Coordinated Highways Action Response Team

Performance Evaluation and Benefit Analysis for Year 2018

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Office of CHART & ITS Development
Maryland Department of Transportation
State Highway Administration
PART A: Performance Evaluation
- Detection and Response Rates
- Response Time
- Incident Duration
- Assistance to Drivers

PART B: Benefit Estimation
- Methodology
- Direct Benefits in Year 2018
- Sensitivity Analysis

PART C: Areas for Potential Improvements
PART A: Performance Evaluation
# Part A: Performance Evaluation

## Total Number of Incidents/Disabled Vehicle Assists

<table>
<thead>
<tr>
<th>Year</th>
<th>Incidents</th>
<th>Disabled Vehicle Assist</th>
<th>Total Records</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>31,535 (25,571)</td>
<td>46,330 (45,228)</td>
<td>77,865 (70,799)</td>
</tr>
<tr>
<td>2015</td>
<td>35,119 (27,375)</td>
<td>42,724 (40,615)</td>
<td>77,843 (67,990)</td>
</tr>
<tr>
<td>2016</td>
<td>37,566 (30,314)</td>
<td>44,287 (42,048)</td>
<td>81,853 (72,362)</td>
</tr>
<tr>
<td>2017</td>
<td>37,100 (30,335)</td>
<td>44,199 (42,046)</td>
<td>81,299 (72,381)</td>
</tr>
<tr>
<td><strong>2018</strong></td>
<td><strong>41,247 (34,692)</strong></td>
<td><strong>46,891 (45,264)</strong></td>
<td><strong>88,138 (79,956)</strong></td>
</tr>
</tbody>
</table>

- **Responded by CHART**
- **Change (2017-2018)**

- This analysis is based on emergency response records in CHART DB.
- Number in the parenthesis shows the incidents or assists responded by CHART.
Part A: Response Time (RT)

Response Time to Incident/Dis_Vehs By Center

- This analysis is based on the data of incidents and disabled vehicles which have indicated the responsible operation center and response times.
- This analysis includes those sample events which have response times between 1 minute and 60 minutes.
- Events included in this analysis were responded by various units, including CHART, fire boards, stat/local polices, private towing companies, etc.
- TOC-3 has been temporarily closed and relocated to SOC since August 2018.
Part A: Incident Durations (ID)

Incident Duration By Center

- This analysis is based on incident records which have indicated the responsible operation center and response times.
- This analysis includes those sample events which have incident durations between 1 minute and 120 minutes.
Part A: Incident Durations (ID)

- This analysis is based on incident records which have included the information of event, duration, lane blockage, and response units.
- This analysis includes those sample events which have incident durations between 1 minute and 120 minutes.
- Cases of “Unknown” blockage were redistributed into different blockage categories.
- The numbers are the weighed average of incidents with different lane blockages, including shoulder only blockage.
PART B: Benefit Estimation
Part B: Benefit Estimation

Reduction in Incident Duration due to CHART operation

Direct Benefits

- Delay reduction
- Fuel consumption
- Emissions

Secondary incidents

Risks at primary incident sites

Frequency

Impacts
Part B: Benefit Estimation

Procedures

- Step 1: Gather information (incident data, traffic data, etc.)
- Step 2: Estimate **the total delay by segment for each major road**
- Step 3: Estimate **the total delay for major roads**
- Step 4: Estimate **the total delay for all roads** in Maryland
- Step 5: Estimate **the total delay reduction** due to CHART operations
- Step 6: Estimate **the reduction in fuel consumption and emissions**
- Step 7: Convert the reduction into the **monetary values**
**Part B: Delay Reduction Estimation**

- **Step 1: Gather Information**
  - Incident Data from CHART DB II
    - Frequency
    - Incident duration
    - Lane blockage
    - CHART involvement, etc.
  - AADT, Peak Hour Factor, Truck % for major roads in MD
  - Income, Gas Price, etc.
Part B: Delay Reduction Estimation

