Automated Pavement Distress Identification and Quantification FDOT Project BDZ 36

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Existing FDOT Practice

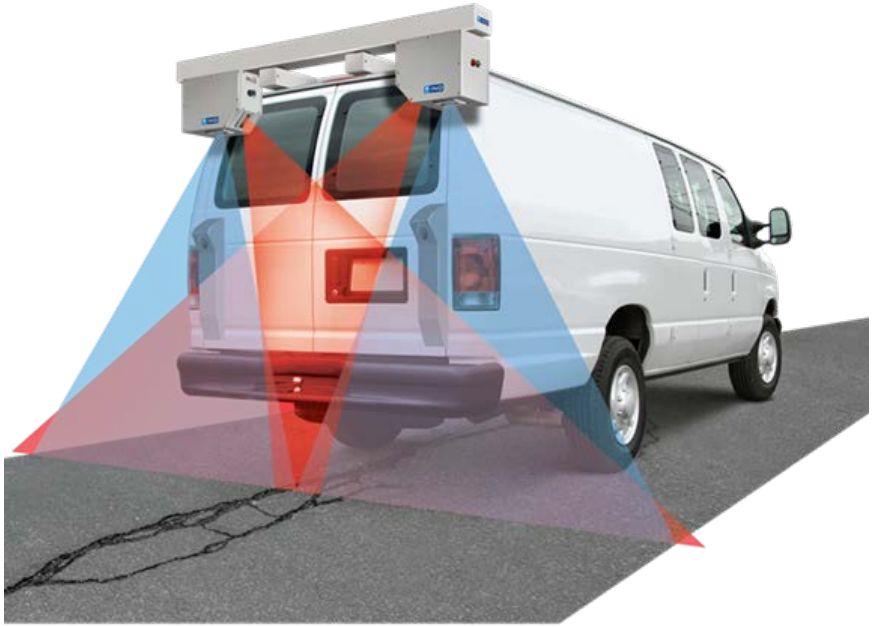
- Annual pavement condition survey (PCS)
  - FDOT Pavement Management System(PMS)
  - FHWA Highway Performance Monitoring System (HPMS)
- Manual windshield survey
  - Main methodology
- Laser Road Imaging System (LRIS)
  - Rate cracks in rigid pavements, especially on urban high-speed roadways
  - Point and trace manual method - inefficient for network level and long projects evaluation

Project Objective

Develop and implement automated crack detection and quantification application(s)

