Determining the Service Life of Traffic Signs in Florida: A review of the research challenges

Presented at the Modeling & Simulation Seminar Series
UCF College of Graduate Studies in partnership with the Institute for Simulation and Training
on October 16, 2015
by
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Why the Research?

1. Congress required the Federal Highway Administration (FHWA) to revise the Manual on Uniform Traffic Control Devices (MUTCD) to include:

   a) A standard for a minimum level of retroreflectivity for pavement markings and signs, which apply to all roads open to public travel

   b) Maintenance of sign retroreflectivity at or above minimum levels by using one or more of the following assessment methods:
      - Annual Night Time Visual Inspection
      - Annual Measurements of Retroreflectivity
      - Periodic Monitoring of Control Signs
      - Expected Sign Life
      - Blanket Replacement
      - Other engineering based method

   c) The goal of the new requirements is to improve safety on roads


2. FDOT has contracted UCF to develop a model to predict the service life of Florida road signs based on empirical data obtained from environmental conditions, sign materials and sign manufacturers variables
   - Dr. Amr A. Oloufa, Principal Investigator
   - Jose Gregorio, Graduate Research Assistant
   - Four Undergraduate Research Assistants for data collection

November 4, 2015
Safety on U.S. Roads
(Or lack thereof)

- Approximately 42,000 people have been killed on U.S. roads each year for the last eight years.

- Although a quarter of the travel occurs at night, about half of the traffic fatalities occur during night time hours
  - The night time fatality rate is approximately three times greater than that of day time.

- It is generally believed that maintaining the day time performance of traffic signs is more easily accomplished than maintaining the night time performance.

- The primary difference between day time and night time performance is a material property called retroreflection.

http://safety.fhwa.dot.gov/roadway_dept/night_visib/policy_guide/fhwahrt08026/chapter1.cfm
Factors affecting the service life of road signs

1. Environmental conditions
   - UV-radiation from the sun
   - Moisture
   - Heat
   - Other pollutants

   Our research focuses on environmental conditions

2. Vandalism and other physical damage
   - Paint ball shots
   - Gunshots
   - Spray paint
   - Accidents

   If observed, data collection will capture the type of damage
Why is Florida different that other States?

- Previous field studies performed by the Florida Department of Transportation (FDOT) outdoor testing facilities in South Florida indicate that signs in Florida deteriorate faster than signs from other states.

- Florida’s southernmost location, weather and other environmental conditions have been identified as potential factors affecting Florida’s signs.

What are the variables that need to be considered in building the predictive service life model for Florida road signs?

1. **Dependent Variable:** Age of Sign

2. **Independent quantitative variables**
   - Retroreflectivity
   - Chromaticity

3. **Independent qualitative variables**
   - Sign sheeting material types*; 4 types:  III, IV, VII, XI
   - Sign colors; 6 different colors*; blue, brown, green, red, white, yellow
   - Sign manufacturers*; 3 manufacturers: 3M, Avery Denninson, Nippon Carbide
   - Area in Florida; 3 areas: South, Central, North
   - Cardinal orientation; 4 orientations: N, S, E, W
   - Roadway location; 4 locations: rural, urban, inland, coastal

* Note: Not all manufacturers provide all material types and colors. Accordingly, there are 23 possible combinations of manufacturers, colors and sheeting material types.

According to FHWA there are no plans for including a maintenance requirement for chromaticity.
Indicating Sign Age

- Stickers on front or back of sign to show when fabricated or installed

![Sticker Examples](image-url)
• Retroreflectivity is important!

- Importance has increased
- Not a part of any educational curriculum
  - “OTJ” training
- Your agency now responsible
Three general ways that light is reflected:

- Matte or Diffuse Reflection
- Specular reflection
- Retroreflection
Retroreflectivity, what is it?

To meet the need for road signs to be bright at night to the driver, a special material with unique optical properties is used in manufacturing road signs.

This special material is referred to in the sign industry as “sheeting type”. It reflects almost all of the light striking the sign from the vehicle’s headlight, or any other source, directly back to the vehicle and contained in a very narrow cone of light. Spreading the cone of light out just enough to include the driver.

