

# Detecting Asphalt Pavement Cracks under Different Lighting and Low Intensity Contrast Conditions Using 3D Laser Technology

Feng Li, Ph.D. Candidate

James Tsai, Ph.D., P.E., Associate Professor

Georgia Institute of Technology

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# Acknowledgement

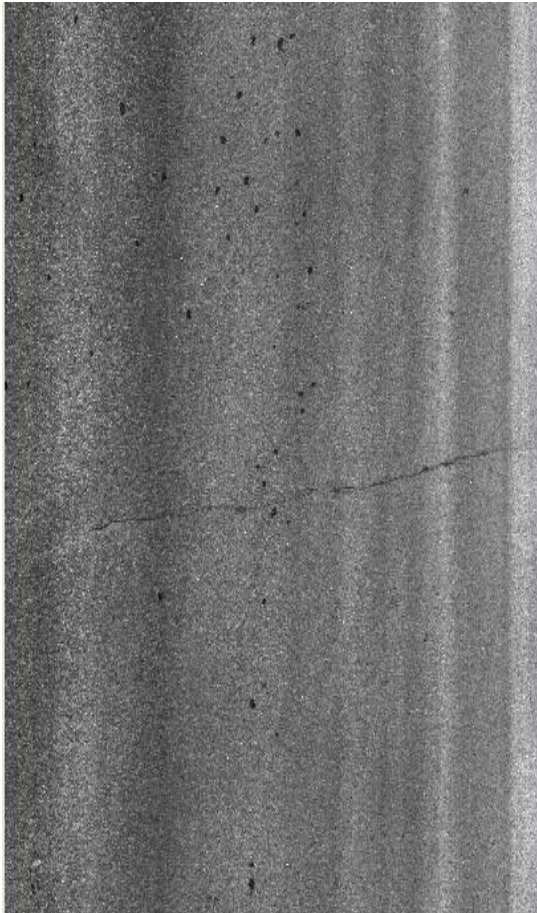
- The study presented in this paper was sponsored by US DOT RITA program (DTOS59-10-H-0003)
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# Outline

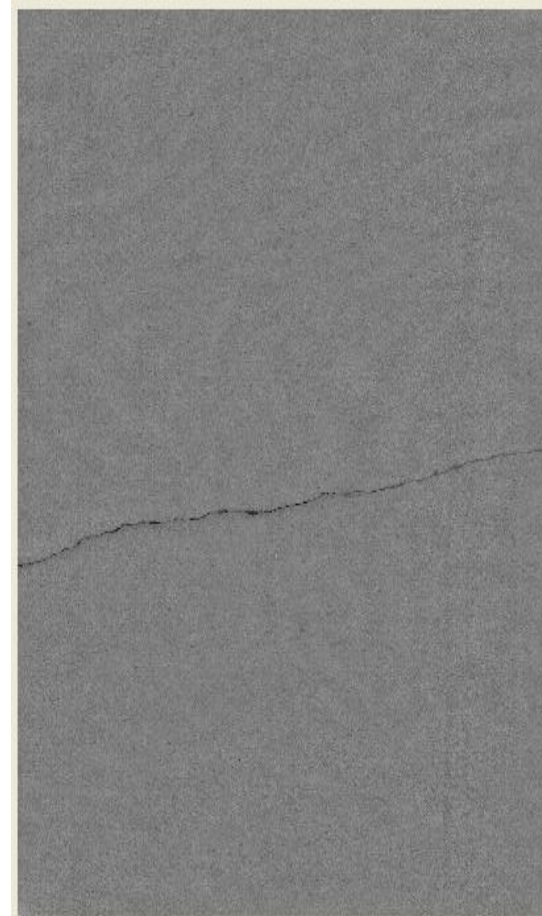
- Motivation
- Research Objectives
- 3D Sensor Technology Introduction
- Proposed Performance Evaluation Method
- Experimental Tests
- Conclusions and Recommendations

