Designing & Implementing a GIS-based Roadway Safety Management System for CTDOT

Presented by
Eric Jackson, Ph.D.
Dale Abbott, GISp

April 25, 2019
Meeting with you today

- CT Transportation Safety Research Center
  - Eric Jackson, PhD
    • Director

- VHB
  - Dale Abbott, GISP
    • New England Applied Technology Manager
Agenda

- Overview of Roadway Safety Analysis
  - Roadway Safety Overview
  - Data Sources
  - Roadway Safety Management Process

- Overview of the CT Roadway Safety Management System (CRSMS)
  - CRSMS Demo
  - Question & Answer
Roadway Safety Overview

Why conduct roadway safety analysis?

- To reduce the number and severity of crashes
- To effectively apply funds by selecting and applying appropriate countermeasures
- To link crashes to their roadway environments
- To gain a better understanding of safety concerns on the roadways

Federal Transportation Legislation Requirements
What is the primary safety issue on your roads?
There are 3 primary sources of data:
1. Crash Data
2. Facility Data (Roadway Data)
3. Traffic Volume Data

GIS is Critical

Analysis is only as good as the input data.....
FHWA Roadway Safety Management Process (RSMP)

**Analyzing** the entire network to identify potential sites or issues for further investigation
- Site-specific: identify specific sites for further analysis (typically those with high crashes or over-represented crashes).

Further investigating sites/issues identified in network screening to identify existing and potential safety issues.

**Identify Contributing Factors**

Identifying ways to **address/mitigate** the underlying **safety issues** identified through diagnosis.
Project Overview

- **Client:** CTDOT
  - Highway Safety Improvement Program (HSIP) Funds

- **Goal:** Turn the 6-Step Roadway Safety Management Process into a custom Safety Management Solution for CTDOT.


- **Agile Development Methodology**
  - Incremental Development Strategy

- **Milestones**
  - Network Screening Module Released in January 2018
  - Data Admin Module – Released in Fall 2018
  - Diagnosis Module – February 2019
  - Countermeasure Selection – May 2019
  - Remaining Modules – December 2019
CT Roadway Safety Management System

Dashboard

Data Management
- Prepare Data for Analysis Tools
- Prepare Homogeneous Sites for SPF
- Update Network Screening SPFs
- Update Project Level SPFs
- Update Crash Comprehensive Cost
- Update Contributing Factors List
- Update Countermeasures List

Safety Analysis
- Network Screening
  - Diagnosis
- Countermeasure Selection
- Economic Evaluation
- Prioritize Projects
- Safety Effectiveness Evaluation

Known Issues

Network Screening: The intersection data contains 100% risk. Diagnosis: Users cannot reload the crash data in the collision indicator.

Application Updates

Mar 13, 2019, 16:00

Diagnosis: (Enhancement) Allow renaming diagnosis report.
Network Screening: (New Feature) Added preliminary 2019 crash data.
Network Screening: (New Feature) Display approximate number of crashes.
CT Roadway Safety Management System

- Custom, GIS-based Web Application
- Leverages Esri Software Stack
  - ArcGIS Enterprise
  - ArcGIS JavaScript API (4.x)
- SQL Server Back-end
- .NET Core Framework
- Angular Front End
CT Roadway Safety Management System

- 6 Modules from RSMP Plus
- Data Admin Module
- Sub-modules
- Interactive Mapping
- Charting/Visualization Tools
- Automated Reporting Engine

### Dashboard

#### Data Management
- Prepare Data for Analysis Tools
- Prepare Homogeneous Sites for SPF
- Update Network Screening SPF
- Update Project Level SPF
- Update Crash Comprehensive Cost
- Update Contributing Factors List
- Update Countermeasures List

#### Safety Analysis
- Network Screening
- Diagnosis
- Countermeasure Selection
- Economic Evaluation
- Prioritize Projects
- Safety Effectiveness Evaluation
Network Screening Module

1. Establish Focus
2. Identify Network and Establish Reference Populations
3. Select Performance Measures
4. Select Screening Method
5. Screen and Evaluate Results
Diagnosis Module

