Potential for Comprehensive Evaluation of Pavement Surface with 3D Laser Imaging

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Problem Statement

- Manual Survey
  - High Cost, Inconsistent, Not Repeatable
  - Unknown/Unacceptable Precision & Bias
  - Result: Wastes & Frustrations
- Safety
  - How Surface Characteristics Impact Safety of Driving Public?

Needs of Quality Pavement Condition Data

- Design
  - New mechanistic oriented approaches rely on pavement cracking & rutting data for analysis
  - No reports of good cracking data in the US for design!
- Management
  - Pavement cracking: critical information for making rehabilitation decisions along with roughness, rutting, & Others

Pavement Surface Safety

- Characteristics
  - Surface Texture
  - Cross Slope
  - Rutting & Crowning
  - Super-elevation
  - Radius
  - Grades
- Data Collection: Different Devices/Passes, Limited Space (Line Instead of Area)

Support for New Technology

- Federal Highway Administration
  - Substantial Effort and Interest in Recent Years
  - Pavement Design, Management, and Safety
- Federal Aviation Administration
  - Largest Indoor Pavement Test Facility
  - Focused on Pavement Materials, &Management
- University of Arkansas & Oklahoma State University
- AR and OK Departments of Transportation
- Clients who Demand the State-of-Art Field-Deployable Technologies

The Team @ Universities/WayLink

- Work Started in the mid 1990's on Pavement Information Systems
  - Multimedia Databases
  - Pavement Management & Decision Systems
  - Field Deployment at Arkansas Highway Dept
- Distress Survey Research Started in the Late 1990's with Limited Funding
  - Digital Frame Cameras, Strobe Lights
  - Feasibility of Using Digital Line Cameras
  - Initial Automated Processing
  - PaveVision3D, from Sensor to Solutions

Opportunities for Fully Automated Cracking Survey

- Precision & Bias Issues
  - Results from Manual, Semi-Automated, & Automated Technologies with 2D Images
- Vast Improvements in Cost & Performance of Components in Lasers, Cameras, Computing, & Software Tools
- Therefore, Push for A New Way to Gather Data
  - Actual 3D Representation of Pavement Surface at 1mm Resolution

Data Collection

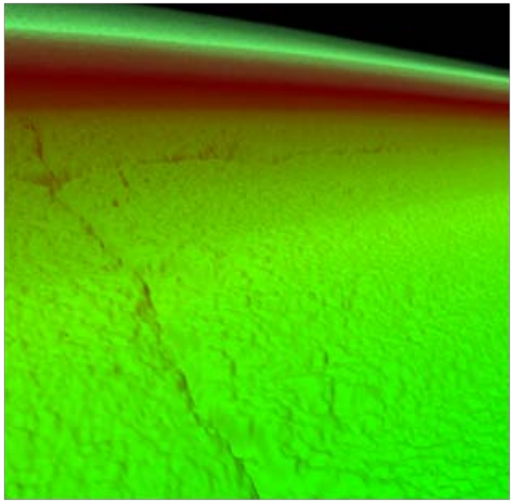
- A groundbreaking new technology to overcome many existing limitations, with the capability of obtaining 3D pavement surface models at true 1mm resolution with full-lane coverage & at highway speed (60MPH)
  - Current Available Technology Only Collects True 1mm Resolution 3D Pavement Data at 10-15MPH

Data Analysis

- Conducting real-time analysis on macro-texture, longitudinal and transverse profiles, the majority of surface distresses, and roadway geometric data
  - Single Vehicular Platform
  - Huge Cost Savings
  - Acceptable Levels of Precision & Bias for Field Deployment

Ultimate Goal

- Complete Virtual Pavement & Roadway Surface at 1mm Resolution & Software Solutions
- Spatial Accuracy of Collected Data via Remote Sensing Technologies
- Single Platform for Surface Data Analysis for Pavement Engineering, Research, & Beyond