Phase I: rigid pavements

Phase II: flexible pavements



Project Scope

- Phase I

  Task 1 Technology State of the Practice Assessment

  Task 2 Rigid Pavement Application Design

  Task 3 Rigid Pavement Application Development and Validation

- Phase II

  Task 4 LRIS Feasibility on Flexible Pavements

  Task 5 Flexible Pavement Application Design

  Task 6 Flexible Pavement Application Development and Validation

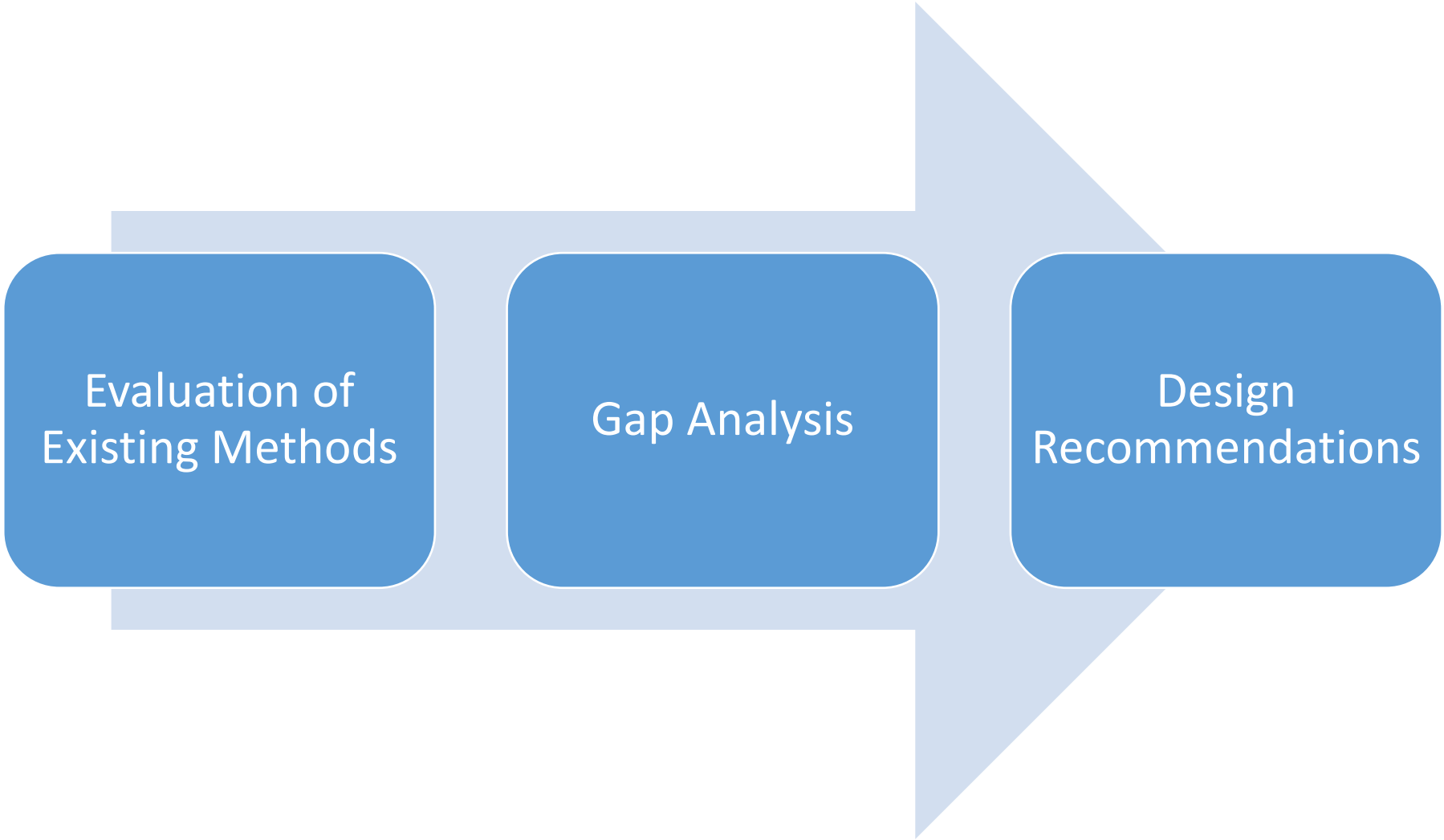
  Task 7 Automated Application(s) Implementation

  Task 8 Technology Needs and Gaps Assessment

  Task 9 Draft and Final Reports

  Task 10 Technical Support

Rigid Pavement Application Design



Evaluation of Existing Distress Survey Methods

WHAT?

- **Distress Type**
  - Long Crack
  - Trans Crack
  - Other Cracks
  - Joints
- **Distress Extent**
  - Length, Width, Density

Where?

- **Representative pavement types**
- **Number of test sections**

HOW?

- **Manual Survey** (min 3 raters)
- **Semi-Automated** Using LRIS Images (min 3 raters)
- **Fully Automated**

METRICS

- **Distress Verification**
  - Missed Cracks
  - False Positives
- **Survey Quantification Performance** (among different test sections and multiple runs)
  - Accuracy: Bias (AVG Error on Cumulative Values)
  - Precision: Standard Deviation of Error
  - Efficiency: processing time

WHY?

