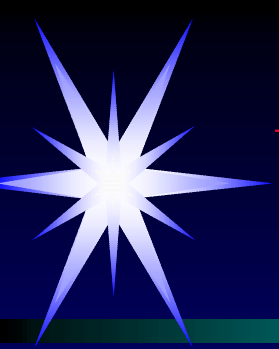


Automated Survey of Pavement Surface Distresses

Kelvin Wang
University of Arkansas

June 25 2002



New Frontier

- Automated Distress Data Collection & Analysis
 - MBTC and AHTD Support
 - UA System: the Only Such System at the Achieved Performance Levels
 - A Number of Test Sections

System Design

Camera Head

1300 x 1024, or
2048 x 1024
Gray-Scale

GPS Receiver



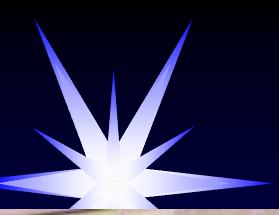
1300 x 1024 Color
Video Camera

Roughness &
Rutting Bar

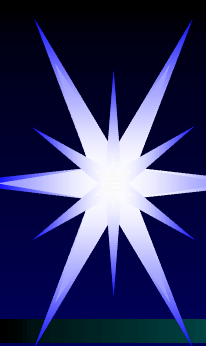
Traveling
Direction

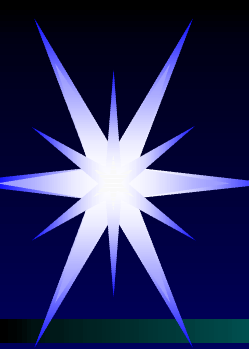
DMI

Computers, RAID
Storage, Image
Compression &
Processing Systems



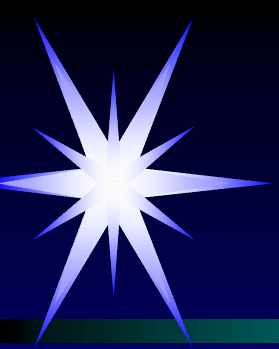
Telescoped Camera and Four Strobe Lights





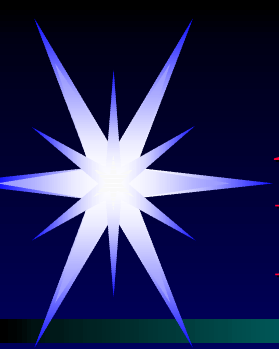
Pavement Surface Imaging

- Digital Frame Camera, Two Options
 - 2/3-in Charged Couple Device (CCD), 12 F/S, 1300 x 1024, 8-bit
 - 1-in CCD, 8-15 F/S, 2k x 1k, 8-bit
- Coverage: 100% Pavement Surface
- Lane-Width: 14-ft, or adjustable
- Strobe Lights: Synchronized Illumination
- Streaming & Compressing
 - 12 frames/second into Computer Storage & Database at Real-Time
- Data Collection Speed: at any highway speed, up to 80 MPH



Data Collection Capability for Pavement Surface Images

- Width: 14-ft, Speed: 60 MPH
- Resolution Per Frame: 1300x1028, 8-bit
- For 1,000-mile Pavement Images
 - 250 KB per Image after compression
 - $0.25 \times 1000 \times 5280 / 10 = 132 \text{ GB}$
- Considering Redundant Storage for Images
 - Maximum 264 GB for 1000-mile Pavement
 - Maximum \$3,000 Cost of Disk Drives
 - Options for 6000 lane miles of data