Status of Pavement Survey: Roughness

- Transition from Response Type Device to Inertial Measurement Device
- Fully Automated with Measurable Precision & Bias based on Standards
- Limitations
  - Largely a Measurement of Single Lines in the Longitudinal Direction; Typically on Two Wheel Paths
  - Accuracy Issue at Low Speed, such as 25MPH or Lower

Status of Pavement Survey: Rutting

- Fully Automated with Point Laser Rangers
- Recent Implementations of 1000 plus Points with 3D Laser Imaging
- Limitations
  - Largely a Single Functional Device

Status of Pavement Survey: Texture

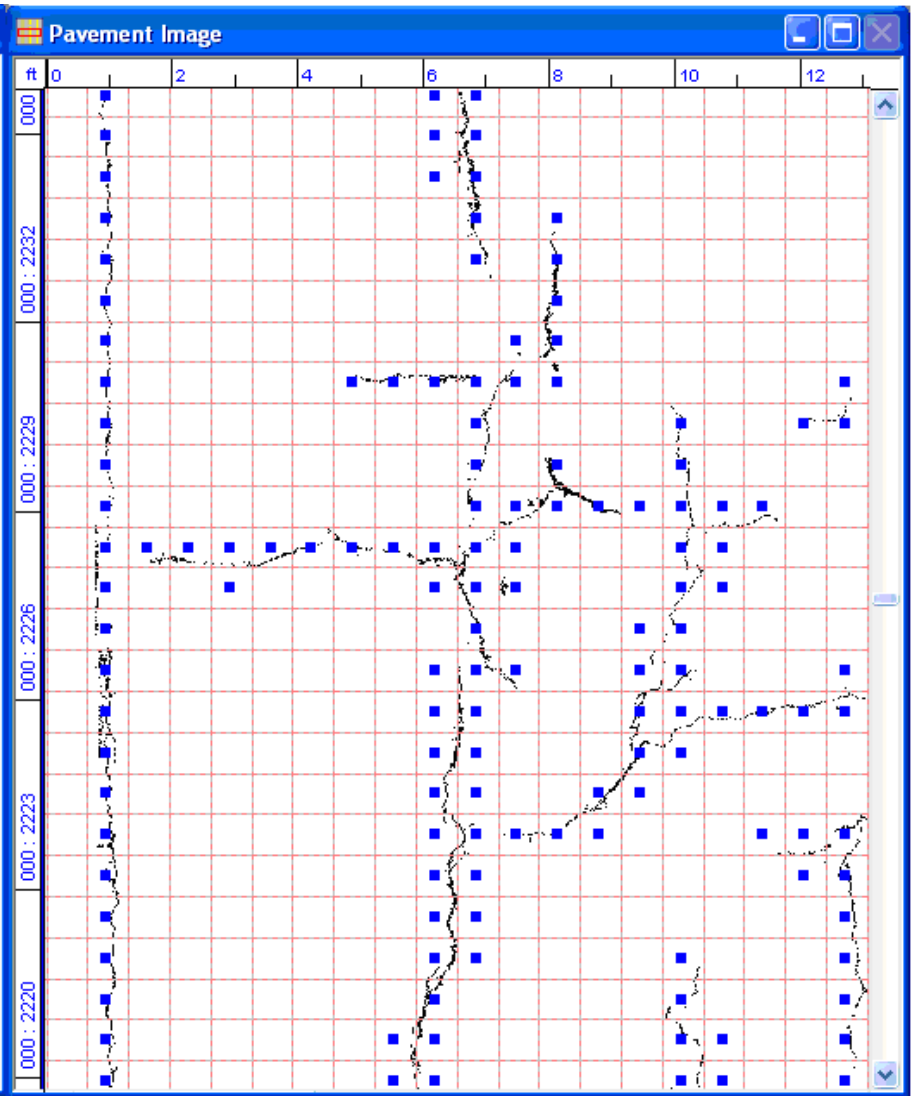
- Macro-Texture Measurement: Fully Automated with 64KHz Laser Ranger
- With Measurable Precision & Bias based on Standards
- Limitations
  - Point Laser Forming A Single Line on Pavement Surface
  - A Single Functional Device

