Estimating Safety Benefits of Connected-Automated Vehicles (CAVs) – SR 70 Pilot
CAV Technologies to be Considered (currently available on the market)

- Control Loss Warning (CLW)
- Road Departure Crash Warning (RDCW)
- Lane-Keeping Assistance (LKA)
- Automatic Emergency Braking (AEB)
- Electronic Stability Control (ESC)
- Backup Collision Intervention (BCI)
- Blind Spot Warning (BSW)
- Lane Change Warning (LCW)
- Do Not Pass Warning (DNPW)
- Forward Collision Warning (FCW)
CAV Introduction

1) 94% of all vehicle crashes are a result of driver error

2) 80% of all crashes could be avoided and/or severity lessened as a result of CAV adoption
   a) Generally assumes 100% CAV market adoption, 100% performance, 100 year horizon

3) CAV technologies are now starting to gain public acceptance

### SAE Levels of Automation – J3016_201806

<table>
<thead>
<tr>
<th>Level</th>
<th>Name</th>
<th>Narrative definition</th>
<th>DDT</th>
<th>ODD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Driving Automation</td>
<td>The performance by the driver of the entire DDT, even when enhanced by active safety systems.</td>
<td>Driver</td>
<td>Driver</td>
</tr>
<tr>
<td>1</td>
<td>Driver Assistance</td>
<td>The sustained and ODD-specific execution by a driving automation system of either the lateral or the longitudinal vehicle motion control subtasks of the DDT (but not both simultaneously) with the expectation that the driver performs the remainder of the DDT.</td>
<td>Driver and System</td>
<td>Driver</td>
</tr>
<tr>
<td>2</td>
<td>Partial Driving Automation</td>
<td>The sustained and ODD-specific execution by a driving automation system of both the lateral and longitudinal vehicle motion control subtasks of the DDT with the expectation that the driver completes the OEDR subtask and supervises the driving automation system.</td>
<td>System</td>
<td>Driver</td>
</tr>
</tbody>
</table>

ADS ("System") performs the entire DDT (while engaged)

<table>
<thead>
<tr>
<th>Level</th>
<th>Name</th>
<th>Narrative definition</th>
<th>DDT</th>
<th>ODD</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Conditional Driving Automation</td>
<td>The sustained and ODD-specific performance by an ADS of the entire DDT with the expectation that the DDT fallback-ready user is receptive to ADS-issued requests to intervene, as well as to DDT performance-relevant system failures in other vehicle systems, and will respond appropriately.</td>
<td>System</td>
<td>System</td>
</tr>
<tr>
<td>4</td>
<td>High Driving Automation</td>
<td>The sustained and ODD-specific performance by an ADS of the entire DDT and DDT fallback without any expectation that a user will respond to a request to intervene.</td>
<td>System</td>
<td>System</td>
</tr>
<tr>
<td>5</td>
<td>Full Driving Automation</td>
<td>The sustained and unconditional (i.e., not ODD-specific) performance by an ADS of the entire DDT and DDT fallback without any expectation that a user will respond to a request to intervene.</td>
<td>System</td>
<td>System</td>
</tr>
</tbody>
</table>
Market Adoption of Advanced Driver Assistance Systems (ADAS)

Registered Vehicles Equipped with ADAS Features

Data Source: HLDI Bulletin Vol. 34, No. 28: Sept. 2017

Surpassed 10% market adoption in 2017.
Project Background

1) Legislatively mandated to account for advanced vehicles technologies in FDOT plans/policies

2) Understand realistic expectations of improved safety as a result of CAV market adoption, 10-15 year planning horizon

3) CAVs have not been incorporated into FDOT corridor analyses or HSM methodologies
   a) This project will establish methodologies for doing so
Project Tasks

1) Data Gathering
2) Predict Volume of Future Crashes
3) Crash/ Technology Mapping and Crash Modification Factors
4) Autonomous Vehicle Crash Modification Factor Validation
5) Reporting

State Road (SR) 70 Corridor – Tampa to Fort Pierce
Data Sources

1) SSOGIS (FDOT State Safety Office (SSO) AGOL)
2) Signal 4 Analytics (UF)
3) FIRES (FL DHSMV)
4) FDOT CARS (SSO raw crash data)
5) RCI (FDOT roadway data)
6) Google Imagery
Utilize HSM Methodology

1) Safety Performance Functions (SPFs) that apply to the corridor (segments and intersections) Predict Volume of Future Crashes

2) Input data and Crash Modification Factors (CMFs) for each SPF

3) Crash prediction validation testing

4) Predicted number of crashes on SR 70 by segment over the next 40 years
HSM Segmentation

- 67 segments for analysis
- Aggregated to 7 segments for reporting
Map Series

- Spatial representation of RCI (roadway characteristics) & CARS (crash) data for SR 70
- Establishes baseline for estimating future crashes in the ‘no build’ (no consideration of CAVs) scenario
- Used to compare ‘before’ & ‘after’ CAV performance assumptions, market adoption, etc.
Crash Summary Statistics