# Advantage of 3D data over 2D data on crack detection

2D data



3D data

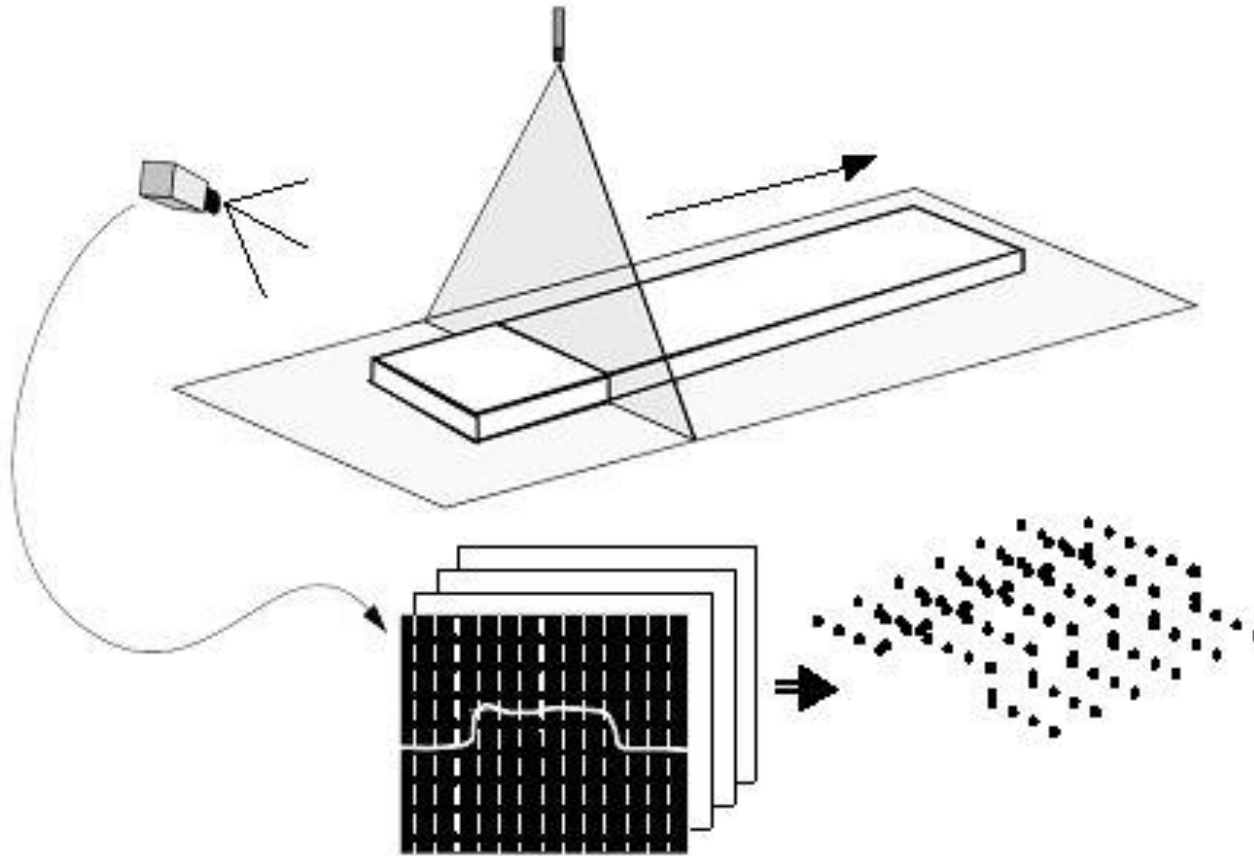


With 3D continuous profile technology, it is a lot more clear to distinguish a crack from the surrounding pavements