Status of Pavement Survey: Cracking

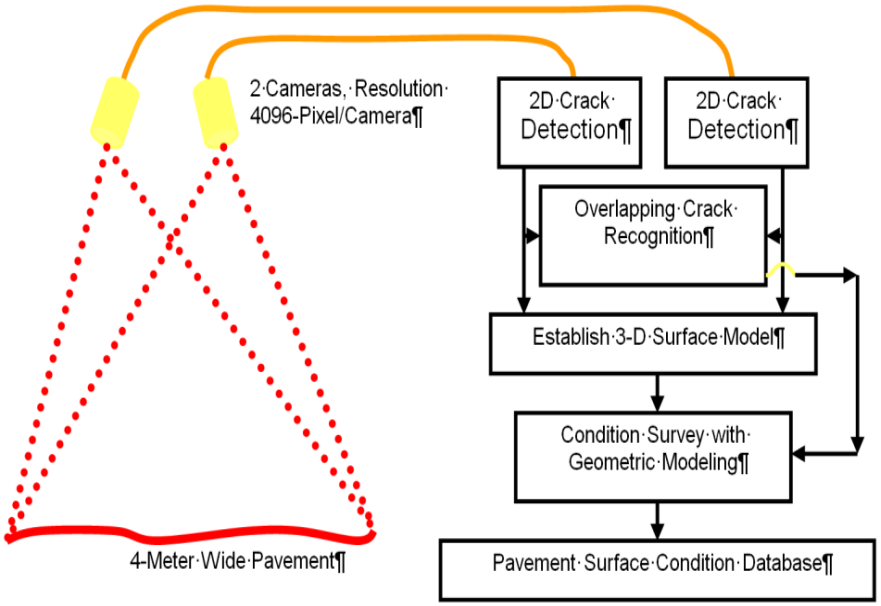
- 2D Laser Imaging for Data Collection at 1mm Resolution
- Most Users: No Automation for Processing;
- Limitations with Full Automation
  - Unknown Precision & Bias
  - Difficulty on Open-Graded or Chip-Seal Surfaces
  - Hitting a Wall in Further Improving Algorithms based on 2D Information