- **Establish reference values**
- **Determine acceptable range based on D2S**
- **Compare different methods**
- **Diagnose areas for improvement**

Manual Distress Survey Workshop

- Office Discussion: review FDOT distress type, extent, and severity
- Field Exercise: 13 distress raters divided into 3 groups
  - 1 experienced FDOT rater
  - 1 non-experienced FDOT rater
  - 1 Fugro rater
  - 1 test section

Distress Workshop Results: Transverse Cracking

Section ID	Statistic	Light	Moderate	Severe	Total
01	AVG	8.67	1.67	0.33	10.67
02	AVG	6.00	2.00	1.33	9.33
03	AVG	21.00	2.00	2.00	25.00
04	AVG	10.25	3.50	1.25	15.00
01	STD	0.58	1.53	0.58	2.08
02	STD	1.73	2.00	0.58	2.31
03	STD	2.00	2.00	2.65	5.20
04	STD	4.99	2.38	1.50	2.45
01	**COV (%)**	6.66	91.65	173.21	19.52
02	**COV (%)**	28.87	100.00	43.30	24.74
03	**COV (%)**	9.52	100.00	132.29	20.78
04	**COV (%)**	48.70	68.01	120.00	16.33
OVERALL VARIATION (%)	**AVG(COV)**	23.44	89.92	117.20	20.34
OVERALL PRECISION (%)	**100-AVG(COV)**	76.56	10.08	-17.20	79.66

Distress Workshop Results: Longitudinal Cracking

Section ID	Statistic	Light	Moderate	Severe	Total
01	AVG	1.00	0.33	0.00	1.33
02	AVG	10.00	4.00	1.00	15.00
03	AVG	2.33	0.67	0.33	3.33
04	AVG	1.25	0.75	0.25	2.25
01	STD	0.00	0.58	0.00	0.58
02	STD	5.20	3.46	1.00	2.65
03	STD	2.52	0.58	0.58	1.53
04	STD	1.26	0.96	0.50	0.96
01	**COV (%)**	0.00	173.21	0.00	43.30
02	**COV (%)**	51.96	86.60	100.00	17.64
03	**COV (%)**	107.85	86.60	173.21	45.83
04	**COV (%)**	100.66	127.66	200.00	42.55
OVERALL VARIATION (%)	**AVG(COV)**	65.12	118.52	118.30	37.33
OVERALL PRECISION (%)	**100-AVG(COV)**	34.88	-18.52	-18.30	62.67

Representative PCC Test Sections

Example Partial Factorial Plan:

Lighting		Shade		Into Sun		Away from Sun	
Texture/Tinning		Heavy	Light	Heavy	Light	Heavy	Light
Distress Type and Severity	Low	SS	TC/LC	SP	CB	TC/LC	SS
	High	SP	CB	TC/LC	SS	CB	SP

TC/LC: Transverse and/or Longitudinal Cracking, CB: Corner Breaks, SS: Shattered Slabs, SP: Spalling