Automated Survey of Pavement Distresses

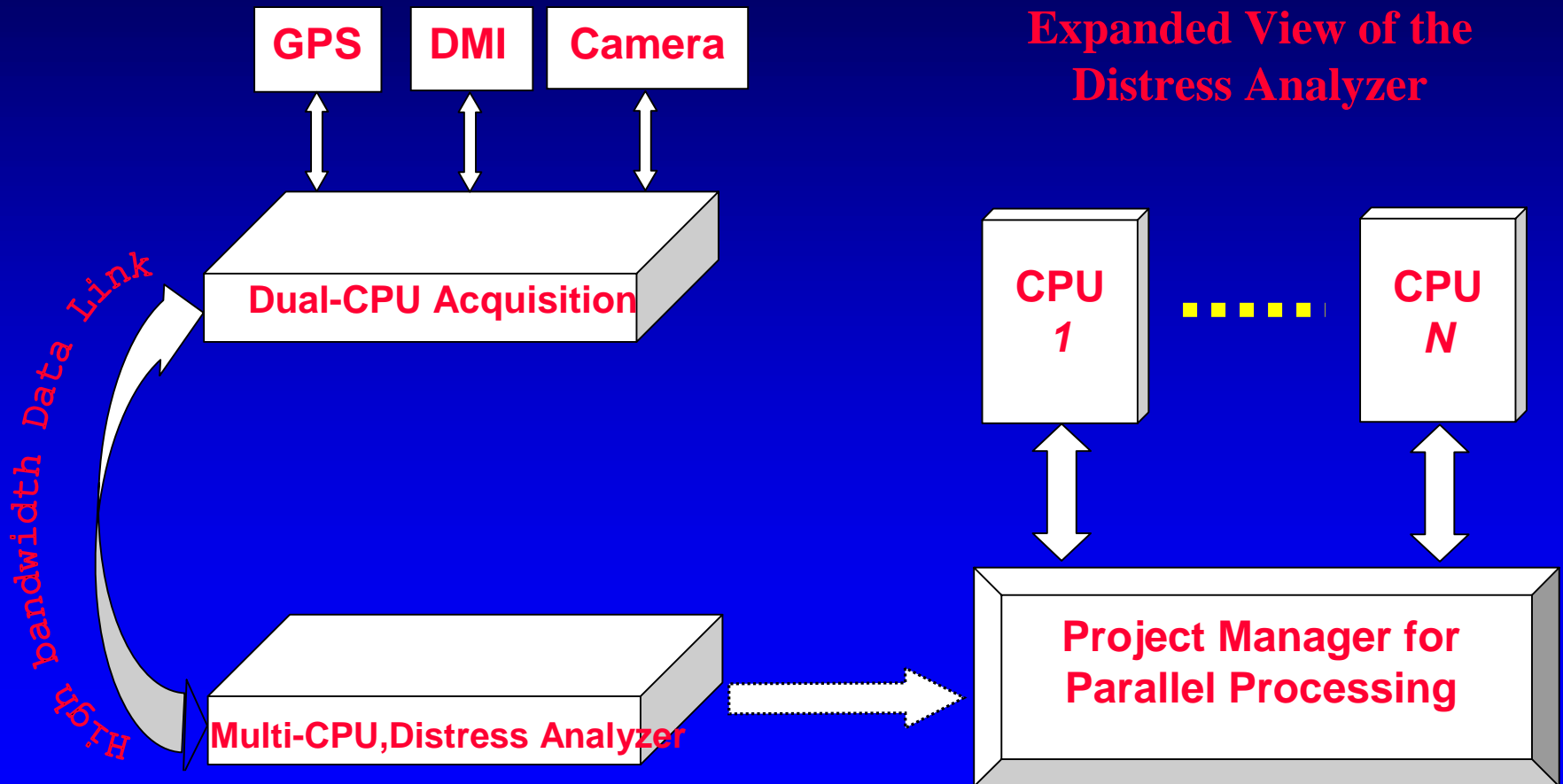
- Issues

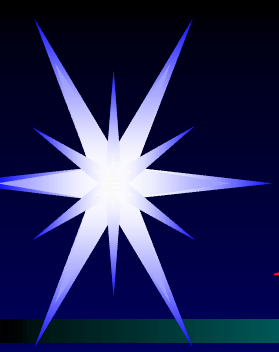
- High quality & high resolution digital images
- Algorithms for auto processing: accuracy & speed
- Establish distress protocols to be consistent with TN DOT requirements

- Our Approach

- Based on the digital data vehicle for collection
 - Speed
 - Accuracy
 - Real-time processing