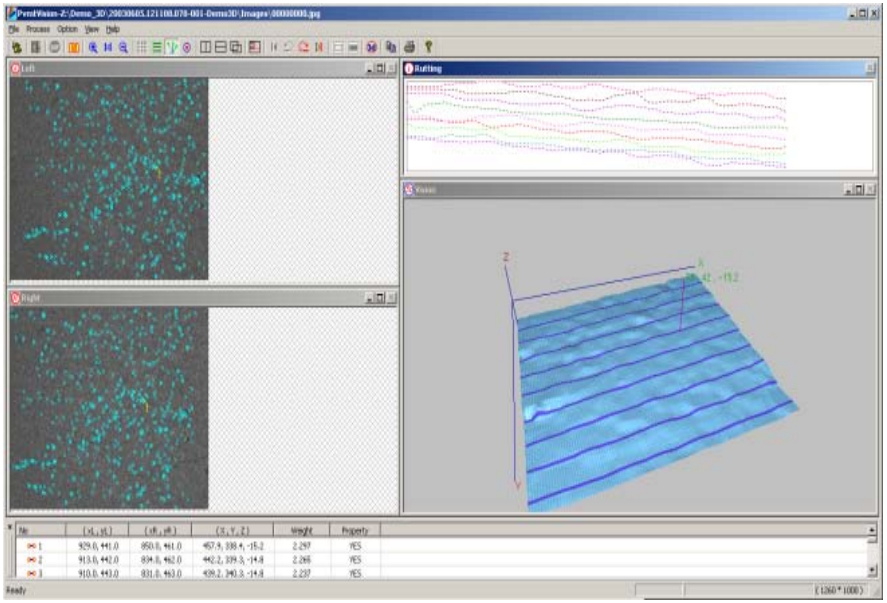
Workstation for Post-Processing

Grid based SCANNER Method



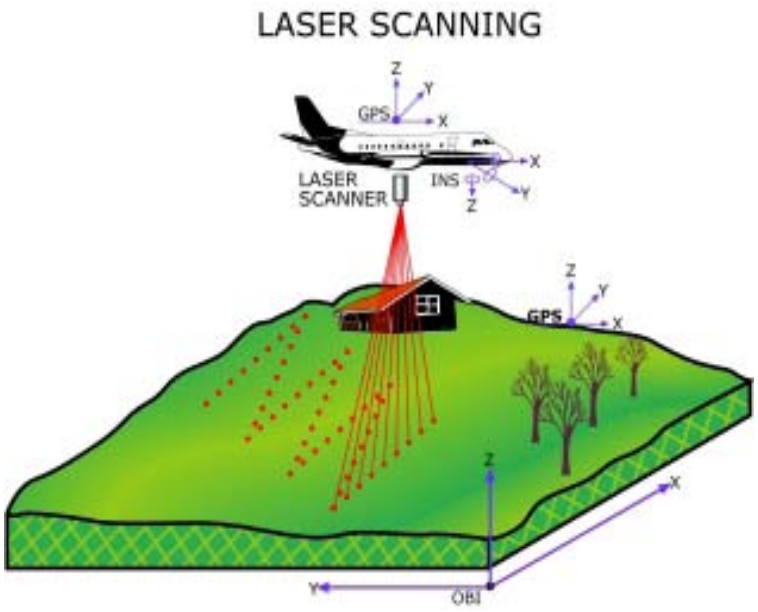
NCHRP-88: "Automated Pavement Distress Survey through Stereovision"