- **Step 2:** Estimate **the total delay by segment for each major road**
  - Simulate the entire highway segment
  - Develop the *Delay function*

\[
(\text{I-Delay}) = f(\text{Incident duration, traffic volume, No. of lane blockage, total No. of lanes, etc.})
\]
Part B: Delay Reduction Estimation

**Step 2: Estimate the total delay by segment for each major road**

*Input*

**Distribution of incidents by segment of each road and lane blockage**

![Chart showing distribution of incidents by segment and lane blockage for different roads.](chart.png)
Part B: Delay Reduction Estimation

Step 2: Estimate the total delay by segment for each major road

Input

Distribution of incidents by segment of each road and lane blockage

Incident duration by lane blockage for the segment of each road
Part B: Delay Reduction Estimation

Step 2: Estimate the total delay by segment for each major road

Input
- Distribution of incidents by segment of each road and lane blockage
- Incident duration by lane blockage for the segment of each road
- AADT by segment of each road, Truck %, PHF
- Number of lanes for the segment of each road, etc.

Output
- The delay by lane blockage for each segment of each major road
- The total delay by segment for each major road

Delay Function
Part B: Delay Reduction Estimation

**Step 3:** Estimate the total delay for major roads

- The total delay by segment for each major road (Step 2)
- Total number of incidents for each major road
- Distribution of incidents by lane blockage
- The total delay for each major road

*For those incidents with all needed information*
Part B: Delay Reduction Estimation

Step 4: Estimate the total delay for all roads in MD

- The delay by lane blockage for each segment of each major road (Step 2)
  - Average delay for incidents with one or two lane blockage
  - Number of incidents on non-major roads

The total delay for non-major roads

The total delay for major road (Step 3)

Total Delay with CHART
Part B: Delay Reduction Estimation

- **Step 5:** Estimate the total delay reduction due to CHART operations

Delay reduction due to CHART: \( (T\text{-Delay})_{\text{w/o CHART}} - (T\text{-Delay})_{\text{w CHART}} \)

- Total I-delay with CHART (A)
- Total I-delay without CHART (B)
- Total I-delay Reduction Due to CHART (B-A)

Ratio difference in avg. incident duration
Part B: Ratio Difference in IDs

Incident Durations: w CHART and w/o CHART

<table>
<thead>
<tr>
<th>Blockage</th>
<th>With CHART</th>
<th></th>
<th>Without CHART</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Duration</td>
<td>Frequency</td>
<td>Duration</td>
<td>Frequency</td>
</tr>
<tr>
<td>Shoulder (SH)</td>
<td>22.79</td>
<td>4,633</td>
<td>30.75</td>
<td>577</td>
</tr>
<tr>
<td>1 lane</td>
<td>26.30</td>
<td>8,813</td>
<td>34.53</td>
<td>544</td>
</tr>
<tr>
<td>2 lanes</td>
<td>37.80</td>
<td>2,728</td>
<td>42.44</td>
<td>201</td>
</tr>
<tr>
<td>3 lanes</td>
<td>43.56</td>
<td>777</td>
<td>53.38</td>
<td>61</td>
</tr>
<tr>
<td>&gt;=4 lanes</td>
<td>46.93</td>
<td>363</td>
<td>62.71</td>
<td>20</td>
</tr>
<tr>
<td>Unknown</td>
<td>18.72</td>
<td>7,661</td>
<td>30.78</td>
<td>1,374</td>
</tr>
<tr>
<td>Weighted Average w/o SH</td>
<td>30.42</td>
<td>12,681</td>
<td>38.53</td>
<td>826</td>
</tr>
<tr>
<td>All</td>
<td>25.42</td>
<td>24,975</td>
<td>33.08</td>
<td>2,777</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Blockage</th>
<th>With CHART</th>
<th></th>
<th>Without CHART</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Duration</td>
<td>Frequency</td>
<td>Duration</td>
<td>Frequency</td>
</tr>
<tr>
<td>Shoulder (SH)</td>
<td>21.32</td>
<td>7,273</td>
<td>30.77</td>
<td>1,284</td>
</tr>
<tr>
<td>1 lane</td>
<td>23.55</td>
<td>13,834</td>
<td>32.47</td>
<td>1,211</td>
</tr>
<tr>
<td>2 lanes</td>
<td>37.80</td>
<td>2,728</td>
<td>42.44</td>
<td>201</td>
</tr>
<tr>
<td>3 lanes</td>
<td>43.56</td>
<td>777</td>
<td>53.38</td>
<td>61</td>
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<td>363</td>
<td>62.71</td>
<td>20</td>
</tr>
<tr>
<td>Unknown</td>
<td>30.75</td>
<td>1,374</td>
<td>30.77</td>
<td>1,284</td>
</tr>
<tr>
<td>Weighted Average w/o SH</td>
<td>27.10</td>
<td>17,702</td>
<td>35.07</td>
<td>1,493</td>
</tr>
<tr>
<td>All</td>
<td>25.42</td>
<td>24,975</td>
<td>33.08</td>
<td>2,777</td>
</tr>
</tbody>
</table>