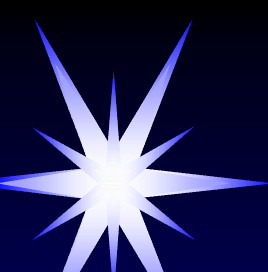
The Parallel Computing Approach





Sample Interface of the Distress Analyzer

Type	Barcode	Area	Direction	Location	Width	Depth
1	ELEVATION	30647156	3488	30407326 7617686	0.30	
2	TRANSVERSE	30647156	3041	3005692 34823486	0.30	
3	ELEVATION	30647156	3021	10062292 7614796	0.20	
4	TRANSVERSE	30647156	3788	30061196 37017636	0.50	
5	ELEVATION	30647156	3028	1001206 4362576	0.30	



Parallel Distress Analyzer

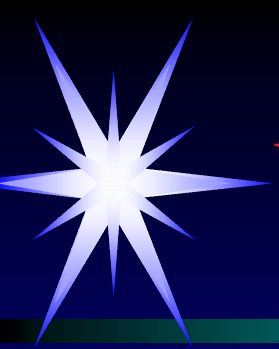
The software interface displays two side-by-side analysis windows. Each window contains a grayscale image of a pavement surface and a corresponding grid overlay with a red circle highlighting a specific area of interest. Below the images are data tables and control panels.

Type	BoundBox	Area	Dt	Location	Width	Field
1	LONGITUD	1794x12296	8880	90	004E1036113011241	3.77
2	LONGITUD	1334x91100	9560	90	02611261120011036	6.24

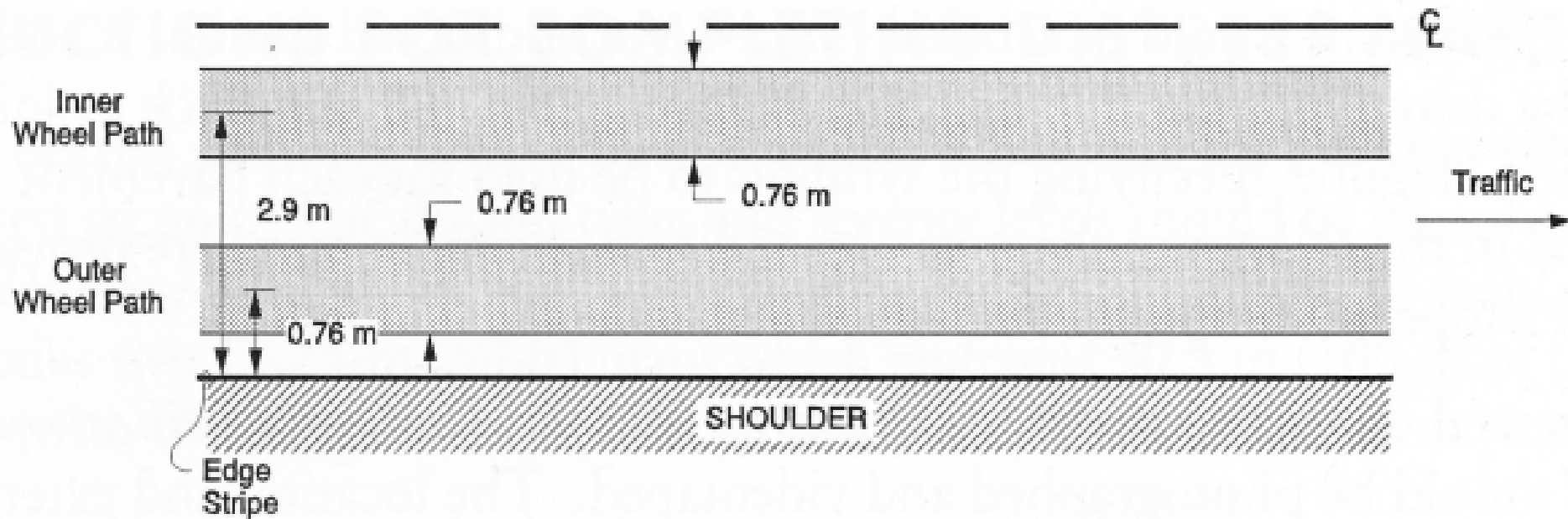
Type	BoundBox	Area	Dt	Location	Width	Field
3	TRANSVE	760x1029	8121	0	0010540113011221	5.54
4	LONGITUD	806x3361	2718	90	22012070130101301	4.17
5	LONGITUD	436x4150	1830	90	01016740125011150	4.07

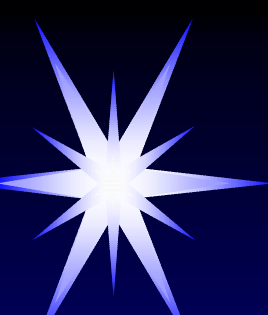
Type	BoundBox	Area	Dt	Location	Width	Field
1	LONGITUD	2736x12296	14817	90	02611261120112476	9.20
2	LONGITUD	806x11401	9130	90	01001124611001112	5.34

At the bottom of the interface, there are control panels for 'Speed' (14.0 mph) and 'Speed' (26.5 mph), along with 'Latitude' and 'Longitude' fields.