# Research objectives

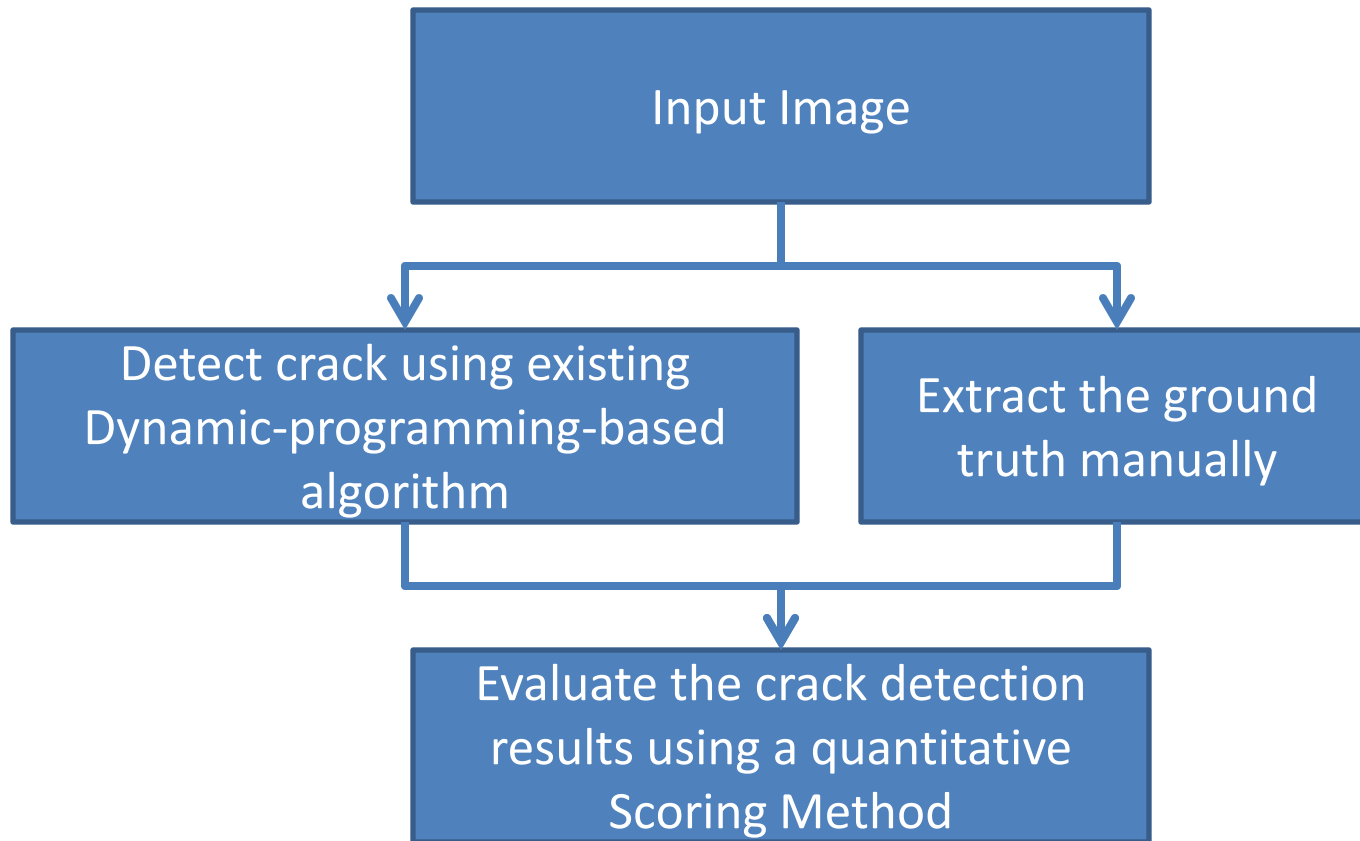
- Evaluate the performance of detecting cracks under different lighting and low intensity contrast conditions using a 3D pavement profile data.
- Evaluate the performance of crack width that can be detected using a 3D pavement profile data.

# 3D Continuous Pavement Profile Data Acquired using 3D Technology



(Laurent, et. al., 2008)