Retroreflection
Informal Definition

- A ratio of the amount of light returned from a sign versus the amount hitting the sign
- A way to measure the efficiency of a material

Cone of Retroreflection

U.S. Department of Transportation
Federal Highway Administration

November 4, 2015
Nighttime Driving

**Daytime**
- Many cues available
- Driver task relatively easy

**Nighttime**
- Few cues remain
- Task more difficult

Retroreflectivity provides nighttime guidance
7 different types of material used on these Stop signs
Can you see the sign?
Retroreflectivity

The specific measure of retroreflectivity is the coefficient of retroreflection abbreviated as Ra.

Ra is measured in units of “candelas per lux per square meter” (cd/lx/m²)

As a road sign ages, and is affected by environmental factors, it becomes less retroreflective and its effectiveness in communicating regulatory, warning and guidance messages to night time road users diminishes to the point that the sign cannot be seen in time for the driver to react properly.

To maintain night time effectiveness, signs must be replaced before they reach the end of their useful retroreflective life.

http://trid.trb.org/view.aspx?id=884217#

### 2014 Traffic Sign Retroreflective Sheeting Identification Guide

This document is intended to help identify sign sheeting materials for rigid signs and their common specification designations. It is not a qualified product list. FHWA does not endorse or approve sign sheeting materials. Many other sheeting materials not listed here are available for delineation and construction/work zone uses.

Many sign sheeting materials have watermarks and/or patterns that are used to identify the material type and manufacturer. The watermarks shown in this guide have been enhanced. The watermarks will be less visible in practice and may not be present on smaller pieces of sheeting due to the spacing.

#### Retroreflective Sheeting Materials Made with Glass Beads

<table>
<thead>
<tr>
<th>Example of Sheeting (Shown to scale)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ASTM D4956-04</strong></td>
<td>I</td>
<td>II</td>
<td>II</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>III</td>
</tr>
<tr>
<td><strong>ASTM D4956-13</strong></td>
<td>(1)</td>
<td>(1)</td>
<td>(1)</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td><strong>AASHTO M268-13</strong></td>
<td>Several companies</td>
<td>Aver Dennison®</td>
<td>Nippon Carbide</td>
<td>3M™</td>
<td>ATSM, Inc.</td>
<td>Aver Dennison®</td>
<td>Nippon Carbide</td>
<td>ORALFOL Americas Inc</td>
</tr>
<tr>
<td><strong>Brand Name</strong></td>
<td><strong>Engineer Grade</strong></td>
<td><strong>Super Engr Grade</strong></td>
<td><strong>Super Engr Grade</strong></td>
<td><strong>High Intensity</strong></td>
<td><strong>High Intensity</strong></td>
<td><strong>High Intensity</strong></td>
<td><strong>High Intensity</strong></td>
<td><strong>ORALITE® High Intensity</strong></td>
</tr>
<tr>
<td><strong>Series</strong></td>
<td>Several</td>
<td>T-2000</td>
<td>15000</td>
<td>2800</td>
<td>3800</td>
<td>ATSM HI</td>
<td>T-5500</td>
<td>N500</td>
</tr>
<tr>
<td><strong>NOTES:</strong></td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(9)</td>
<td>(3)</td>
<td>(4)</td>
<td>(9)</td>
<td>(4)</td>
</tr>
</tbody>
</table>

1. Sheeting material does not meet minimum AASHTO classification criteria.
2. Glass Bead Engineer Grade sheeting is uniform without any patterns or identifying marks.
3. Material no longer sold in the United States as of the date of this publication.
4. Section 2A.08 of the 2009 MUTCD (http://mutcd.fhwa.dot.gov) does not allow this sheeting type to be used for new legends on green signs.

