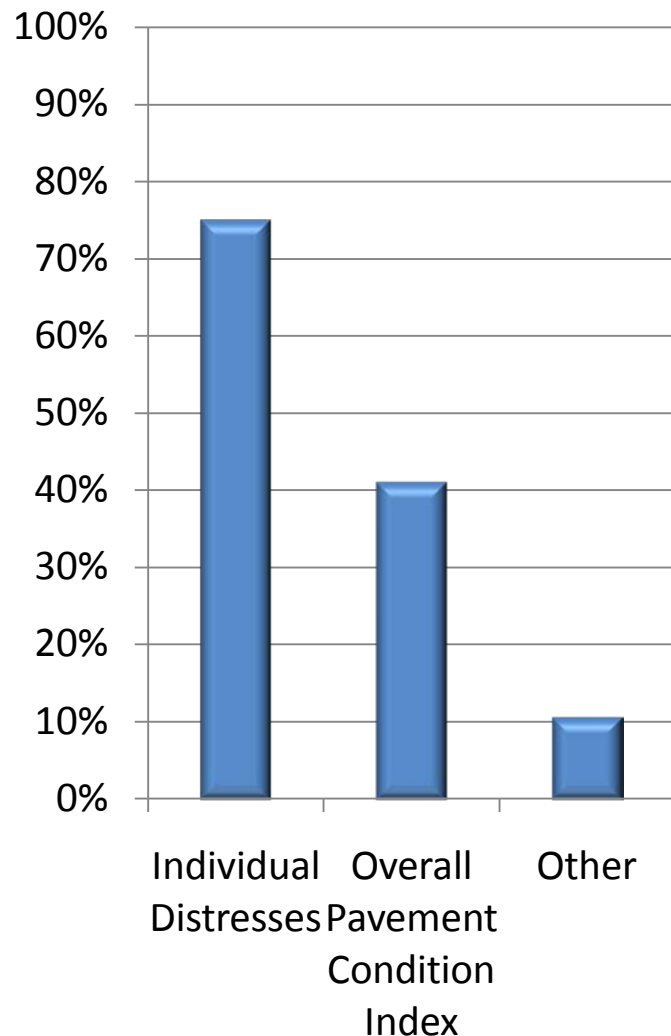
- **Most common methods/ tools:** (in order of decreasing frequency, the percentage of agencies citing each method/tool is provided between brackets):
 - Calibration of equipment and/or analysis criteria before the data collection (80%),
 - Testing of known “control” segments before data collection (73%),
 - Periodic testing of known “control” segments during production (71%),
 - Software routines that check if the data are within the expected ranges (71%),
 - Software routines that check for missing road segments or data elements (61%),
 - Statistical/software routines that check for inconsistencies in the data (50%), and
 - Comparison with existing time-series data (50%).

Quality Acceptance Sample Size

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



Criteria



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

Findings

1. Data Quality Requirements:

- It is important that agencies tailor the data collection practices and quality management processes to the use of the data and the level of decisions being supported.
- The level of detail, accuracy, and coverage (and consequently “quality”) required is different for supporting network- and project-level PM.
- In general, surface distress (98% of respondents) and smoothness (95%) data are collected for network level analysis using automated processes or windshield surveys.

2. Quality Management Plan:

- Documents how the agency plans, implements, and assesses the effectiveness of its pavement data collection quality control, quality acceptance, and independent verification operations.
- Approximately one-third of the state and provincial highway agencies (35%) already have a formal plan and an additional 27% are working on developing such a plan.
- Agencies with larger networks were more likely to have a formalized quality management plan than the smaller agencies.

3. Quality Management Tools and Methods:

- Calibration/ verification of equipment/ methods before the data collection (94% for QC and 80% for QA)
- Testing of known control segments before data collection (94% for QC and 73% for QA)
- Testing of known control or verification segments during data collection (81% for QC and 71% for QA)
- Software routines for checking
 - Data reasonableness (57% for QC and 71% for QA)
 - Data completeness (55% for QC and 61% for QA)

4. Quality Control

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

5. Quality Acceptance

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

6. Independent Assurance:

- Quality engineering practices typically recommend the inclusion of at least some degree of external audit in the quality management plan.
- The purpose of the independent assurance testing is to validate the data for the user agency.
- However, only 4% of the agencies surveyed use independent verification for quality control and 12% for quality acceptance.