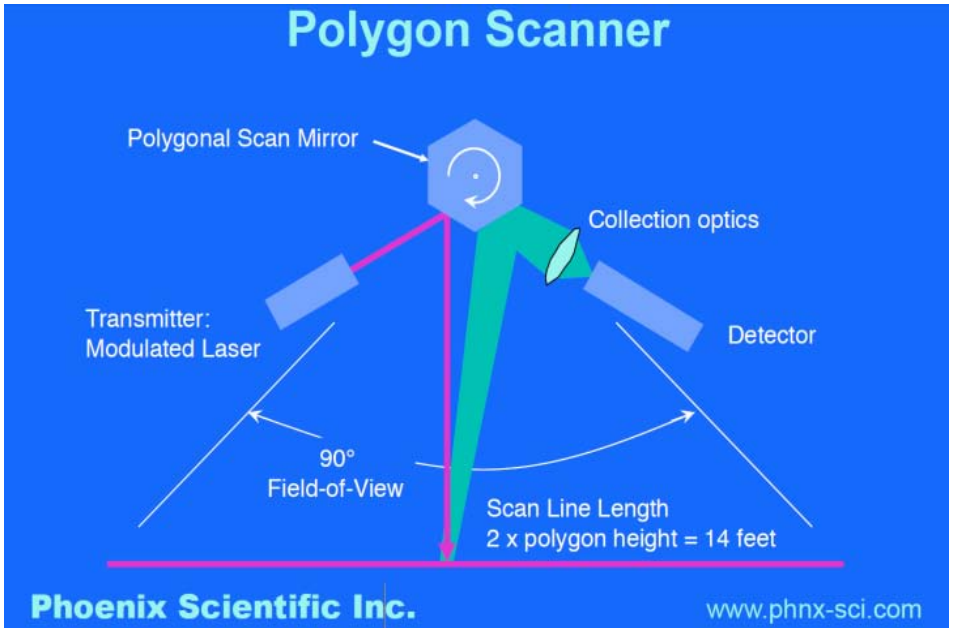




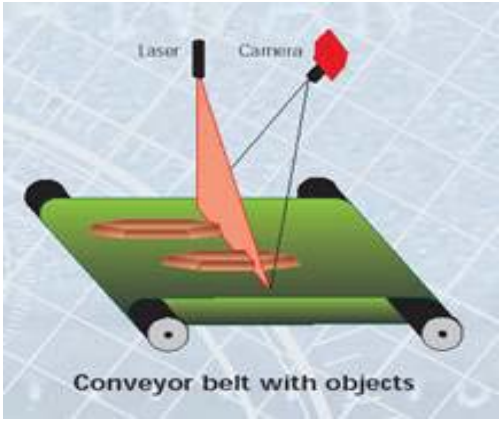
U of Arkansas Team: mid-2000

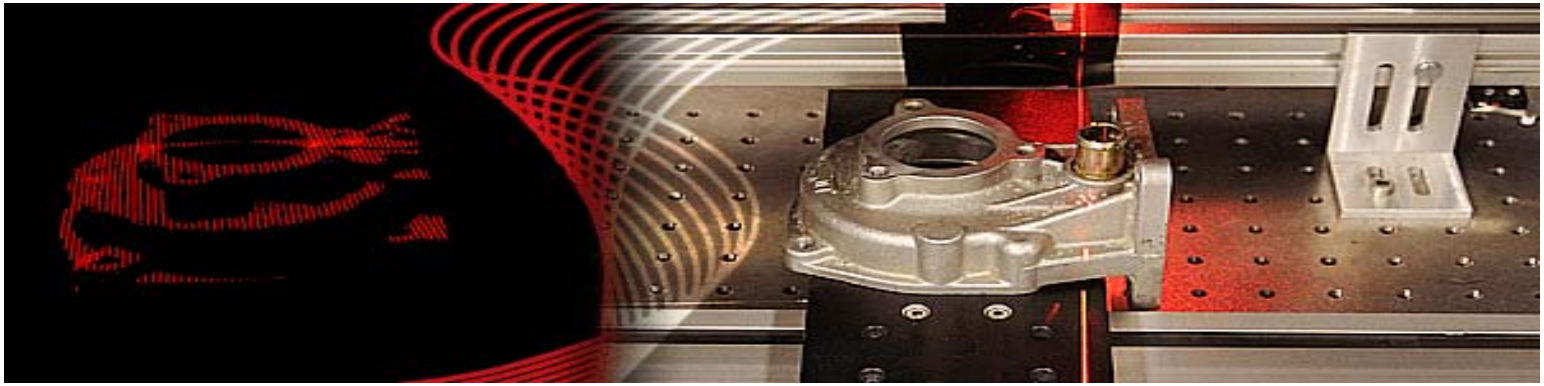
LIDAR & Its Derivative for Pavement Survey