- ASTM D4956-04 is referenced in Table 2A-3 of the 2009 MUTCD.
- ASTM D4956-13 is the most current ASTM sign sheeting specification (the 2013 version is designated by “-13”).
- AASHTO M268-13 is the most current AASHTO specification (the 2013 version is designated by “-13”).
FHWA Reflective Sheeting Identification Guide, made with Micro-Prisms

**2014 Traffic Sign Retroreflective Sheeting Identification Guide**

This document is intended to help identify sign sheeting materials for rigid signs and their common specification designations. It is not a qualified product list. FHWA does not endorse or approve sign sheeting materials. Many other sheeting materials not listed here are available for delineation and construction/work zone uses. Many sign sheeting materials have watermarks and/or patterns that are used to identify the material type and manufacturer. The watermarks shown in this guide have been enhanced. The watermarks will be less visible in practice and may not be present on smaller pieces of sheeting due to the spacing.

### Retroreflective Sheeting Materials Made with Micro-Prisms

<table>
<thead>
<tr>
<th>Example of Sheeting (Shown to scale)</th>
<th>D4956-04</th>
<th>D4956-13</th>
<th>M268-13</th>
<th>Manufacturer</th>
<th>Brand Name</th>
<th>Series</th>
<th>NOTES:</th>
</tr>
</thead>
<tbody>
<tr>
<td>(5)</td>
<td>I</td>
<td>I</td>
<td>B</td>
<td>3M™</td>
<td>EGP</td>
<td>3430</td>
<td>(8)</td>
</tr>
<tr>
<td>(5)</td>
<td>III, IV</td>
<td>III, IV</td>
<td>B</td>
<td>Avery Dennison®</td>
<td>PEG</td>
<td>T-2500</td>
<td>(8)</td>
</tr>
<tr>
<td>III, IV, X</td>
<td>III, IV</td>
<td>III, IV</td>
<td>B</td>
<td>Avery Dennison®</td>
<td>HIP</td>
<td>T-6500</td>
<td></td>
</tr>
<tr>
<td>(5)</td>
<td>III, IV</td>
<td>III, IV</td>
<td>B</td>
<td>3M™</td>
<td>HIP</td>
<td>3930</td>
<td></td>
</tr>
<tr>
<td>(5)</td>
<td>III, IV</td>
<td>III, IV</td>
<td>B</td>
<td>ORAFOL Americas Inc</td>
<td>CRG 94000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(5)</td>
<td>VIII</td>
<td>VIII</td>
<td>B</td>
<td>Nippon Carbide</td>
<td>CRG 92000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(5)</td>
<td>VIII</td>
<td>VIII</td>
<td>B</td>
<td>3M™</td>
<td>Reflective Sheeting</td>
<td>3940</td>
<td></td>
</tr>
</tbody>
</table>

### Example of Sheeting (Shown to scale)

<table>
<thead>
<tr>
<th>D4956-04</th>
<th>D4956-13</th>
<th>M268-13</th>
<th>Manufacturer</th>
<th>Brand Name</th>
<th>Series</th>
<th>NOTES:</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIII</td>
<td>VIII</td>
<td>VIII</td>
<td>3M™</td>
<td>MVP Prismatic</td>
<td>T-7500</td>
<td>(9)</td>
</tr>
<tr>
<td>VII, VIII, X</td>
<td>IX</td>
<td>IX</td>
<td>Avery Dennison®</td>
<td>Diamond Grade™ LDP</td>
<td>3970</td>
<td></td>
</tr>
<tr>
<td>IX</td>
<td>IX</td>
<td>IX</td>
<td>Avery Dennison®</td>
<td>Diamond Grade™ VIP</td>
<td>3990</td>
<td></td>
</tr>
<tr>
<td>(5)</td>
<td>(5)</td>
<td>(5)</td>
<td>(5)</td>
<td>Omniview™</td>
<td>T-9500</td>
<td>(9)</td>
</tr>
<tr>
<td>(5)</td>
<td>(5)</td>
<td>(5)</td>
<td>(5)</td>
<td>Crystal Grade</td>
<td>7900</td>
<td></td>
</tr>
<tr>
<td>(5)</td>
<td>(5)</td>
<td>(5)</td>
<td>(5)</td>
<td>ORALITE®</td>
<td>4000</td>
<td></td>
</tr>
<tr>
<td>(5)</td>
<td>(5)</td>
<td>(5)</td>
<td>(5)</td>
<td>Diamond Grade™ DG3</td>
<td>Omniview™</td>
<td>T-11500</td>
</tr>
</tbody>
</table>