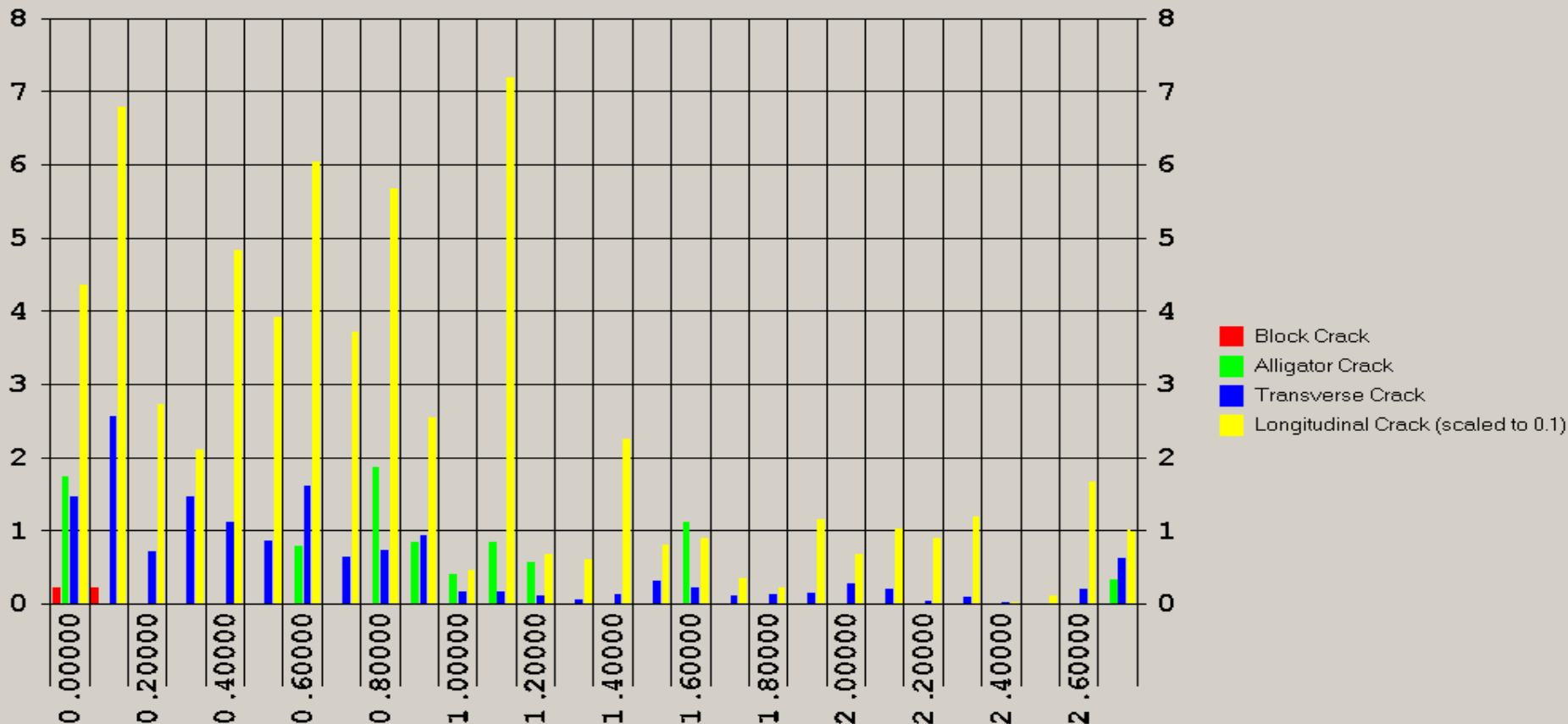
Wheel-Path Designations





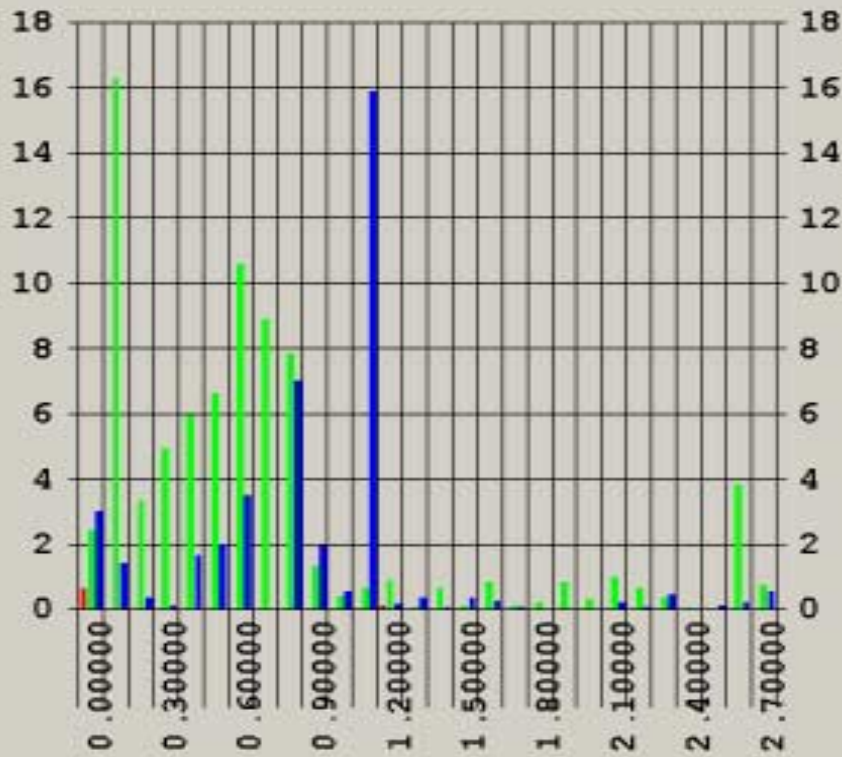
Data with Texas Method, 2.8-Mile