Automated vs. Windshield Surveys

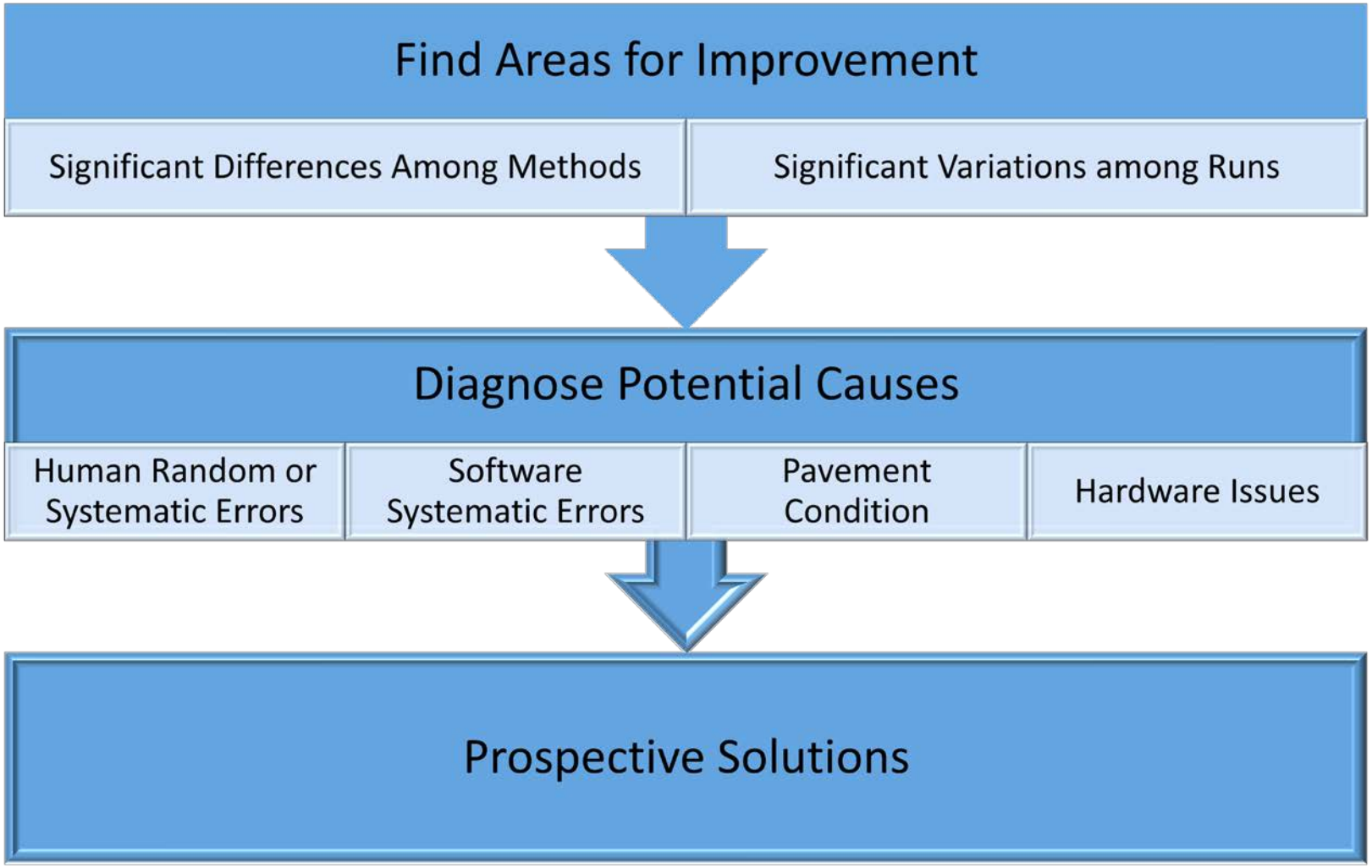
- Accuracy: Bias (average and median of error on cumulative values) between automated results and the reference values (the consensus from windshield surveys)
- Precision: Standard deviation of error among different test sections on each run
- Repeatability: Standard deviation of error among multiple runs on each test section
- Reproducibility: Standard deviation of cumulative distress values among different operators on each test section
- Efficiency: Average processing time