5) Material was either unavailable in 2005 (previous version of this Guide) or unassigned in the 2004 version of ASTM D4956.
6) Sheeting material does not meet minimum AASHTO classification criteria.
7) Material has been discontinued prior to AASHTO M268-10.
8) Section 2A.08 of the 2009 MUTCD (http://mutcd.fhwa.dot.gov) does not allow this sheeting type to be used for new yellow or orange signs, or new legends on green signs.
9) Material no longer sold in the United States as of the date of this publication.

### Resources

- Texas A&M Transportation Institute – http://tti.tamu.edu/visibility
- ASTM – http://www.astm.org
- AASHTO – http://www.transportation.org

November 4, 2015
Why Create Minimums?

Daytime

Nighttime

U.S. Department of Transportation
Federal Highway Administration
# New MUTCD Table 2A.3
Minimum Maintained Retroreflectivity Levels

<table>
<thead>
<tr>
<th>Sign Color</th>
<th>Sheeting Type (ASTM D4956-04)</th>
<th>Additional Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Beaded Sheeting</td>
<td>Prismatic Sheeting</td>
</tr>
<tr>
<td></td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>White on Green</td>
<td>W*; G ≥ 7</td>
<td>W*; G ≥ 15</td>
</tr>
<tr>
<td></td>
<td>W*; G ≥ 7</td>
<td>W ≥ 120; G ≥ 15</td>
</tr>
<tr>
<td>Black on Yellow</td>
<td>Y*; O*</td>
<td>Y ≥ 50; O ≥ 50</td>
</tr>
<tr>
<td>or Black on Orange</td>
<td>Y*; O*</td>
<td>Y ≥ 75; O ≥ 75</td>
</tr>
<tr>
<td>White on Red</td>
<td>W ≥ 35; R ≥ 7</td>
<td></td>
</tr>
<tr>
<td>Black on White</td>
<td>W ≥ 50</td>
<td></td>
</tr>
</tbody>
</table>

1. The minimum maintained retroreflectivity levels shown in this table are in units of cd/lx/m² measured at an observation angle of 0.2° and an entrance angle of -4.0°.
2. For text and fine symbol signs measuring at least 1200 mm (48 in) and for all sizes of bold symbol signs.
3. For text and fine symbol signs measuring less than 1200 mm (48 in).
* This sheeting type should not be used for this color for this application.
TAPCO’s GR3 Retroreflectometer with Remote Control Extension Pole
Chromaticity

Graphs of the x and y coordinates of lights are called chromaticity diagrams. Chromaticity diagrams show two of the three dimensions of color, the third being luminance (held constant).
Chromaticity Specifications

TABLE 11 Color Specification Limits (Daytime)\(^A\)