Crack Statistics in Texas Indices



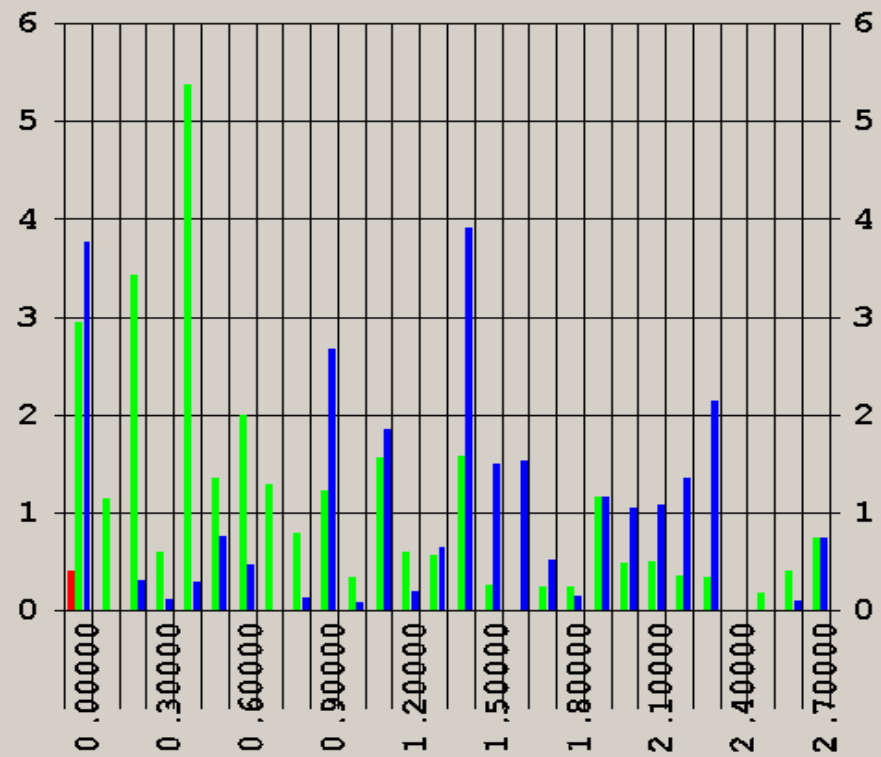
Data with AASHTO Interim Protocol, 2.8-Mile