Light Condition During Crash

- Unknown: 0.28%
- Other, Explain in Narrative: 0.05%
- Dark - Unknown Lighting: 0.19%
- Dark - Not Lighted: 16.60%
- Dark - Lighted: 9.35%
- Dawn: 2.32%
- Dusk: 3.34%
- Daylight: 67.69%

0.00% 10.00% 20.00% 30.00% 40.00% 50.00% 60.00% 70.00% 80.00%
Crash Summary Statistics

Weather Condition During Crash

- Clear: 70.14%
- Cloudy: 17.29%
- Rain: 10.83%
- Fog, Smog, Smoke: 1.48%
- Sleet/Hail/Freezing Rain: 0.23%
- Blowing Sand, Soil, Dirt: 0%
- Severe Crosswinds: 0%
- Other, Explain in Narrative: 0.23%
Crash Summary Statistics

Surface Condition During Crash

- Dry: 83.26%
- Wet: 16.18%
- Other: 0.28%
- Unknown: 0.19%
- Sand: 0.09%
- Oil: 0.09%
- Mud, Dirt, Gravel: 0.09%
- Water (standing/moving): 0.09%
- Ice/Frost: 0.09%
Crash Summary Statistics

Driver Condition During Crash

- Unknown 4.19%
- Other, Explain in Narrative 0.78%
- Under the Influence of Medications/Drugs/Alcohol 4.29%
- Emotional (depression, angry, disturbed, etc.) 0.24%
- Physically Impaired 0.29%
- Seizure, Epilepsy, Blackout 0.39%
- Ill (sick) or Fainted 0.49%
- Asleep or Fatigued 1.80%
- Apparently Normal 87.47%
Crash Summary Statistics

Maximum Speed (mph)

- 63 mph: 0.83%
- 60 mph: 37.20%
- 55 mph: 7.14%
- 50 mph: 20.11%
- 45 mph: 14.47%
- 40 mph: 1.83%
- 35 mph: 11.22%
- 25 mph: 7.19%
Crash Summary Statistics

Driver's Action During Crash

- Operated MV in Erratic, Reckless or Aggressive Manner: 6.83%
- Operated MV in Careless or Negligent Manner: 36.36%
- Operated MV in Careless or Negligent Manner: 15.91%
- Operated MV in Careless or Negligent Manner: 14.20%
- Operated MV in Careless or Negligent Manner: 12.22%
- Operated MV in Careless or Negligent Manner: 11.12%
- Operated MV in Careless or Negligent Manner: 10.37%
- Operated MV in Careless or Negligent Manner: 9.44%
- Operated MV in Careless or Negligent Manner: 8.54%
- Operated MV in Careless or Negligent Manner: 7.98%
- Operated MV in Careless or Negligent Manner: 7.60%
- Operated MV in Careless or Negligent Manner: 7.01%
- Operated MV in Careless or Negligent Manner: 6.49%
- Operated MV in Careless or Negligent Manner: 6.00%
- Operated MV in Careless or Negligent Manner: 5.57%
- Operated MV in Careless or Negligent Manner: 5.15%
- Operated MV in Careless or Negligent Manner: 4.74%
- Operated MV in Careless or Negligent Manner: 4.34%
- Operated MV in Careless or Negligent Manner: 4.01%
- Operated MV in Careless or Negligent Manner: 3.68%
- Operated MV in Careless or Negligent Manner: 3.37%
- Operated MV in Careless or Negligent Manner: 3.05%
- Operated MV in Careless or Negligent Manner: 2.73%
- Operated MV in Careless or Negligent Manner: 2.31%
- Operated MV in Careless or Negligent Manner: 2.00%
- Operated MV in Careless or Negligent Manner: 1.68%
- Operated MV in Careless or Negligent Manner: 1.37%
- Operated MV in Careless or Negligent Manner: 1.05%
- Operated MV in Careless or Negligent Manner: 0.73%
- Operated MV in Careless or Negligent Manner: 0.42%
- Operated MV in Careless or Negligent Manner: 0.10%
- Operated MV in Careless or Negligent Manner: 0.00%
Crash Summary Statistics

- Operated MV in Careless or Negligent Manner
- Failed to Yield Right-of-Way
- No Contributing Action
- No Other Contributing Action
- Improper Turn
- Failed to Keep in Proper Lane
- Followed too Closely
- Ran Red Light
- Ran off Roadway
- Drove too Fast for Conditions
- Improper Passing
- Improperly Backing
- Ran Stop Sign
- Improperly Parked
- Drove or Avoided Due to Slippery Surface, O
- Over-Connecting/Over-Steering
- Wrong Side of Wrong Way
- Exceeded Posted Speed
- Disregarded Other Traffic Sign
- Disregarded Other Road Markings
## Comparison of SR 70 Predicted Crashes with Actual Crashes