Ratio difference in ID:
\[
\frac{(35.07-27.10)}{35.0}=22.73\%
Part B: Benefit Estimation

Reduction in Incident Duration Due to CHART Operation

Direct Benefits

- Delay reduction
- Fuel consumption
- Emissions

Secondary incidents

Risks at primary incident sites

Frequency

Impacts
Part B: Fuel Consumption

❖ Estimate **Reduction** in Fuel Consumption
  - Method 1: from the results of simulation

\[
\Delta Fuel = e^{-10.77} \times (\text{Traffic Volume})^{2.27} \\
\times \left(\frac{\text{No. of Lane Blocked}}{\text{Total No. of Lanes}}\right)^{0.9} \times (\text{Incident Duration})^{1.69}
\]

❖ Method 2: conversion from the total delay reduction
Part B: Benefit Estimation

Direct Benefits

- Delay reduction
- Fuel consumption
- Emissions

Reduction in Incident Duration Due to CHART Operation

Secondary incidents

Impacts

Frequency

Risks at primary incident sites
Part B: Emission Reduction

Estimate Reduction in Emission

Total Delay Reduction

- **HC**: 13.073 grams / hour of delay
  - $6,700 / ton

- **CO**: 146.831 grams / hour of delay
  - $6,360 / ton

- **NO**: 6.261 grams per hour of delay
  - $12,875 / ton

Fuel Consumption Reduction

- **CO2**: 19.564 lbs / gallon of gasoline
  - 22.384 lbs / gallon of diesel
  - $23 / metric ton

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1. MDOT in Year 2000
2. Literature (DeCorla-Souza, 1998)
3. Energy Information Administration
Part B: Benefit Estimation

- References for converting the reduction into the monetary values
  - Truck driver’s unit cost is based on the information from the Bureau of Labor Statistics in year 2018.
  - Car driver’s unit cost is based on household income by the U.S. Census Bureau (2018).
  - The gasoline and diesel unit costs are from the Energy Information Administration in year 2018.
  - The fuel consumption was computed based on the rate of 0.156 gallons of gas per hour for passenger cars from the Ohio Air Quality Development Authority and the rate of 0.85 gallon per hour for trucks from the literature “Heavy-Duty Truck Idling Characteristics-Results from a Nationwide Truck Survey” by Lutsey et al. and the Environmental Protection Agency (EPA).
  - The unit rates of 19.56 lbs CO2/gallon of gasoline and 22.38 lbs CO2/gallon of diesel are from the Energy Information Administration and $23/metric ton of CO2 from CBO (Congressional Budget Office)’s cost estimate for S. 2191, America’s Climate Security Act of 2007.
### Direct Benefits in Year 2018 (Year 2017)

