Session 52

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FDOT

Mobile Retroreflectivity Testing for a Pavement Marking Management System

Topic Description

Research update on the implementation of a pavement marking Management system using a mobile retroreflectivity unit (MRU).

Speaker Biography

Masters of Engineering degree from the University of Florida. Worked for FDOT for over 6 years. Currently working as a Pavement Performance Engineer in the Nondestructive Testing Unit. Specificializing with friction falling weight deflectometer, and ground penetrating radar testing.

Mobile Retroreflectivity Testing for a Pavement Marking Management System

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Research Effort

- UNF Researchers: Dr. Jim Fletcher and Aaron Philpott
- Research Goals:
  - ✓ Implementation of a Pavement Marking Management System (PMMS).
  - ✓ Document previous pavement striping literature review techniques.
  - ✓ Document limitations with existing technology and recommend/implement upgrades.
  - ✓ Establish operating procedures, guidelines, and data base applications.

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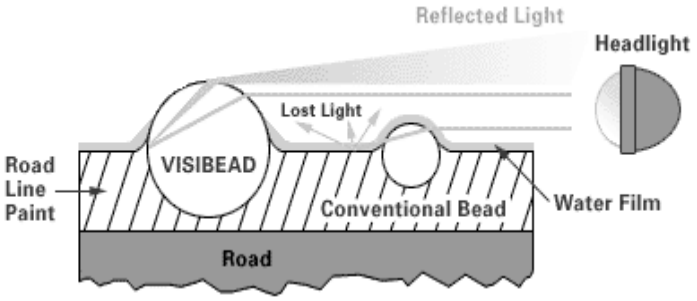
What is Retroreflectivity?

- The reflection of light off a target back in the direction from which it came, for a wide range of angles of incidence.



http://www.pottersbeads.com/markets/highwaysafetyVisibead.asp

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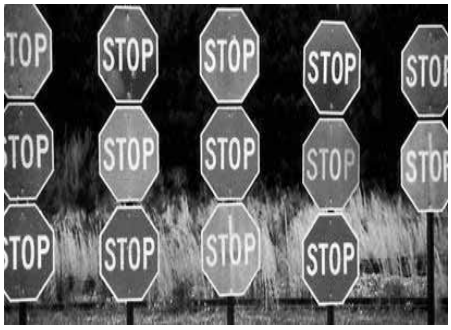
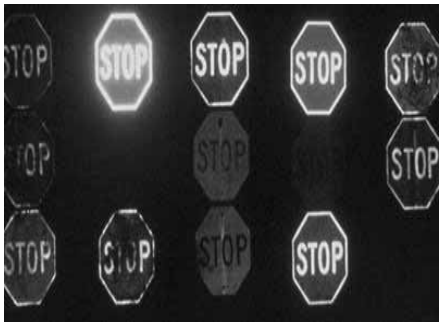
Can you tell the difference between the retroreflectivity of these signs?

How about now?





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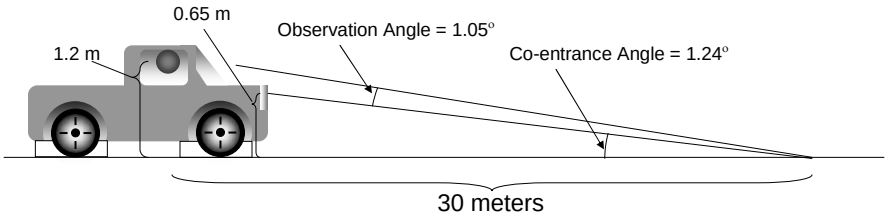
Line Stripe Retroreflectivity

- Standard based on FHWA recommendation and recognized as an international standard

Standard 30 meter geometry



- In order to measure retroreflectivity, several instruments maintain the 30 meter geometry but measure at a shorter distance

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Current Methods of Retroreflectivity Analysis

- Visual Nighttime Methods:
  - ✓ Visual inspection with a vehicle using low beam headlights at rated speed.
  - ✓ Compare against known test panels
- Measured Retroreflectivity Method:
  - ✓ Use ASTM Standard test with minimum levels of retroreflectivity based on state limits
  - ✓ Handheld Retroreflectometer typically used