# Proposed Performance Evaluation Method



# Existing Dynamic-Programming-based Crack Segmentation Algorithm

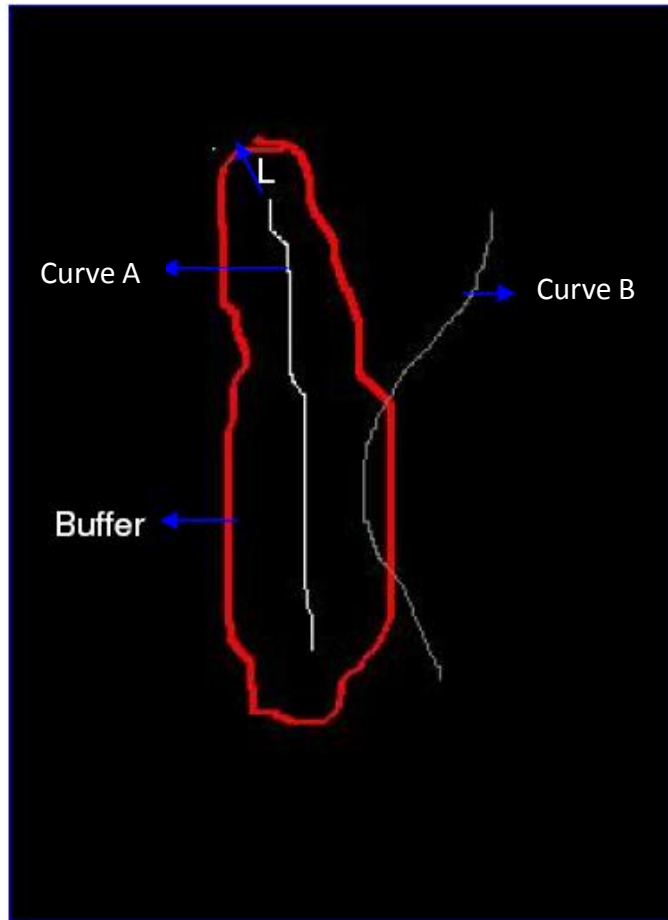
- Under all possible shapes and positions of the crack indication, one combination is sought to maximize the score function

$$Crack = \arg \max_{(n, p_1, \dots, p_n)} f(p_1, p_2, \dots, p_n)$$

- $p_i$ 's are coordinates of the pixels along the crack indication
- The dynamic-programming-based algorithm outperformed the other five crack segmentation methods for almost all test images (Kaul et al. 2010)



# A Linear Buffered Hausdorff Scoring Method



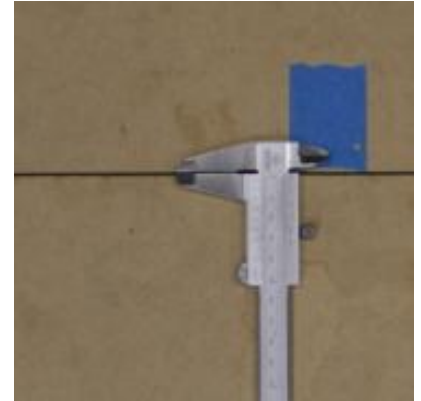
$$BH(A, B) = \max(h(A, B), h(B, A))$$

$$h(A, B) = \frac{1}{m} \sum_{a \in A} \min_{b \in B} \|a - b\|$$

$$\text{Scoring Measure(SM)} = 100 - \frac{BH(A, B)}{L} \times 100$$

# Experimental Test

- Laboratory tests
  - Simulated cracks with known widths
    - 1mm, 2mm, 3mm, and 5 mm
  - Daytime and night
- First field tests
  - Ten longitudinal cracks and one transverse crack
  - Daytime (no shadow), shadow, and night
- Second field tests
  - An actual crack with low intensity contrast to the surround pavement background



# Laboratory Test Result



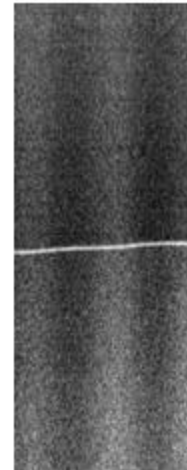
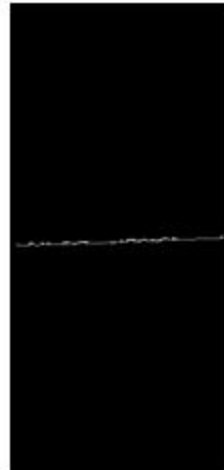
(a) 1mm (daytime)



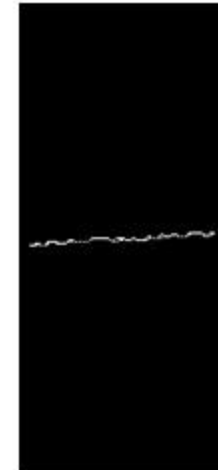
(b) 1mm (night)