Non-wheel Path Crack Statistics in AASHTO Indices

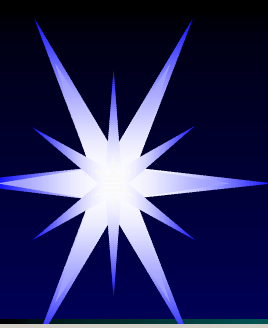


■ Severity Level 1 Crack Intensity ■ Severity Level 3 Crack Intensity
■ Severity Level 2 Crack Intensity

Wheel Path Crack Statistics in AASHTO Indices

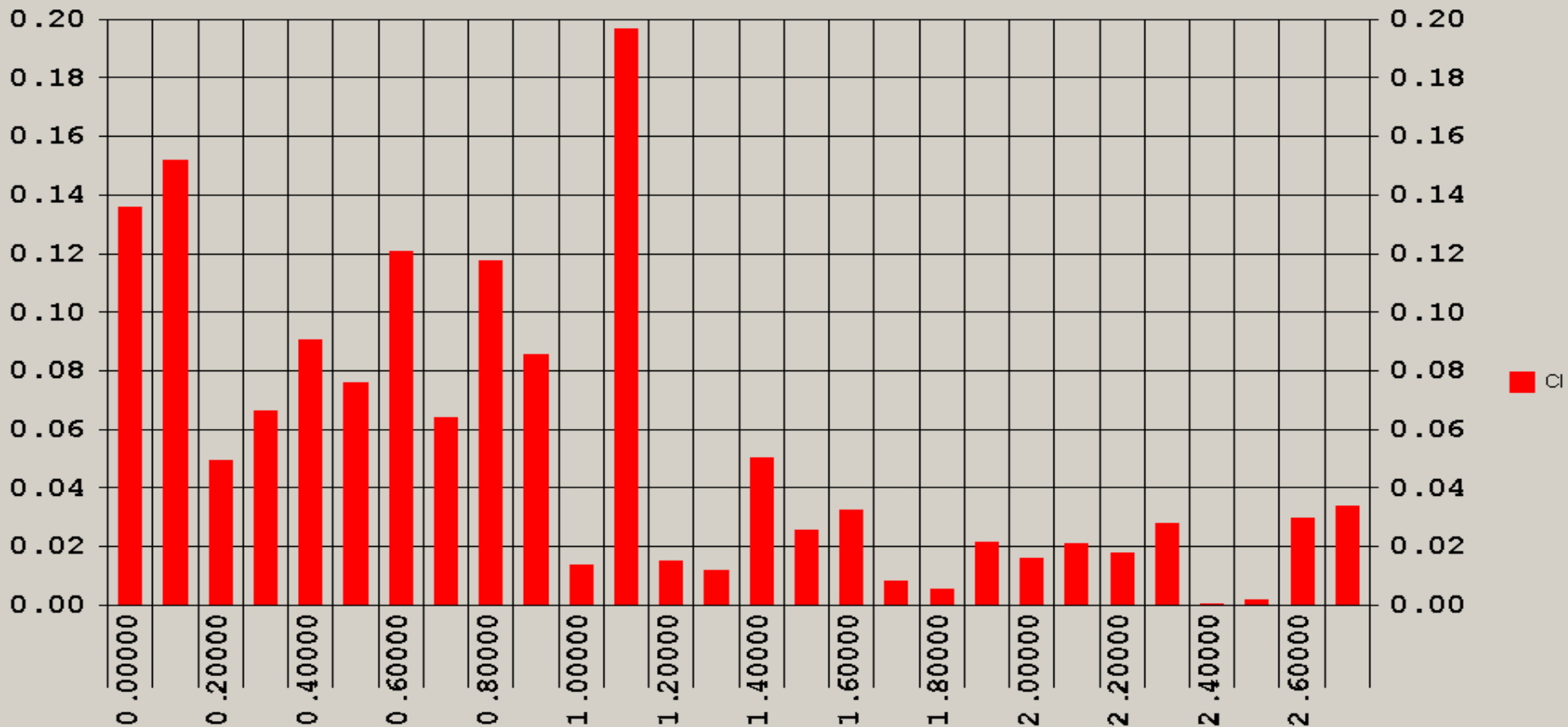