Laser Line based 3D Imaging Technique on a Conveyer Belt



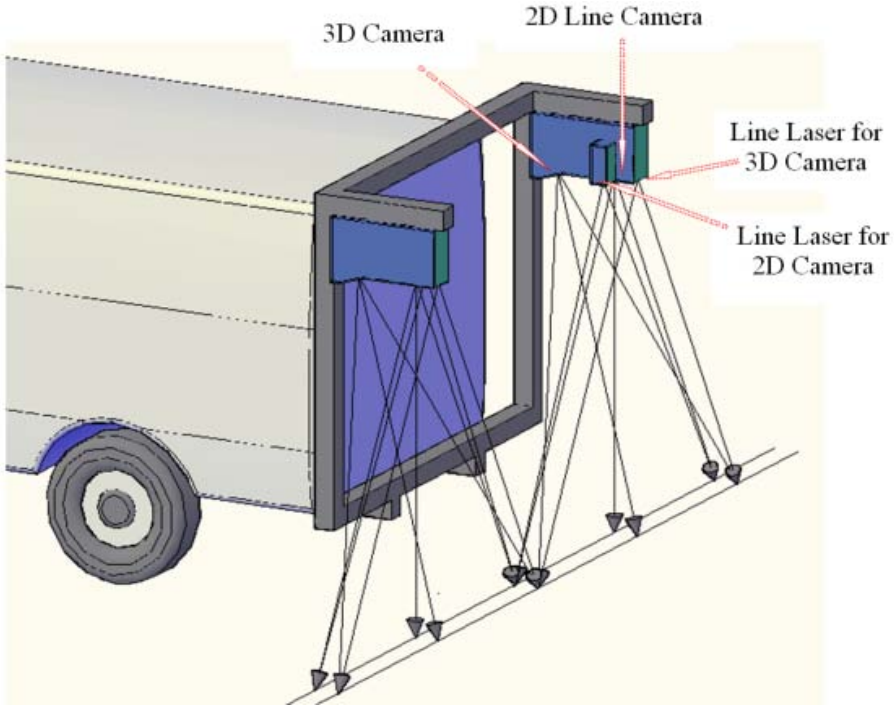


http://www.adept.net.au/news/newsletter/200810-oct/3D_Camera.shtml

Basis for Using the Laser Line based 3D Imaging for the Proposed Research