Verification of Automatically Detected Distresses

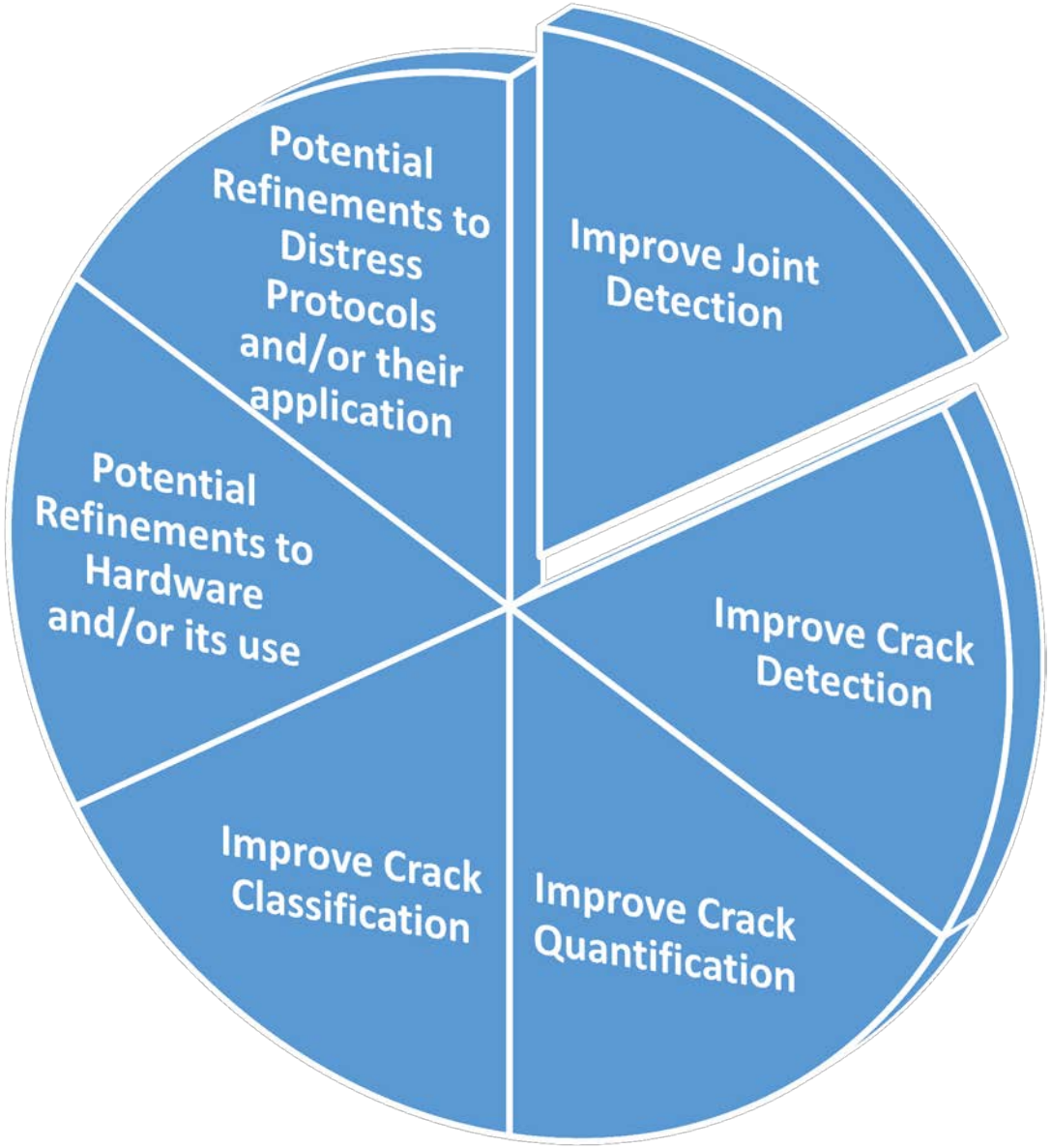
Compare Automated to Semi-Automated Surveys

- True Positives: correctly detected cracks (or distress)
- False Positives: detected cracks that don't exist in the reference survey
- False Negatives: Missed cracks
- Distress Validity (or Precision): ratio of true positives to total detected cracks (true positives and false positives)
- Distress Sensitivity (or Recall): ratio of correctly detected cracks to total existing cracks (true positives and false negatives)
- Distress Classification Performance: ratio of correctly classified cracks (according to the reference survey) to number of detected cracks