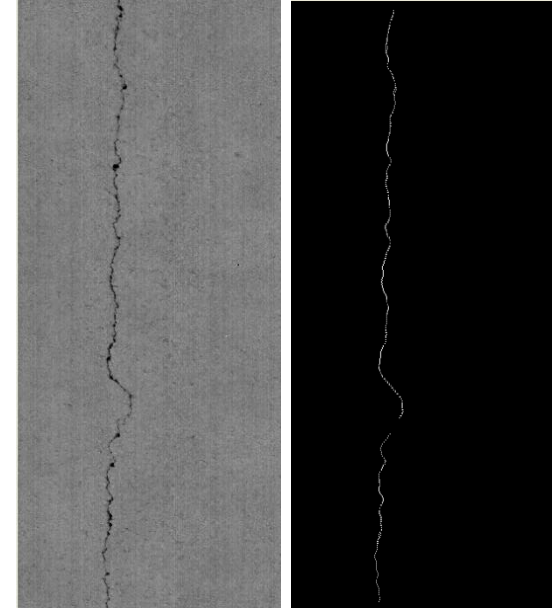
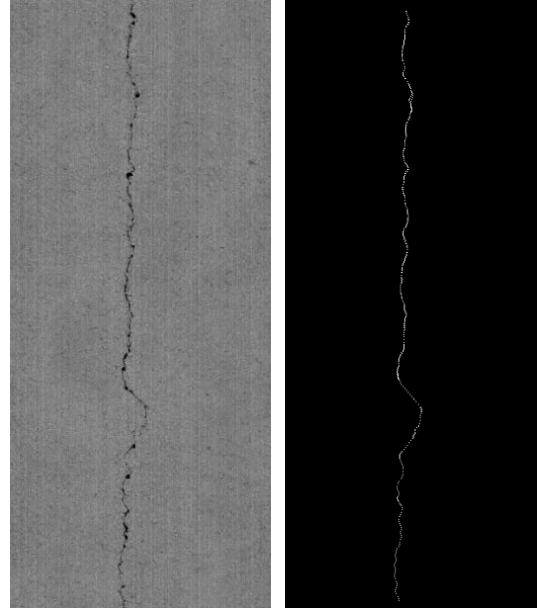
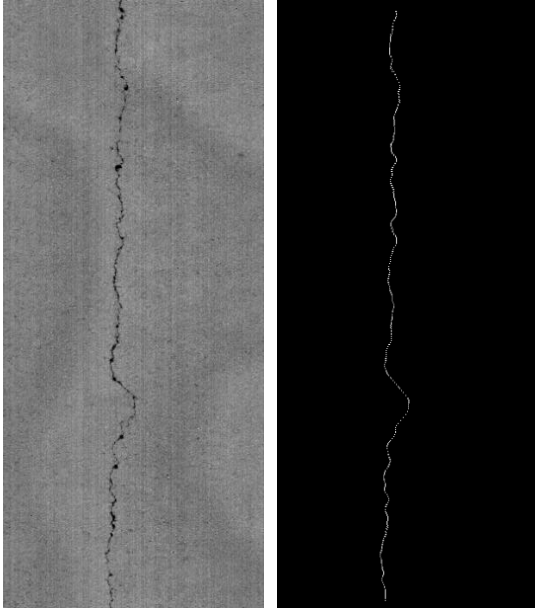
(c) 2mm (daytime)



(d) 2mm (night)



# First Field Test Results



Daytime (no shadow)

Shadow

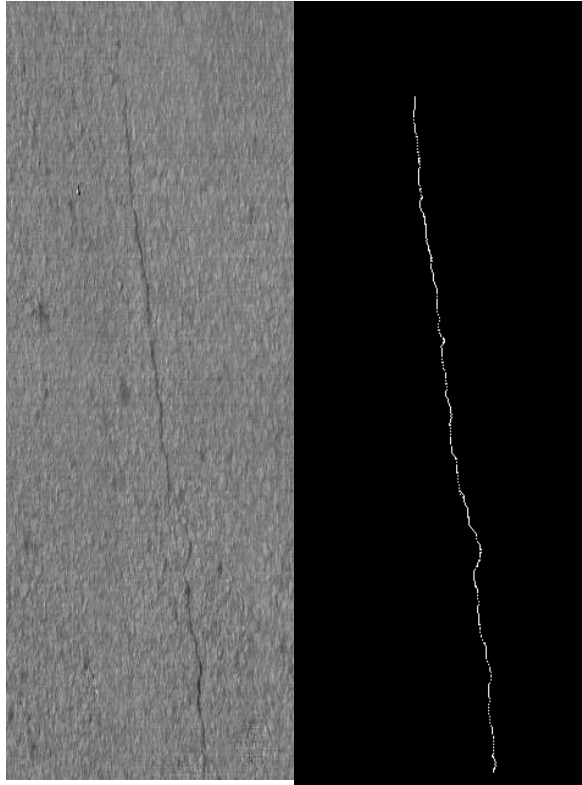
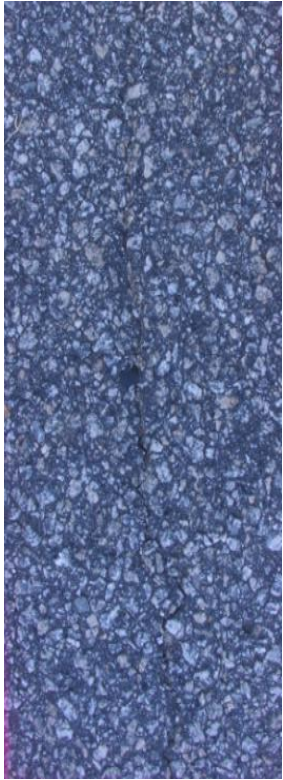
Night