7. Equipment/ Method Calibration, Certification, and Verification:

- The verification that the equipment is functioning according to expectations and that the collection and analysis methods are being followed is key for assuring the quality of the collected data.
- This is typically done before the initiation of the data collection activities and periodically after that.
- Equipment or process verification and validation is typically assessed by determining their accuracy, repeatability and reproducibility.

8. Control and Verification Sites:

- A common procedure to verify the quality of the pavement data collection during production is the use of a sample of control or verification sections that are re-surveyed or re-analyzed.
- The locations of these segments can be known or “blind” for data collection teams.
- The reference value (or ground truth) measurements on these sections are determined using the best available, practical technique.
- Statistical methods are typically used to establish acceptable ranges for various techniques.

9. Software Checks:

- Many agencies and all service providers use software routines that check the data for inconsistencies for both quality control and quality assurance.
- While there is some variation in verification methods, most software can perform checks for detecting missing segments, corrupted records, and ratings that are out of expected ranges.
- Some packages can also provide statistical analysis to check for data inconsistencies, compare condition time-series, and/or graphically display the results using GIS.

10. Data Collection Contracting:

- Agencies are increasingly considering the outsourcing of data collection and processing. However, while most agencies have evaluated this possibility, most of the pavement data are still collected in-house.
- Pavement distress and smoothness data are the data types which are most frequently outsourced (43% and 38% of respondents, respectively)
- More than two-thirds of the agencies that have outsourced at least part of the data collection indicated that data collection outsourcing was a positive step.

11. Changing Requirements/Technologies:

- The adoption of automated (and semi-automated) data collection technologies has created challenges for the roadway agencies that must verify that the new equipment results are consistent with the historical practices.
- Furthermore, institutional changes, such as the reassessment of the HPMS or the adoption of mechanistic-empirical pavement analysis and design methodologies are also influencing the pavement condition data detail and quality requirements.

Example

of Quality Management Plan Components

Activities

Before Data Collection

- Define & set up:
 - Scope of work
 - Project schedule
 - Project team
- Select control sites and ground truth determination
- Setup collection subsystems
- Control site data collection and processing

Quality Management

Quality Acceptance

- Define:
 - Data accuracy, precision, and resolution
 - Rating system/ protocol
 - Specific requirements/ specifications
- Known control site testing & review

Quality Control

- Equipment calibration & acceptance
- Rater Training (certification)
- Standardization of operation procedures
- Develop quality check program
- Equipment/method validation using control sites

After Zhang & Smadi, 2009/ Rada et al. 2004

Example

of Quality Management Plan Components (cont.)

Activities

Quality Management

During Production (Data Collection & Processing)

- Pilot data collection & processing
- Production data collection
- Production data processing
- Control site (known & blind) testing
- Reruns and exceptions

Quality Acceptance

- Pilot feedback
- Blind (or known) control site testing
- Periodic raw data review (e.g., weekly)
- Periodic processed data review (e.g., monthly)

Quality Control

- Equipment inspection
- Real-time data checks
- Raw data checks (e.g., daily)
- Processed data checks (e.g., weekly)
- Control site data monitoring
- Rater consistency monitoring
- Fike and project tracking/ documentation

After Zhang & Smadi, 2009/ Rada et al. 2004

Example

of Quality Management Plan Components (cont.)

Activities

After Data Collection Production

- Data assembly
- Exception flags
- Data Delivery
- Final Reports

Quality Management

Quality Acceptance

- Final data review & feedback
- Review for missing segments (e.g., GIS-based)
- Sampling and statistical comparisons
- Independent quality assurance
- Time series comparisons

Quality Control

- Check for missing segments or data elements
- Final database software checks
- Verification of distress ratings (e.g., using time series comparisons)

After Zhang & Smadi, 2009/ Rada et al. 2004

Issues Identified

- **Lack of uniformity on the type of data collected by the various DOTs and the approaches followed to manage the quality of the data collection process**
- **Although there seems to be common agreement that data quality is important, several agencies still do not have formal quality management plans**
- **Several agencies are facing problem with the consistency of data after the adoption of automated methodologies.**
- **Several agencies also reported problems with the consistency of their location referencing systems, especially as they migrate from linear to geodetic methods.**
- **Need for guidelines to help agencies define the level of data quality and detail needed for the various pavement management functions and decision-making levels.**