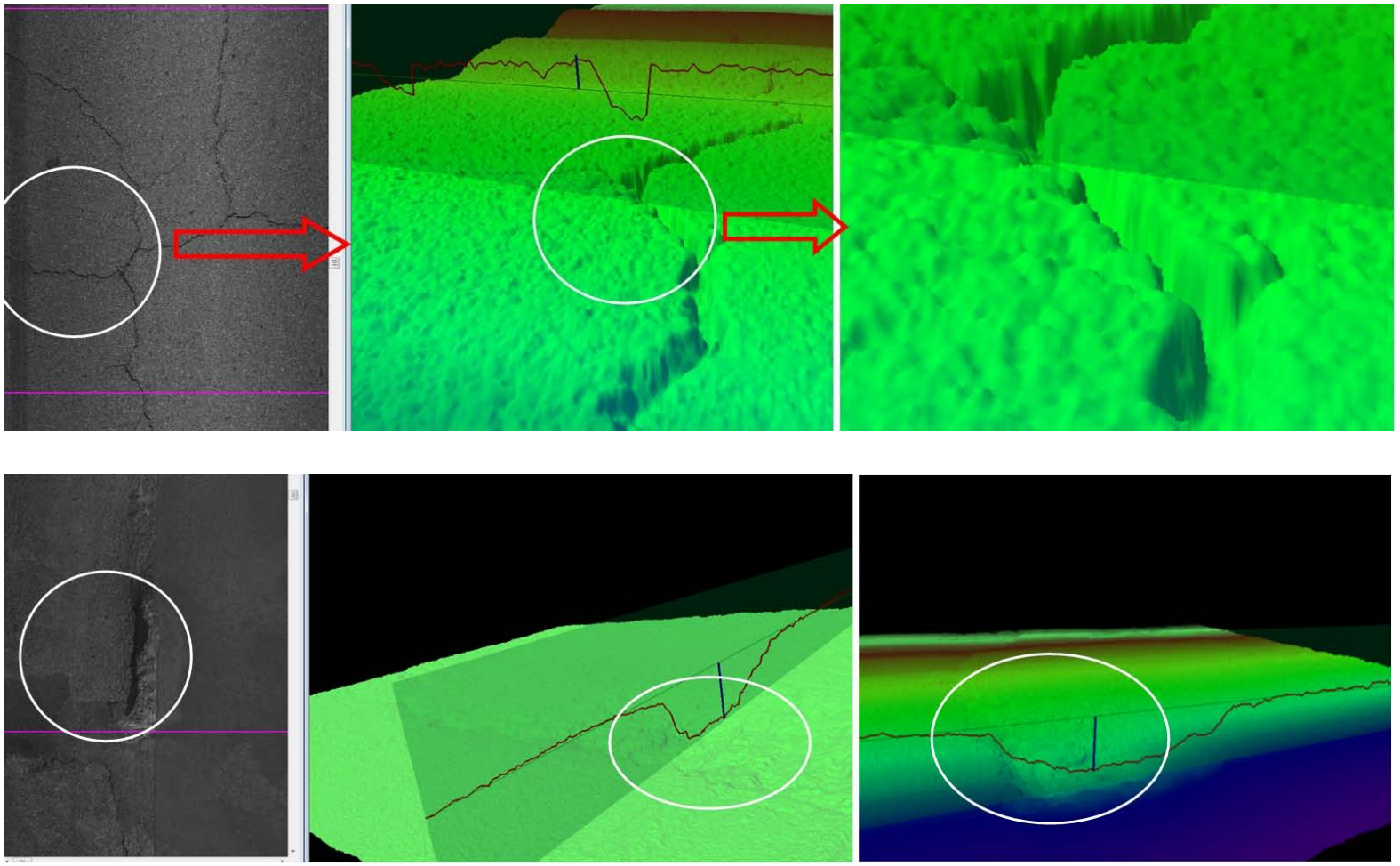
- Unrealistic Illumination Requirement for Stereovision based Principle
- Struggling of the Technology based on LIDAR due to Resolution & Accuracy Issues
- Prototyping Laser Line 3D System by the Team: Positive!