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Observed</td>
<td>Predicted</td>
<td></td>
</tr>
<tr>
<td>I-75 to Lorraine Road</td>
<td>104</td>
<td>108</td>
<td>4</td>
</tr>
<tr>
<td>Lorraine Road to Peace River</td>
<td>75</td>
<td>77</td>
<td>2</td>
</tr>
<tr>
<td>Peace River to Arcadia Walmart</td>
<td>37</td>
<td>41</td>
<td>4</td>
</tr>
<tr>
<td>Arcadia Walmart to US 98</td>
<td>76</td>
<td>82</td>
<td>6</td>
</tr>
<tr>
<td>US 98 to SR 710</td>
<td>66</td>
<td>69</td>
<td>3</td>
</tr>
<tr>
<td>SR 710 to Florida’s Turnpike</td>
<td>44</td>
<td>44</td>
<td>0</td>
</tr>
<tr>
<td>Florida’s Turnpike to I-95</td>
<td>29</td>
<td>33</td>
<td>4</td>
</tr>
<tr>
<td>SR 70 (I-75 to I-95) Total Crashes</td>
<td>431</td>
<td>454</td>
<td>23</td>
</tr>
</tbody>
</table>
## Future Year Predicted Total Crashes

<table>
<thead>
<tr>
<th>Segments</th>
<th>Year 2020</th>
<th>Year 2025</th>
<th>Year 2030</th>
<th>Year 2035</th>
<th>Year 2040</th>
<th>Year 2045</th>
<th>Year 2050</th>
<th>Year 2055</th>
<th>Year 2060</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-75 to Lorraine Road</td>
<td>123</td>
<td>128</td>
<td>132</td>
<td>136</td>
<td>140</td>
<td>143</td>
<td>147</td>
<td>151</td>
<td>154</td>
</tr>
<tr>
<td>Lorraine Road to Peace River</td>
<td>100</td>
<td>105</td>
<td>109</td>
<td>113</td>
<td>117</td>
<td>121</td>
<td>125</td>
<td>129</td>
<td>133</td>
</tr>
<tr>
<td>Peace River to Arcadia Walmart</td>
<td>57</td>
<td>60</td>
<td>62</td>
<td>65</td>
<td>68</td>
<td>71</td>
<td>73</td>
<td>76</td>
<td>79</td>
</tr>
<tr>
<td>Arcadia Walmart to US 98</td>
<td>106</td>
<td>120</td>
<td>133</td>
<td>147</td>
<td>161</td>
<td>174</td>
<td>188</td>
<td>201</td>
<td>215</td>
</tr>
<tr>
<td>US 98 to SR 710</td>
<td>76</td>
<td>82</td>
<td>88</td>
<td>95</td>
<td>101</td>
<td>108</td>
<td>115</td>
<td>121</td>
<td>128</td>
</tr>
<tr>
<td>SR 710 to Florida’s Turnpike</td>
<td>62</td>
<td>70</td>
<td>77</td>
<td>85</td>
<td>92</td>
<td>100</td>
<td>108</td>
<td>115</td>
<td>124</td>
</tr>
<tr>
<td>Florida’s Turnpike to I-95</td>
<td>41</td>
<td>43</td>
<td>45</td>
<td>47</td>
<td>48</td>
<td>50</td>
<td>52</td>
<td>53</td>
<td>55</td>
</tr>
<tr>
<td>SR 70 (I-75 to I-95) Total Crashes</td>
<td>565</td>
<td>608</td>
<td>646</td>
<td>688</td>
<td>727</td>
<td>767</td>
<td>808</td>
<td>846</td>
<td>888</td>
</tr>
</tbody>
</table>
Crash/ Technology Mapping and Crash Modification Factors

1) Utilize HDR refined methodology for estimating CMFs that are based on new vehicle technology solutions

2) Update methodology to reflect new vehicle technology crash statistics

3) Identify the root cause of each crash from the crash records

4) Identify which technologies could have potentially reduced the severity of each crash, or prevented each crash

5) Apply assumed effectiveness of each technology to each crash
CAV Crash Modification Factor Validation

• Take findings and apply factors for various rates of adoption of CAVs
• Provides a validation of the estimates as well as provide a lower bound on the anticipated crash reductions for future conditions as a function of AV/CV adoption
For more information please contact:

Edward R. Hutchinson
Transportation Data and Analytics Office Manager
605 Suwannee Street
Tallahassee, FL 32399
850-414-4910; ed.hutchinson@dot.state.fl.us

Tanner Martin
HDR Project Manager
605 Suwannee Street
Tallahassee, FL 32399
850-414-4919; tanner.martin@dot.state.fl.us