CT-15 between 5.310 and 5.410

Crash Date Range:
from 01/01/2016 to 12/31/2018

Summary Statistics

Highlights

Crashes:
- Total: 28
- Fixed Object: 17
- Front to Rear: 5
- K: 0
- A: 0
- B: 2
- C: 5
- O: 21

Top 2 Crash Types:
- Aggressive Driving Related: 18
- Young Driver: 9
- Adverse Weather Conditions: 7
- Wet Road Surface: 15
- Roadway Departure: 20

Pre-Defined Reports

Crash Information
- Crash Severity
- Crash Type
- Crashes by Town
- Traffic Surface Condition
- Type of Intersection

Vehicle Information
- Vehicle Action
- Vehicle Body Type
- Most Harmful Event
- Contributing Circumstances Vehicle
- Damaged Areas

Summary Statistics Summary

Include in report

Hints: Are the percentages of some crash categories (e.g. crash type, crash severity, adverse weather, wet pavement) higher than the others? Do the hotspot figures indicate crashes are mainly clustered under some conditions (e.g. time, day and month; environmental and roadway conditions)?
# Countermeasure Selection (in-progress)

## Storrs Multi-Site Test

### Countermeasures

<table>
<thead>
<tr>
<th>Countermeasure</th>
<th>CMF ID</th>
<th>Category</th>
<th>Subcategory</th>
<th>CMF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change pavement friction from 40 to 5K (in friction number)</td>
<td>6613</td>
<td>Roadway</td>
<td>Pavement condition and friction</td>
<td>View Function</td>
</tr>
<tr>
<td>Change pavement friction from 40 to 5K (in friction number)</td>
<td>6617</td>
<td>Roadway</td>
<td>Pavement condition and friction</td>
<td>View Function</td>
</tr>
<tr>
<td>Change pavement friction from 40 to 5K (in friction number)</td>
<td>6821</td>
<td>Roadway</td>
<td>Pavement condition and friction</td>
<td>View Function</td>
</tr>
<tr>
<td>Install edgelines (curves)</td>
<td>2 CMF(s)</td>
<td>Delineation</td>
<td>On-pavement markings</td>
<td>0.66 to 0.71</td>
</tr>
<tr>
<td>Install edgelines (tangents and curves)</td>
<td>2 CMF(s)</td>
<td>Delineation</td>
<td>On-pavement markings</td>
<td>0.75 to 0.82</td>
</tr>
<tr>
<td>Install in-lane curve warning pavement markings</td>
<td>2 CMF(s)</td>
<td>Delineation</td>
<td>On-pavement markings</td>
<td>0.91 to 0.92</td>
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<tr>
<td>Install oversized chevron signs</td>
<td>2 CMF(s)</td>
<td>Signs</td>
<td>None</td>
<td>0.85 to 0.95</td>
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<tr>
<td>Install transverse rumble strips and raised pavement markers</td>
<td>1 CMF(s)</td>
<td>Delineation</td>
<td>Supplemental delineation</td>
<td>0.47</td>
</tr>
<tr>
<td>Install transverse rumble strips, raised pavement markers, and transverse markings</td>
<td>1 CMF(s)</td>
<td>Delineation</td>
<td>Supplemental delineation</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Rows: 13 of 6916  Selected: 1
Countermeasure Selection (in-progress)

Storrs Multi-Site Test

Countermeasures: Diagnosis Summary

Contributing Factors

<table>
<thead>
<tr>
<th>Name</th>
<th>Category</th>
<th>Site Classes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greg’s user-created CF</td>
<td>-User-</td>
<td>-User-</td>
</tr>
<tr>
<td>Inadequate Lane Width</td>
<td>Roadway</td>
<td>Segment Related</td>
</tr>
<tr>
<td>Inappropriate Driveway Access</td>
<td>Roadway Access</td>
<td>Segment Related</td>
</tr>
</tbody>
</table>

Final Summary

Greg’s final summary of this diagnosis report. Also included user-created CFs

Diagnosis Tool Summaries

Map
Greg entered a summary in the Map Tool

Crash Data
Greg entered a summary in the Crash Data Tool

Summary of Statistics
Countermeasure Selection (in-progress)
Known Issues

**Network Screening**: The intersection data contains 100% state-state and 80% post-processed state-local intersections
**Diagnosis**: Users cannot reload the crash data in the collision diagram