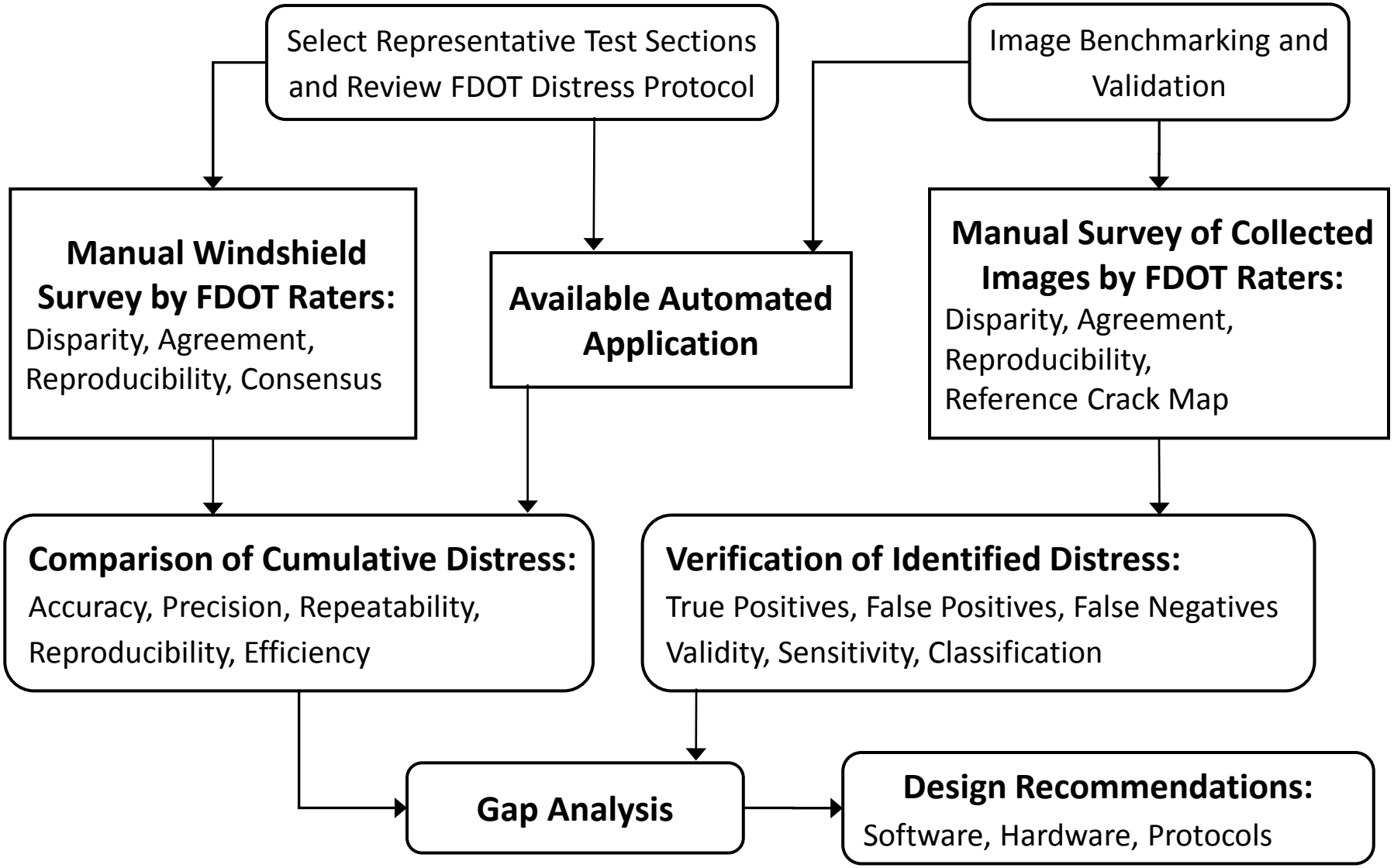
Gap Analysis



Design Recommendations



Rigid Pavement Application Design



Thank You