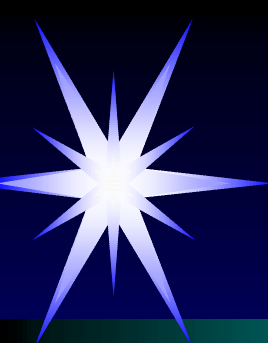
■ Severity Level 1 Crack Intensity ■ Severity Level 3 Crack Intensity
■ Severity Level 2 Crack Intensity



Data Using Universal Crack Indicator (CI), 2.8-Mile

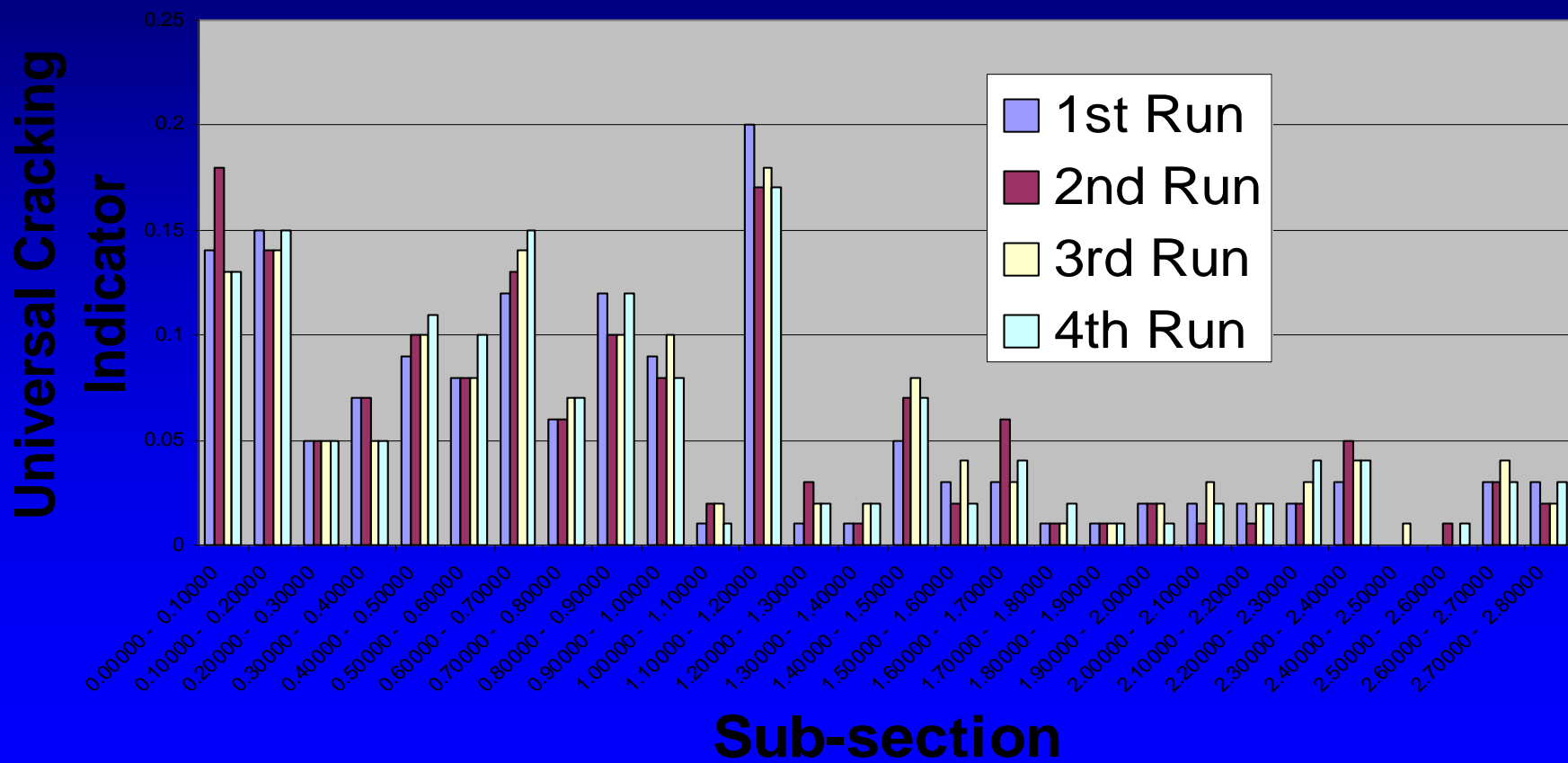
Crack Statistics Using Universal Cracking Indicator