Application Updates

Mar 13, 2019, 16:00

**Diagnosis**: (Enhancement) Allow renaming diagnosis reports
**Network Screening**: (New Feature) Added preliminary 2018 crash data to the network screening module
**Diagnosis**: (New Feature) Added preliminary 2018 crash data to the diagnosis module
**Network Screening**: (New Feature) Display approximate number of sites in each facility type

DIVE INTO THE TOOL FEATURES (LIVE DEMO)
Network Screening

Known Issues

Network Screening: The intersection data contains 100% state-state and 80% post-processed state-local intersections
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Mar 13, 2019, 16:00
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Network Screening: (New Feature) Display approximate number of sites in each facility type
Network Screening Results
Diagnosis Module

This chart presents bar charts showing the performance measure values in the y-axis and the site rankings in the x-axis. The bar chart provides an easy way to gauge the magnitude of differences between adjacent rankings.

Average Crash Frequency
Automated Reporting Engine

Sample Report
Question & Answer
Thank you

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Dale Abbott, GISP  |  dabbott@vhb.com  |  603.391.3964
Network Screening Module

Known Issues

**Network Screening:** The intersection data contains 100% state-state and 80% post-processed state-local intersections
**Diagnosis:** Users cannot reload the crash data in the collision diagram

Application Updates

Mar 13, 2019, 16:00

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**Diagnosis:** (New Feature) Added preliminary 2018 crash data to the diagnosis module
**Network Screening:** (New Feature) Display approximate number of sites in each facility type
Network Screening Module

Year Range
- From 2016 to 2018

Emphasis Areas (optional)
- DUI Related
- Young Driver Involved
- Qualifying Commercial Vehicle Involved
- Wet Road Surface Involved
- Bicycle Involved
- Aggressive Driving Related
- Motorcycle Involved
- Adverse Weather Involved
- Pedestrian Involved
- Roadway Departure

Establish Focus

Establish Focus is where a user chooses a subset of crash data by specifying crash year range, emphasis areas, crash types and severities which will be used for ranking sites with the highest potential for safety improvement.

Crash Severity
- KABC
- KAB
- KA
- PDO

Crash Type
- All
  - Multiple-Vehicle
  - Single-Vehicle
Network Screening Engine

Area of Interest (optional)

- BOUNDARY TYPE: Maintenance Districts
- BOUNDARY NAME: 4

1 items

RESET
Select State-Maintained Routes (optional)

These routes are filtered by the optionally specified Areas of Interest from the previous step.

Show Only Selected Routes

- CT-10
- CT-102
- CT-107
- CT-109
- CT-112
- CT-115
Network Screening Engine

Innovation Conference

Filtered by one Area of Interest and one State-Maintained Route:

- All Facilities (~112 sites)
- State Roadway Segments (~79 sites)
- State-Maintained Intersections with Full Traffic Volume Information (~6 sites)
- State-Maintained Intersections with Partial Traffic Volume Information (~27 sites)

Identify Network

Identify Network is where a user chooses a subset of the transportation network for their network screening. This list of facilities is filtered by any specified areas of interest and state routes.
Network Screening Engine

InnovationConference

Select Performance Measures

Select Performance Measures is where a user chooses which analytical methodologies are used to rank sites. Certain performance measures might depend on supporting data and the subset of the network that will be screened.

For a description of all the performance measures and their calculations, see:
USER MANUAL APPENDIX A.1
Network Screening Engine

InnovationConference

DemoInnovationConference

Select Screening Method

Select Screening Method is where a user specifies how a performance measure is calculated for a site.