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Issues with the Current Practice

- Visual Inspection:
  - ✓ How reflective is reflective enough?
    - Examiner bias
    - Variable illumination types and focus of headlamps
- Using Reflectometer:
  - ✓ Puts workers into oncoming traffic
  - ✓ Slow operation for long stretches of roadway
  - ✓ Point measurements of a line

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Mobile Retroreflectivity Unit (MRU)

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Potential Benefits of MRU

- Faster data collection
  - ✓ MRU can collect 1000+ data points per mile in less than a minute. Same amount of data points with handheld would take all day
- Little or no operator bias
- RL average based on many more data points than handheld
- Improved safety: Does not require MOT
- Possible to incorporate MRU data into Pavement Marking Management System (PMMS)

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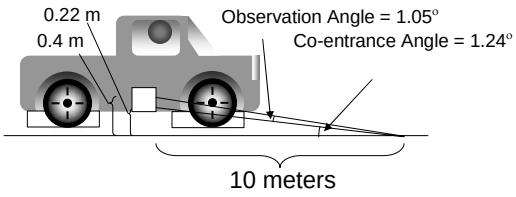
Mobile Retroreflectometer Unit (MRU)

1/3rd scale of 30 meter geometry (Used in Laserlux)



- Uses same method as handheld unit but on a mobile platform
- Performs 42” scan of the road to account for lane wandering
- Capable of many more measurements than possible with a handheld (1 scan every 5 feet at 60 mph)
- Can be used day or night

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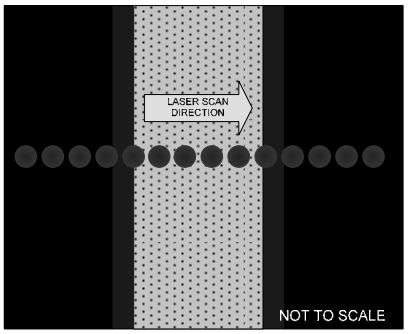
How MRU Works

- Incorporates laser with spinning mirror to scan 1.1m wide section of pavement
  - ✓ Scan width allows for some forgiveness in vehicle wander in lane
  - ✓ 200 discrete measurements are collected over 1.1m scan width, of which about 30 are on the stripe
  - ✓ 18-20 scans per second typical



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MRU Literature Review

- Literature review revealed some concerns about MRU unit
  - ✓ Many MRU owners stated the units to be very finicky and difficult to use
  - ✓ Some owners quit using them as too much time and effort was required to properly operate and analyze data
- Due to the potential upside and need for the technology, FDOT decided to pursue implementing the MRU
  - ✓ UNF was tasked with assessing/optimizing the equipment and supporting the development of an implementation plan

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System Sensitivities

- Internal Temperature of Unit
- Location of stripe within the 1.1 m scan width
- Measurement Response time
- Calibration Methods and Procedures
- Range of Retroreflectivity

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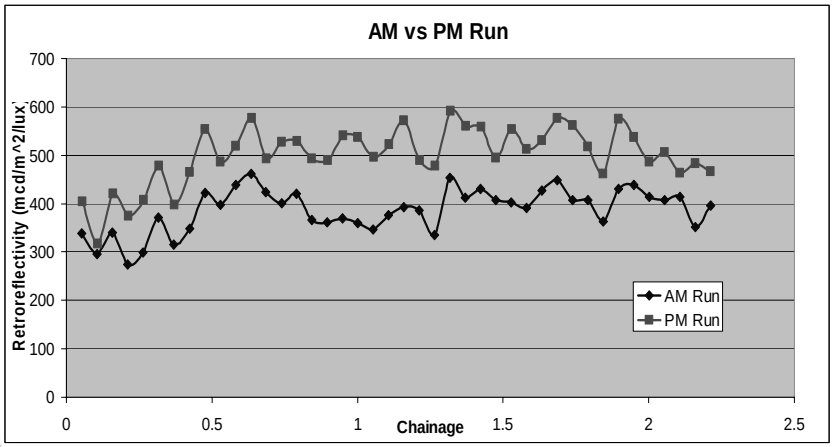
Internal Temperature of Unit

- While testing same section during AM and PM, the trends were similar but reported retroreflectivity values were different.