<table>
<thead>
<tr>
<th>Color</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>x</td>
<td>y</td>
<td>x</td>
<td>y</td>
<td>x</td>
</tr>
<tr>
<td>White</td>
<td>0.303</td>
<td>0.300</td>
<td>0.368</td>
<td>0.366</td>
<td>0.340</td>
</tr>
<tr>
<td>Yellow</td>
<td>0.498</td>
<td>0.412</td>
<td>0.557</td>
<td>0.442</td>
<td>0.479</td>
</tr>
<tr>
<td>Orange</td>
<td>0.558</td>
<td>0.352</td>
<td>0.636</td>
<td>0.364</td>
<td>0.570</td>
</tr>
<tr>
<td>Green(^B)</td>
<td>0.026</td>
<td>0.399</td>
<td>0.166</td>
<td>0.364</td>
<td>0.286</td>
</tr>
<tr>
<td>Red</td>
<td>0.648</td>
<td>0.351</td>
<td>0.735</td>
<td>0.265</td>
<td>0.629</td>
</tr>
<tr>
<td>Blue(^B)</td>
<td>0.140</td>
<td>0.035</td>
<td>0.244</td>
<td>0.210</td>
<td>0.190</td>
</tr>
<tr>
<td>Brown</td>
<td>0.430</td>
<td>0.340</td>
<td>0.610</td>
<td>0.390</td>
<td>0.550</td>
</tr>
<tr>
<td>Fluorescent Yellow-Green</td>
<td>0.387</td>
<td>0.610</td>
<td>0.369</td>
<td>0.546</td>
<td>0.428</td>
</tr>
<tr>
<td>Fluorescent Yellow</td>
<td>0.479</td>
<td>0.520</td>
<td>0.446</td>
<td>0.483</td>
<td>0.512</td>
</tr>
<tr>
<td>Fluorescent Orange</td>
<td>0.583</td>
<td>0.416</td>
<td>0.535</td>
<td>0.400</td>
<td>0.595</td>
</tr>
<tr>
<td>Fluorescent Pink</td>
<td>0.600</td>
<td>0.340</td>
<td>0.450</td>
<td>0.332</td>
<td>0.430</td>
</tr>
</tbody>
</table>

\(^A\) The four pairs (five pairs for fluorescent pink) of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 Standard Colorimetric System measured with CIE Standard Illuminant D65.

\(^B\) The saturation limit of green and blue may extend to the border of the CIE chromaticity locus for spectral colors.
HunterLab’s MiniScan EZ is a portable, reflected-color measurement spectrophotometer.

HunterLab's handheld spectrophotometer provides a 31.8 mm port size that has a 25mm viewed area. The large viewed area makes this unit suitable for a wide range of sample types, such as fabrics, paper, powders, granules and liquids when measured through a sample cup.

http://www.hunterlab.com/miniscan-ez-4500l-spectrophotometer.html
Twenty three combinations of sheeting types, colors and manufacturers

<table>
<thead>
<tr>
<th>Sheeting Type</th>
<th>Color</th>
<th>3M</th>
<th>Avery Denninson (AD)</th>
<th>Nippon Carbide (NC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>III</td>
<td>blue</td>
<td>3M</td>
<td>AD</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>brown</td>
<td>3M</td>
<td>AD</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>green</td>
<td>3M</td>
<td>AD</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>red</td>
<td></td>
<td>AD</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>white</td>
<td>3M</td>
<td>AD</td>
<td>NC</td>
</tr>
<tr>
<td>III</td>
<td>yellow</td>
<td>3M</td>
<td>AD</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>blue</td>
<td>3M</td>
<td>AD</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>brown</td>
<td>3M</td>
<td>AD</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>green</td>
<td>3M</td>
<td>AD</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>red</td>
<td></td>
<td>AD</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>white</td>
<td>3M</td>
<td>AD</td>
<td>NC</td>
</tr>
<tr>
<td>IV</td>
<td>yellow</td>
<td>3M</td>
<td>AD</td>
<td></td>
</tr>
<tr>
<td>VII</td>
<td>blue</td>
<td>3M</td>
<td>AD</td>
<td></td>
</tr>
<tr>
<td>VII</td>
<td>brown</td>
<td>3M</td>
<td>AD</td>
<td></td>
</tr>
<tr>
<td>VII</td>
<td>green</td>
<td>3M</td>
<td>AD</td>
<td></td>
</tr>
<tr>
<td>VII</td>
<td>red</td>
<td>3M</td>
<td>AD</td>
<td></td>
</tr>
<tr>
<td>VII</td>
<td>white</td>
<td>3M</td>
<td>AD</td>
<td>NC</td>
</tr>
<tr>
<td>VII</td>
<td>yellow</td>
<td>3M</td>
<td>AD</td>
<td></td>
</tr>
<tr>
<td>XI</td>
<td>blue</td>
<td>3M</td>
<td>AD</td>
<td></td>
</tr>
<tr>
<td>XI</td>
<td>brown</td>
<td>3M</td>
<td>AD</td>
<td></td>
</tr>
<tr>
<td>XI</td>
<td>green</td>
<td>3M</td>
<td>AD</td>
<td></td>
</tr>
<tr>
<td>XI</td>
<td>white</td>
<td>3M</td>
<td>AD</td>
<td></td>
</tr>
<tr>
<td>XI</td>
<td>yellow</td>
<td>3M</td>
<td>AD</td>
<td></td>
</tr>
</tbody>
</table>
Areas
Florida is divided into seven transportation districts and the Turnpike