For a description of all the screening methods, see: USER MANUAL APPENDIX A.2
Network Screening Engine

Establish Focus
Scenario: innovationConference
Year Range: from 2016 to 2018
Emphasis Areas: DUI Related, Roadway Departure
Crash Severity: Injury Only
Crash Types: Total

Identify Network
Area(s) of Interest: Maintenance District 4
State-Maintained Routes: 10-N
Facility Types: Rural non-freeway undivided 2 or more lanes, Urban non-freeway undivided 2 lanes, Urban non-freeway undivided 3 lanes, Urban non-freeway undivided 4 or more lanes

Select Performance Measures
Area Weight (Urban): 1.0
Area Weight (Rural): 1
Performance Measures: Average Crash Frequency, Relative Severity Index

Select Screening Method
Network Screening Engine

District 4 (cloned)
High Frequency Crash Locations (Intersections only)

<table>
<thead>
<tr>
<th>Site Id</th>
<th>Type Code</th>
<th>Description</th>
<th>Average Crash Frequency</th>
<th>EPDO Avg Crash Frequency</th>
<th>Relative Severity Index</th>
<th>Excess Predicted Using M...</th>
<th>Excess Proportion by Type</th>
<th>Critical Crash Rate</th>
<th>Excess Expect</th>
</tr>
</thead>
<tbody>
<tr>
<td>133295</td>
<td>IN</td>
<td>CT-69 and UNION ST in Waterbury</td>
<td>8.66667</td>
<td>106.66667</td>
<td>1</td>
<td>152985</td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>133490</td>
<td>IN</td>
<td>CT-69 and EAST MAIN ST in Waterbury</td>
<td>8.66667</td>
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<td>1</td>
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<td>135251</td>
<td>IN</td>
<td>CT-69 and LAKEWOOD RD in Waterbury</td>
<td>5.66667</td>
<td>83.33333</td>
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<td>152985</td>
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<td>135246</td>
<td>IN</td>
<td>CT-69 and SHARON RD in Waterbury</td>
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<td>126.66667</td>
<td>144</td>
<td>14760.9298</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Diagnosis Module

Diagnosis

Add sites to diagnose:

1. FROM NETWORK SCREENING RESULTS
2. FROM A MAP

For an explanation on creating diagnosis reports, see: USER MANUAL - USING MODULE 2 - DIAGNOSIS

<table>
<thead>
<tr>
<th>Diagnosis ID</th>
<th>Source</th>
<th>Name</th>
<th>Crash Date Range</th>
<th>Created By</th>
<th>Report Status</th>
<th>Completed Analyses</th>
<th>Contributing Factors</th>
<th>Last Updated</th>
</tr>
</thead>
<tbody>
<tr>
<td>9748</td>
<td>Network Screening</td>
<td>CT-69 and UNION ST in Waterbury</td>
<td>Jan 1, 2016 - Dec 31, 2018</td>
<td><a href="mailto:kai.wang@uconn.edu">kai.wang@uconn.edu</a></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>9749</td>
<td>Network Screening</td>
<td>CT-69 and EAST MAIN ST in Waterbury</td>
<td>Jan 1, 2016 - Dec 31, 2018</td>
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<tr>
<td>9747</td>
<td>Map</td>
<td>I-91 Interchange 74</td>
<td>Jan 1, 2016 - Dec 31, 2018</td>
<td><a href="mailto:jonathan.corilla@ct.gov">jonathan.corilla@ct.gov</a></td>
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<tr>
<td>9746</td>
<td>Map</td>
<td>East Lyme 44-150</td>
<td>Jan 1, 2016 - Dec 31, 2018</td>
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<td>Apr 8, 2019</td>
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<tr>
<td>9743</td>
<td>Network Screening</td>
<td>CT-160 and WEBSTER LA in Rocky Hill</td>
<td>Jan 1, 2016 - Dec 31, 2018</td>
<td><a href="mailto:shanshan.zhao@uconn.edu">shanshan.zhao@uconn.edu</a></td>
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</tr>
<tr>
<td>9744</td>
<td>Network Screening</td>
<td>CT-160 and GRIMES RD in Rocky Hill</td>
<td>Jan 1, 2016 - Dec 31, 2018</td>
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</tr>
<tr>
<td>9745</td>
<td>Network Screening</td>
<td>CT-332 and GROVE AV in Wiscott</td>
<td>Jan 1, 2016 - Dec 31, 2018</td>
<td><a href="mailto:shanshan.zhao@uconn.edu">shanshan.zhao@uconn.edu</a></td>
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<td></td>
<td>Apr 5, 2019</td>
</tr>
<tr>
<td>9742</td>
<td>Network Screening</td>
<td>CT-37 and WAKEMAN HILL RD in Sherman</td>
<td>Jan 1, 2016 - Dec 31, 2018</td>
<td><a href="mailto:shanshan.zhao@uconn.edu">shanshan.zhao@uconn.edu</a></td>
<td>incomplete</td>
<td></td>
<td></td>
<td>Apr 5, 2019</td>
</tr>
</tbody>
</table>
Diagnosis Module