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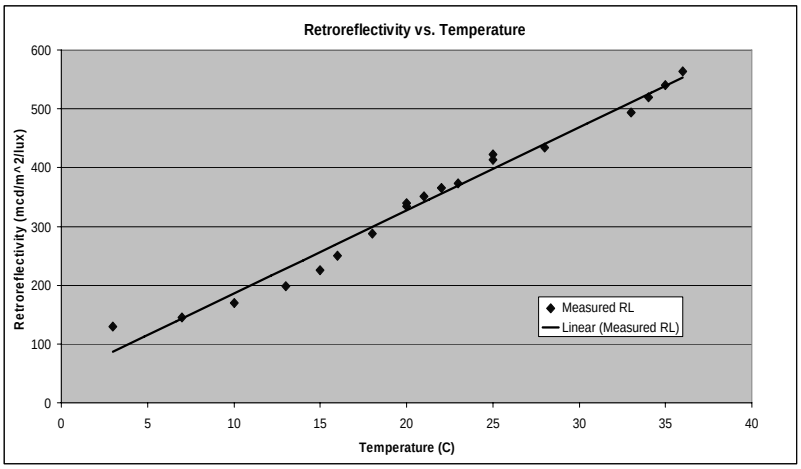
Temperature (cont.)

- Experimentation determined temperature had the following effect on retroreflectivity (same calibration stripe):



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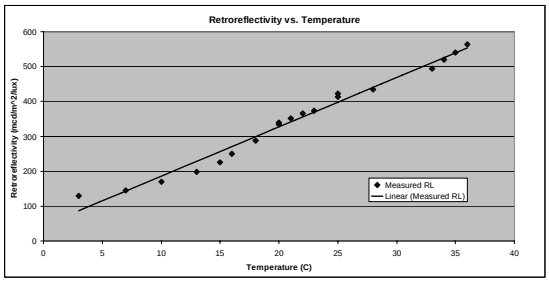
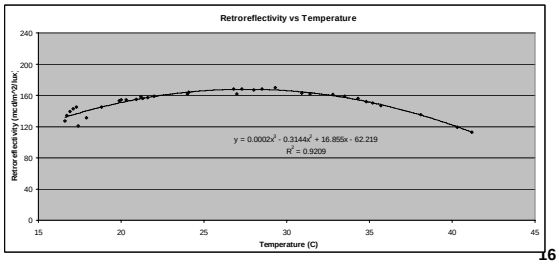
Temperature (cont.)

- Different units have different temperature sensitivities





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Source of Temperature Problem

- Data showed that temperature sensitivity rested with interference filters which transmit laser line but block stray, unwanted light (i.e. headlights).
- A change in temperature changes how much light is transmitted through the filter.
- Each filter has different response due to construction variability.

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Temperature Solutions

- Temperature Correction Algorithm
  - ✓ Incorporated temperature correction tables into software package. Each unit can be "tuned" to correct it's own response. Not a suitable solution alone.
- Cooling System
  - ✓ Added more robust thermoelectric cooler to unit to help stabilize internal temperature
- Custom Filters
  - ✓ Investigating new filter technology which is less sensitive to temperature than current ones

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Thermoelectric Cooling System

Original System

UNF Modified System w/ Cooler

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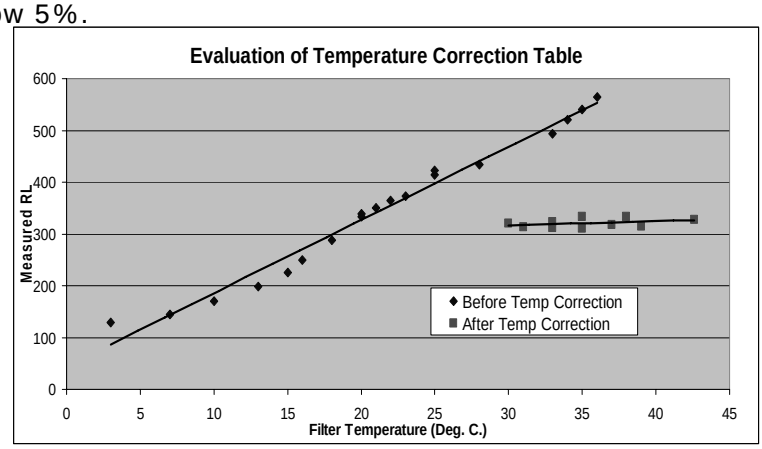
Effectiveness of Temp Correction