# First Field Test Results (Cont'd)

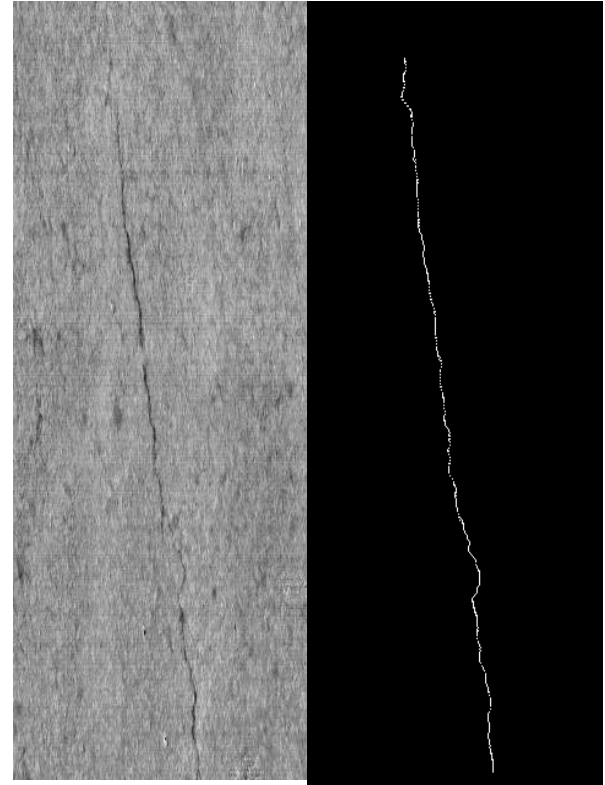
Crack Name	Score			Score Difference
	Daytime	Shadow	Night	
A	97.2	97.4	95.8	1.6
B	95.4	96.1	95.5	0.7
C	97.2	96.8	93.6	3.6
D	96.9	97.2	95.0	2.2
E	97.3	97.8	96.5	1.3
F	97.5	98.0	96.5	1.5
G	97.5	97.7	95.1	2.6
H	97.6	96.6	95.4	2.2
I	97.4	96.3	96.3	1.1
J	97.7	97.6	95.6	2.1
T	97.6	96.9	95.9	1.7

Average Score difference = 1.9

# Second Field Test Results



Daytime (score = 98.3)



Night (score = 98.0)

# Conclusions

- The proposed system can work consistently under different lighting conditions with the average score difference less than 2 (out of 100).
- The proposed system can potentially detect the cracks under poor intensity contrast conditions.
- Cracks with the width equal to and greater than 2mm can be segmented well from the pavement background, and the 1mm crack can be partially segmented.
- In summary, the proposed 3D laser technology is a promising technology for crack detection.

# Recommendations

- A comprehensive test with a large data set, including different asphalt pavement surfaces (i.e. dense graded, open graded pavement, chip seal, and etc.) and different roadway conditions, including oil stains and patches, is recommended.
- Study the optimal 3D sensing system configurations, including the parameters, such as tilt angle (it is 12 degree counter-clockwise), range parameters that might potentially impact the 3D pavement surface data quality and will impact the crack detection capability.



**Thank you**