**District 1** - Southwest Florida (Bartow)

**District 2** - Northeast Florida (Lake City & Jacksonville)*

**District 3** - Northwest Florida (Chipley)

**District 4** - Southeast Florida (Ft. Lauderdale)*

**District 5** - Central Florida (Deland)

**District 6** - South Florida (Miami)

**District 7** - West Central Florida (Tampa)*

**Florida's Turnpike**

* Signage inventory capabilities being investigated
Data collection is a challenging activity
Draft of Model for Predicting the Service Life of Road Signs in Florida:
A first order model with quantitative and qualitative (categorical) variables

\[ \hat{Y} = \beta_0 + \beta_1 X_{Rt} + \beta_2 X_{Cr} \]

(Independent Variable: Age of Sign)

Independent Variables: Constant reflecting Sheeting Material type III, Color Green, Manufacturer 3M, Area South, Cardinal Orientation North, Roadway Location Inland; and Quantitative Variables for Retroreflectivity and Chromaticity)

+ \beta_3 X_{SIV} + \beta_4 X_{SVII} + \beta_5 X_{SXI} \quad \text{(Qualitative Variables for Sheeting Materials types IV, VII, XI)}

+ \beta_6 X_{CBn} + \beta_7 X_{CBe} + \beta_8 X_{CR} + \beta_9 X_{CW} + \beta_{10} X_{CY} \quad \text{(Qualitative Variables for Brown, Blue, Red, White, Yellow)}

+ \beta_{11} X_{Mad} + \beta_{12} X_{Mnc} \quad \text{(Qualitative Variables for Manufactures: Avery Denninsson, Nippon Carbide)}

+ \beta_{13} X_{AC} + \beta_{14} X_{AN} \quad \text{(Qualitative Variables for Area: Central and North)}

+ \beta_{15} X_{Cos} + \beta_{16} X_{CoE} + \beta_{17} X_{CoW} \quad \text{(Qualitative Variables for Cardinal Orientation: South, East, West)}

+ \beta_{16} X_{RIR} + \beta_{17} X_{RIU} + \beta_{18} X_{CoWRIC} \quad \text{(Qualitative Variables for Road Locations: Rural, Urban, Coastal)}

+ \varepsilon \quad \text{(Error)}
Estimated Minimum Sample Size for the Draft of the Predictive Model

300 sign observations

Provided however:

1. We know where the various signage factors combinations are located
2. We are able to obtain a fairly large range for the age of the signs, the dependent variable, from which service life prediction is appropriate
3. The model only accounts for the main effects, i.e., no interactions or other 2\textsuperscript{nd} order models
4. No additional levels on the qualitative variables are required
Project Milestones

• Project Start: mid August 2015
• Literature Review: due Oct 2015
• Safety and Data Collection Training: Early to Mid November 2015
• Data Collection: Start Late November 2015, due on November 2016
• Model Development & Validation: due January 2017
• Project Completion: February 2017
Challenging Topics

• Tight timeline for fulfilling the FDOT contract
• Data collectors: undergraduate UCF students and their vehicles
• Not knowing where the specific sign combinations are located
• Ability to obtain a fairly large range of values for the age of the various signs, the dependent variable, from which service life can be predicted
• Colorimeter: No remote control extension pole to reach high level signs; and is it more a lab instrument than a field instrument?
• A second order Prediction model may be required for interactions of the main-effects.
• A Logistic Regression Model may be required to determine a pass or fail dependent variable to serve as a marker for the Predictive model.
Questions?

Suggestions?

Thank You!