Create New Diagnosis Report
Diagnosis Module

CT-15 between 5.310 and 5.410

Crash Date Range
from 01/01/2016 to 12/31/2018

Map Summary

Hints: Are crashes clustered at a spot or section along the segment? Do the adjacent land uses and environment affect the safety of this site?
### Crash Data Summary

Hints: Are any certain crash, vehicle or driver characteristics overrepresented than the others? Are any crash categories (e.g. crash type, crash severity, adverse weather, wet pavement) overrepresented than the others?

<table>
<thead>
<tr>
<th>Crash Id</th>
<th>Diagram</th>
<th>Crash Date</th>
<th>Crash Time</th>
<th>Crash Town Name</th>
<th>Route Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>208521</td>
<td>VIEW</td>
<td>May 22, 2016</td>
<td>08:44</td>
<td>Greenwich</td>
<td>State</td>
</tr>
<tr>
<td>227482</td>
<td>VIEW</td>
<td>Jul 25, 2016</td>
<td>23:06</td>
<td>Greenwich</td>
<td>State</td>
</tr>
<tr>
<td>228605</td>
<td>VIEW</td>
<td>Jul 29, 2016</td>
<td>07:52</td>
<td>Greenwich</td>
<td>State</td>
</tr>
<tr>
<td>235800</td>
<td>VIEW</td>
<td>Jul 31, 2016</td>
<td>05:58</td>
<td>Greenwich</td>
<td>State</td>
</tr>
<tr>
<td>261772</td>
<td>VIEW</td>
<td>Sep 19, 2016</td>
<td>14:17</td>
<td>Greenwich</td>
<td>State</td>
</tr>
<tr>
<td>275043</td>
<td>VIEW</td>
<td>Jan 10, 2016</td>
<td>13:14</td>
<td>Greenwich</td>
<td>State</td>
</tr>
<tr>
<td>307616</td>
<td>VIEW</td>
<td>Oct 9, 2016</td>
<td>17:24</td>
<td>Greenwich</td>
<td>State</td>
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<tr>
<td>326790</td>
<td>VIEW</td>
<td>Nov 18, 2016</td>
<td>06:53</td>
<td>Greenwich</td>
<td>State</td>
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<td>348637</td>
<td>VIEW</td>
<td>Jan 8, 2017</td>
<td>13:57</td>
<td>Greenwich</td>
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</tr>
<tr>
<td>346650</td>
<td>VIEW</td>
<td>Jan 8, 2017</td>
<td>18:52</td>
<td>Greenwich</td>
<td>State</td>
</tr>
</tbody>
</table>
Diagnosis Module

CT-15 between 5.310 and 5.410

Crash Date Range:
- From: 01/01/2016
- To: 12/31/2018

Summary Statistics

- **Highlights**
  - **Crashes**: 28
  - **Top 2 Crash Types**
    - Fixed Object: 17
    - Front to Rear: 5
  - **Crash Severity**
    - K: 0
    - A: 0
    - B: 2
    - C: 5
    - O: 21
  - **Emphasis Areas**
    - Aggressive Driving Related: 18
    - Young Driver: 9
    - Adverse Weather Conditions: 7
    - Wet Road Surface: 15
    - Roadway Departure: 20
  - Qualifying Commercial Vehicle: 1

Summary Statistics Summary

- **Pre-Defined Reports**
  - All pre-defined report data shows counts by number of crashes.
  - Crash Information
    - Crash Severity
    - Crash Type
    - Crashes by Town
    - Traffic Surface Condition
    - Type of Intersection
  - Vehicle Information
    - Vehicle Action
    - Vehicle Body Type
    - Most Harmful Event
    - Contributing Circumstances Vehicle
    - Damaged Areas

