LiDAR: Another Potential Data Source

Leslie C. Harwood, Project Associate (CAAR)
Zac Doerzaph, Director (CAAR)
Problems Assessing Visibility

- How can we assess visibility in situations where the roadway infrastructure occludes a driver’s view?
  - At intersections/around corners
  - Around horizontal curves
  - Over vertical curves

- Previous methods have included:
  - Video reduction
  - Road surveys
LiDAR — What?

- What is LiDAR?
  - Light Detection and Ranging
  - A remote sensing method used to examine the surface of the earth

- How is it collected?
  - Often by air
  - Uses a pulsed laser to measure ranges to the surface of the earth
  - Captures:
    - “Top” of vegetation, built-environment
    - Surface of the earth
    - Multiple pulses which penetrate through vegetation
  - Point-clouds
Challenges...

- Requires expert knowledge and specialized software
- Not available in all areas
- Can be difficult and costly to obtain
- Requires ability to handle extremely large datasets
LiDAR — How?

How can we use it?

- Create:
  - Digital Elevation Models (DEM)
  - Bare-earth model
  - Digital Surface Models (DSM)
  - Vegetation and built-environment

- Collect:
  - Naturalistic or other driving data including GPS locations

- Derive:
  - Driver eye-heights from vehicles used
  - Vehicle representations along path
LiDAR – How?

➢ How can we use it?
  ◦ Analyze:
    ◦ Visibility at intersections
    ◦ Visibility around horizontal curves
    ◦ Visibility over vertical curves
    ◦ ...and more
  ◦ Decide:
    ◦ Use results from these analyses to make decisions about:
      ◦ Roadway design
      ◦ Vehicle design
      ◦ How emerging technologies can overcome visibility issues
      ◦ Etc.
Measuring Visibility

- Driver eye height
  - Centroid of driver eye positions from ground (Sivak, et. al., 1996):
    - Cars: 1.11 meters
    - Light Trucks/Vans: 1.42 meters

- Driver Field of Vision:
  - ~180° (Lockhart, et. al., 2009)
Measuring Visibility

Vehicle width
- Average widths (Edmunds.com, 2007):
  - Sedan Compact: 1.75 meters
  - Sedan Midsize: 1.81 meters
  - Sedan Large: 1.91 meters
  - SUV Compact: 1.80 meters
  - SUV Midsize: 1.87 meters
  - SUV Large: 1.99 meters

Vehicle height
- Average heights (Edmunds.com, 2007):
  - Sedan Compact: 1.46 meters
  - Sedan Midsize: 1.46 meters
  - Sedan Large: 1.49 meters
  - SUV Compact: 1.73 meters
  - SUV Midsize: 1.77 meters
  - SUV Large: 1.91 meters
Urban Intersection Visibility

- Assess visibility from a stop bar of cross-traffic in an urban environment including multiple-story buildings and some vegetation.

- Methods for analysis:
  - Create vehicle paths
  - Model vehicle and driver eye-height
  - Model Topography
Urban Intersection Visibility

- Analyze visibility
  - Visibility along sight lines
  - Identify first partial-car visible from driver’s POV (orange)
  - Identify first full-car visible from driver’s POV (blue)
  - Calculate distances

- Further Analysis:
  - Time to Intersection (TTI)
    - Roadway is 25mph

<table>
<thead>
<tr>
<th>Distance to</th>
<th>LOS</th>
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</thead>
<tbody>
<tr>
<td>First Visible Partial-Car</td>
<td>26 meters</td>
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<tr>
<td>First Visible Full-Car</td>
<td>24 meters</td>
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</table>

<table>
<thead>
<tr>
<th>TTI to</th>
<th>Along Path</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Visible Partial-Car</td>
<td>2 seconds</td>
</tr>
<tr>
<td>First Visible Full-Car</td>
<td>1.7 seconds</td>
</tr>
</tbody>
</table>
Horizontal Curve Visibility

- Assess visibility within a curve in a rural environment including heavy vegetation and some buildings.

- Methods for analysis:
  - Create vehicle paths
  - Model vehicle and driver eye-height
  - Model Topography
Horizontal Curve Visibility

- Analyze visibility
  - Visibility along sight lines
  - Identify first partial-car visible from driver’s POV (orange)
  - Identify first full-car visible from driver’s POV (blue)
  - Calculate distances

- Further Analysis:
  - Time to Collision (TTC)
    - Roadway is 25mph

<table>
<thead>
<tr>
<th>Distance to</th>
<th>LOS</th>
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<tbody>
<tr>
<td>Last Visible Full-Car</td>
<td>58 meters</td>
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<tr>
<td>Last Visible Partial-Car</td>
<td>62 meters</td>
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</table>

<table>
<thead>
<tr>
<th>TTC to</th>
<th>Along Path</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last Visible Full-Car</td>
<td>5.2 seconds</td>
</tr>
<tr>
<td>Last Visible Partial-Car</td>
<td>5.5 seconds</td>
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</tbody>
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Vertical Curve Visibility

- Assess visibility within a curve in a rural environment including heavy vegetation and some buildings.

- Methods for analysis:
  - Create vehicle paths
  - Model vehicle and driver eye-height
  - Model Topography
Vertical Curve Visibility

- Analyze visibility
  - Visibility along sight lines
  - Identify first partial-car visible from driver’s POV (orange)
  - Identify first full-car visible from driver’s POV (blue)
  - Calculate distances

Further Analysis:
- Time to Collision (TTC)
  - Roadway is 25mph

<table>
<thead>
<tr>
<th>Distance to</th>
<th>LOS</th>
</tr>
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<tbody>
<tr>
<td>Last Visible Full-Car</td>
<td>166 meters</td>
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<tr>
<td>Last Visible Partial-Car</td>
<td>184 meters</td>
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<table>
<thead>
<tr>
<th>TTC to</th>
<th>Along Path</th>
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</thead>
<tbody>
<tr>
<td>Last Visible Full-Car</td>
<td>15 seconds</td>
</tr>
<tr>
<td>Last Visible Partial-Car</td>
<td>16.6 seconds</td>
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Conclusions

➢ LiDAR is a valuable tool for evaluating line of sight

➢ Though setup is time-intensive, able to be used as an automated process

➢ More objective and efficient than video reduction or survey methods

➢ Topic areas:
  ◦ Roadway design
  ◦ Vehicle design
  ◦ How emerging technologies can overcome visibility issues
    ◦ V2V
    ◦ Autonomous
    ◦ Etc.
Questions?

Leslie C. Harwood  
Project Associate  
Center for Advanced Automotive Research, VTTI  
lharwood@vti.vt.edu

Dr. Zachary R. Doerzaph  
Director  
Center for Advanced Automotive Research, VTTI  
zdoerzaph@vti.vt.edu