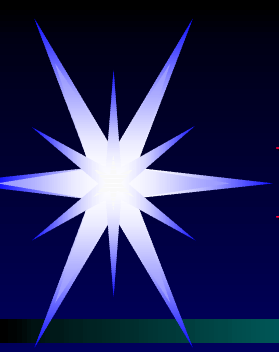




Four-Pass Test with Universal Crack Indicator (CI), 2.8-Mile

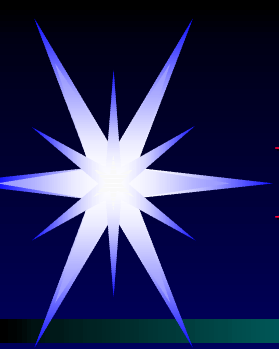
Repeatability Test





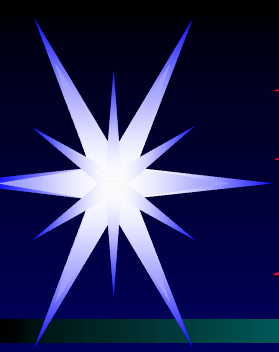
Importance of Image Quality

- Automated Processing Algorithms must minimize shadows
- Limitation of Digital Cameras CCD Sensors
 - Blooming of Bright Objects under Sunlight, such as striping, marking, and others
- Solution
 - Using Artificial Strobe Lights at Night or under Cloudy Weather



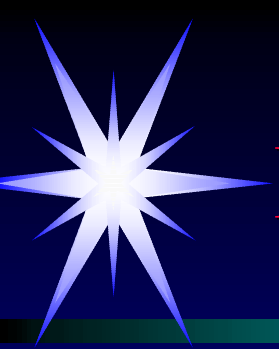
Data Compression & Reduction

- JPEG Compressed image:
 - Quality comparable to raw image's
- Automated image processing
 - Relying on the compressed images only
- Traveling speed
 - Dynamically adjust frame-rate in data collection
 - Stitch images into contiguous pavement surface



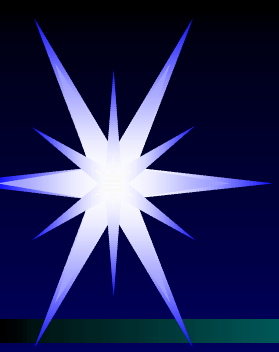
Performance of the Current Automated System

- Accuracy
 - Produce crack map and geometrics of nearly all cracks shown in images
 - Correctly classify vast majority of longitudinal, transverse, block, & alligator cracks
- Speed
 - Over 60 MPH with Two Hi-End Processors
 - Ready-to-Use Tabulated Distress Results upon the Completion of Data Collection (Real-Time Processing)

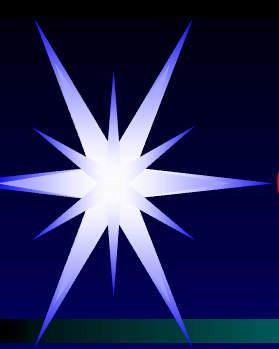


Future Work

- The NCHRP IDEA Project
 - Using Stereovision to model pavement surface in 3-D at 1 to 2-millimeter resolution
 - Potential to automatically provide ride (roughness), rutting, pothole, cracking, and other distress data.



Demonstrations



Conclusion

- Leader in Automated Survey of Pavement Distress in terms of Accuracy & Speed
- 3D Vision at 1 to 2-Millimeter Resolution for Comprehensive Pavement Survey