Temperature correction significantly reduced sensitivity, but not entirely. Maintaining a temperature stability to within +/- 3˚C combined with the correction tables should keep the sensitivity below 5%.



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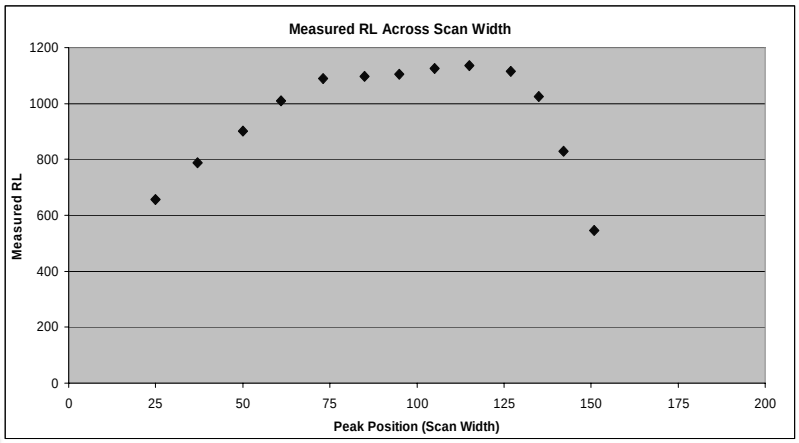
Scan Width Sensitivity

- System uses spinning mirror to scan 1.1 m distance (200 samples in ~5mm increments left to right) to allow for vehicle wander in lane. Measured retroreflectivity falls off sharply at edges of scan width.



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Scan Width Sensitivity

- Results showed that only about middle ½ of 1.1m width yielded near flat response.
- Incorporated programmable cutoff filters into software. Any data measured outside of “flat response” range is considered invalid and warning light flashes at operator (to make aware that he/she needs to move vehicle).
- More accurate data substituted for less forgiveness with approach

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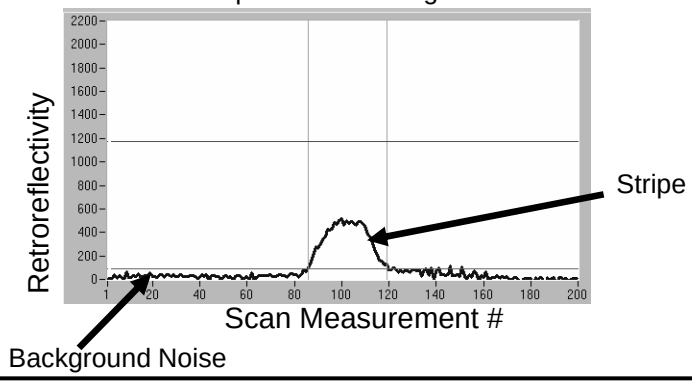
Photo-detector Response

- Photo-detector has a response time which causes a lag in measurements.
  - ✓ causes the stripe retroreflectivity profile to be a Gaussian curve rather than a square wave.
- Other causes of curve shape under investigation



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Response (cont.)