Hints: Are the percentages of some crash categories (e.g., crash type, crash severity, adverse weather, wet pavement) higher than the others? Do the hotspot figures indicate crashes are mainly clustered under some conditions (e.g., time, day and month, environmental and roadway conditions)?
Diagnosis Module
## Diagnosis Module

### CT-15 between 5.310 and 5.410

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Facility Type</th>
<th>Category</th>
<th>Over Represented</th>
<th>Site Ob</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT-15 between 5.310 and 5.410</td>
<td>SR-RRFWDVNA26</td>
<td>Single-Other</td>
<td>NA</td>
<td>0</td>
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<tr>
<td>CT-15 between 5.310 and 5.410</td>
<td>SR-RRFWDVNA26</td>
<td>Sideswipe - Opposite Direction</td>
<td>NA</td>
<td>0</td>
</tr>
<tr>
<td>CT-15 between 5.310 and 5.410</td>
<td>SR-RRFWDVNA26</td>
<td>Sideswipe - Same Direction</td>
<td>N</td>
<td>3</td>
</tr>
<tr>
<td>CT-15 between 5.310 and 5.410</td>
<td>SR-RRFWDVNA26</td>
<td>DUI</td>
<td>NA</td>
<td>0</td>
</tr>
<tr>
<td>CT-15 between 5.310 and 5.410</td>
<td>SR-RRFWDVNA26</td>
<td>Aggressive Driving</td>
<td>N</td>
<td>18</td>
</tr>
<tr>
<td>CT-15 between 5.310 and 5.410</td>
<td>SR-RRFWDVNA26</td>
<td>Young Driver</td>
<td>N</td>
<td>9</td>
</tr>
<tr>
<td>CT-15 between 5.310 and 5.410</td>
<td>SR-RRFWDVNA26</td>
<td>Motorcycle</td>
<td>NA</td>
<td>0</td>
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<tr>
<td>CT-15 between 5.310 and 5.410</td>
<td>SR-RRFWDVNA26</td>
<td>Commercial Vehicle</td>
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<td>1</td>
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<tr>
<td>CT-15 between 5.310 and 5.410</td>
<td>SR-RRFWDVNA26</td>
<td>Adverse Weather</td>
<td>N</td>
<td>7</td>
</tr>
<tr>
<td>CT-15 between 5.310 and 5.410</td>
<td>SR-RRFWDVNA26</td>
<td>Wet Pavement Surface</td>
<td>Y</td>
<td>15</td>
</tr>
<tr>
<td>CT-15 between 5.310 and 5.410</td>
<td>SR-RRFWDVNA26</td>
<td>Pedestrian</td>
<td>NA</td>
<td>0</td>
</tr>
<tr>
<td>CT-15 between 5.310 and 5.410</td>
<td>SR-RRFWDVNA26</td>
<td>Bicycle</td>
<td>NA</td>
<td>0</td>
</tr>
<tr>
<td>CT-15 between 5.310 and 5.410</td>
<td>SR-RRFWDVNA26</td>
<td>Work Zone</td>
<td>N</td>
<td>1</td>
</tr>
<tr>
<td>CT-15 between 5.310 and 5.410</td>
<td>SR-RRFWDVNA26</td>
<td>Roadway Departure</td>
<td>N</td>
<td>20</td>
</tr>
<tr>
<td>CT-15 between 5.310 and 5.410</td>
<td>SR-RRFWDVNA26</td>
<td>Distracted Driving</td>
<td>NA</td>
<td>0</td>
</tr>
</tbody>
</table>
Diagnosis Module

CT-15 between 5.310 and 5.410

For a detailed explanation of how to use the Collision Diagram tool, see: USING MODULE 2 - DIAGNOSIS: COLLISION DIAGRAM
Parcel Mapping Experience

CT-15 between 5.310 and 5.410

Total Crashes
28
100%

count of v
17
60.7%
count of v
9
32.1%
count of v
3
7.1%
weather
Clear
10
58.8%
weather
else
7
41.2%

Hints: Are there any crash patterns (e.g. severe single-vehicle crashes on a urban four-lane arterials, fatal commercial vehicle crashes under rainy weather) existed from the systemic point of view?