Sensor Design & Prototyping



Sensor Illustrations

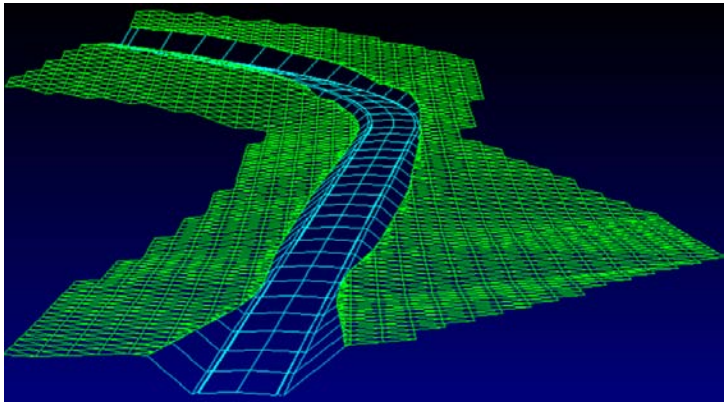
Collected 3D Sample Images with the Prototyping System

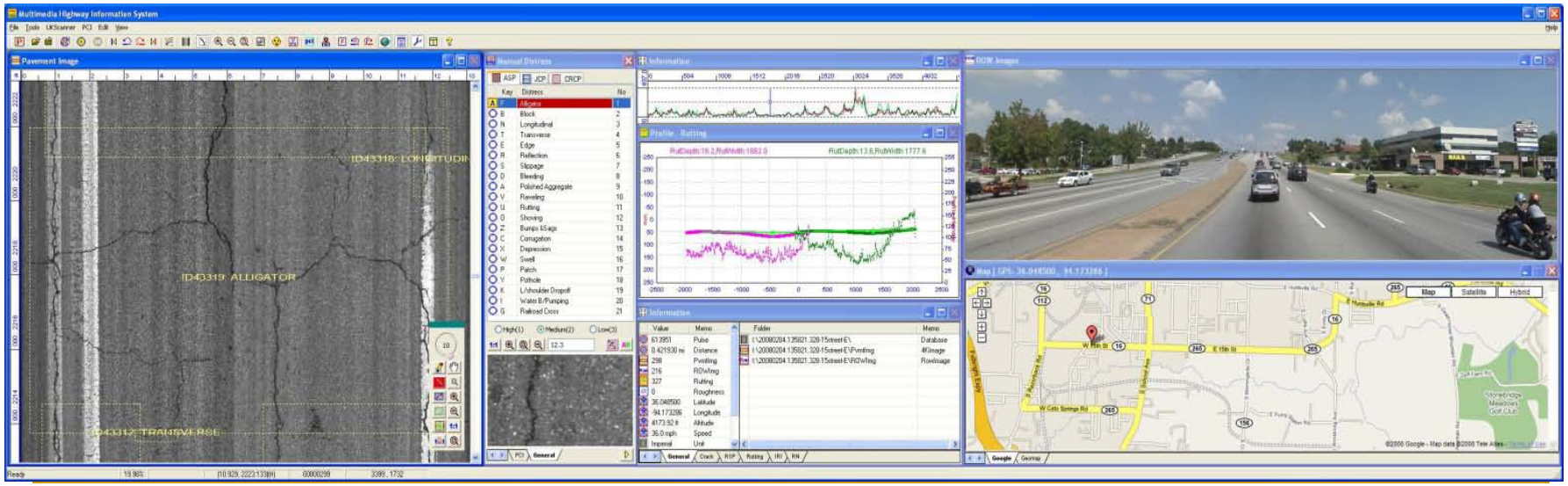


Spatial Positioning Data with Remote Sensing

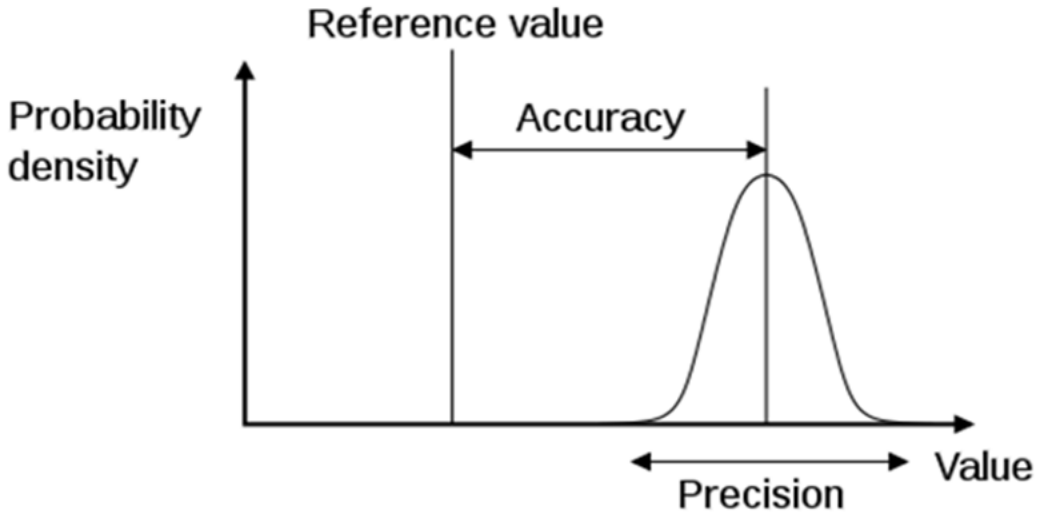
- GPS Receiver
- DMI Linear Referencing
- Inertial Measurement Instrument (IMU)
  - Key to availability of positioning data at all times, such as during GPS outages
  - Critical for Building Virtual Pavement

Remote-Sensing based 1mm 3D Pavement Surface in GIS & Databases





Precision & Bias Concept



Good accuracy, Low precision

High precision, Low accuracy

- Variability: Unevenness, Changeability
- Precision and Accuracy
- Reference Value and Probability

Video Demos