- Original calculation algorithm integrated area under the response curve to calculate retroreflectivity
- Approach caused systematically lower readings due to the response lag
- Changed algorithm to average N number of peak positions (user defined) to reduce influence of detector lag

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Calibration Requirements

- Calibration is required when:
  - ✓ Movement of unit from one side of vehicle to other
  - ✓ Color of line stripe changes
  - ✓ Background retroreflectivity changes (pavement type)
- Many users calibrate often (up to 30 times a day) to minimize system sensitivities

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Calibration Procedure Issues

- The manufacturer's calibration procedure required someone not performing testing to assist with setting instrument height (so that operator body weight does not disrupt geometry)
- Time consuming to find flat section of roadway for calibration in certain areas. (flat sections of roadway needed to ensure proper geometry is maintained)
- Calibration stripe not uniform and may not be same width as striping

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Solution to Calibration Issues

- Working with manufacturer to rework their calibration procedure to make it more practical
  - ✓ More uniform calibration standard that doesn't degrade over time (i.e. ceramic block at fixed geometry)
  - ✓ A calibration device which mounts on to the unit eliminating effects of road geometry
  - ✓ Displacement sensor and range finder so operator can ensure correct geometry
  - ✓ Calibration should be able to be performed by single operator

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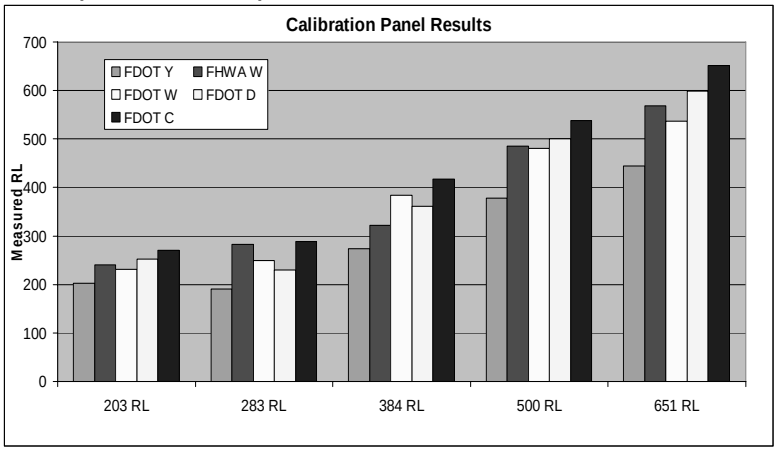
Retroreflectivity Range Error

- Determined that when the unit is calibrated to a standard with low value, results are systematically lower (vice-a-versa)



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Retroreflectivity Range Error

- Effect under investigation
- Initial study shows strong interaction with other effects such as photo-detector response time
- Critical to calibration standard

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Implementation

- In addition to assessing and resolving instrument issues, UNF also working with FDOT to put implementation procedures and strategies in place. These include:
  - ✓ Developing a comprehensive operations manual to serve as a training guide for operators
  - ✓ Drafting vendor acceptance protocol for contract service
  - ✓ Determining best way to implement data in Pavement Marking Management System

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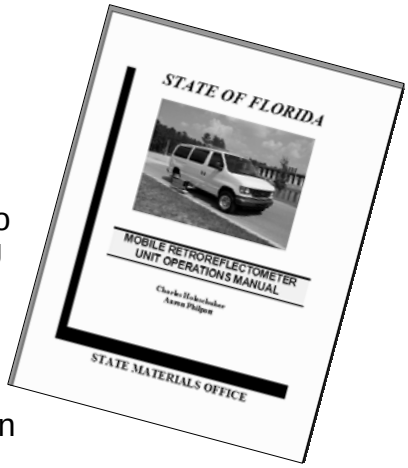
Operational Procedures

- Currently developing comprehensive operations manual
- Will cover everything needed to know to correctly operate MRU and process data
- To be finalized upon completion of system sensitivity testing



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MRU Vendor Acceptance Protocol

- FDOT plans to contract out data collection services. Due to known potential system issues, it is critical to verify the vendor capability to collect accurate data
  - ✓ Currently developing testing procedures to “qualify” MRU vendors to bid on state contracts for data collection
  - ✓ Vendor units will be tested and compared to FDOT unit.

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Implementing into PMMS

- Collecting retroreflectivity data is overwhelming without a system in place to manage it. Working to define how best to use the MRU to do the following tasks:
  - ✓ Perform an inventory assessment of the state of pavement markings in Florida
  - ✓ Develop degradation models to plan for restriping
  - ✓ Assess the performance of new striping materials
- All of those tasks are important to the final goal:

Determining the most efficient way to maximize road-user safety while minimizing cost

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Questions ???

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