<table>
<thead>
<tr>
<th>Reduction due to CHART</th>
<th>Amount</th>
<th>Unit rate</th>
<th>Dollars (million)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Delay (M veh-hrs)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Truck</td>
<td>1.51</td>
<td>DRIVER: $21.18/hr</td>
<td>32.09 (34.09)</td>
</tr>
<tr>
<td></td>
<td>(1.64)</td>
<td>(20.79)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>CARGO: $45.40/hr</td>
<td>68.68 (74.45)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(34.99)</td>
<td></td>
</tr>
<tr>
<td>Car</td>
<td>30.75</td>
<td>$36.94/hr</td>
<td>1,155.87 (1,294.01)</td>
</tr>
<tr>
<td></td>
<td>(29.57)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fuel Consumption (M gallons)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Car</td>
<td>6.23</td>
<td>GASOLINE: $2.82/gal</td>
<td>17.84 (19.01)</td>
</tr>
<tr>
<td></td>
<td>(6.39)</td>
<td>DIESEL: $3.18/gal</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Emission (tons)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HC</td>
<td>428.88</td>
<td>$6,700/ton</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(504.92)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>4,816.98</td>
<td>$6,360/ton</td>
<td>37.45 (44.07)</td>
</tr>
<tr>
<td></td>
<td>(5,671.12)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO</td>
<td>205.40</td>
<td>$12,875/ton</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(241.82)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂</td>
<td>56,382.46</td>
<td>$23/metric ton³</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(565,355.70)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total (M dollars)</td>
<td></td>
<td></td>
<td>1,311.89 (1,465.62)</td>
</tr>
</tbody>
</table>

- The number in each parenthesis is the data in year 2017.
- All values are rounded to the nearest hundredth in this table only for the presentation purpose, since the actual values need more spaces to be presented. For example, the benefit from truck drivers = 15,128,829.2394 veh-hr * $21.18/hr = $ 320,428,603.29…
Part B: Sensitivity Analysis

- Computing **the marginal impacts of each key factor**, using its 2018 value, but setting all other factors identical to those in 2017

- **Key factors**
  - Total Number of Incidents Eligible for Benefit Estimate
  - Average Incident Durations with and without CHART
  - The adjusted AADTs (with PHF) for Major Roads
  - Truck Percentages for Major Roads

<table>
<thead>
<tr>
<th>Key Factor</th>
<th>Δ ('17 - '18)</th>
<th>Benefit Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of incidents</td>
<td>↑ 10.86 %</td>
<td>1,580.05 (↑ 7.81%)</td>
</tr>
<tr>
<td>Incident duration difference between w/ and w/o CHART</td>
<td>↓ 28.24 %</td>
<td>1,111.22 (↓ 24.18%)</td>
</tr>
<tr>
<td>Adjusted AADT</td>
<td>↓ 0.31 %</td>
<td>1,467.59 (↑ 0.13%)</td>
</tr>
<tr>
<td>Truck percentage</td>
<td>↑ 1.57 %</td>
<td>1,465.87 (↑ 0.02%)</td>
</tr>
</tbody>
</table>

Benefits of the Previous Year (2017) 1,465.62

Benefits of the Current Year (2018) 1,311.89 (↓ 10.49%)
Part B: Benefit Estimation

Reduction in Incident Duration Due to CHART Operation

Direct Benefits

- Delay reduction
- Fuel consumption
- Emissions

Secondary incidents

Risks at primary incident sites

Frequency

Impacts
Part B: Secondary Incidents

Secondary Incidents in Year 2018

- Reported number of secondary incidents

Diagram showing the cumulative number of secondary incidents over time and distance from the primary incident.
Part B: Secondary Incidents

- Reported secondary incident (1,467)
- Ratio reduction in average ID (22.72%)
- The estimated number of secondary incidents without CHART/MSHA = 1,898
- Reduced Secondary Incident 1,897-1,467=431
Part B: Benefit Estimation

Direct Benefits

- Delay reduction
- Fuel consumption
- Emissions

Reduction in Incident Duration Due to CHART Operation

Secondary incidents

Frequency

Impacts

Risks at primary incident sites
Part B: Potential Incidents

Risks at primary incident sites

- No. & Type of blockages per peak-hours per day
- Daily Peak-volumes
- Δ Blockage Duration w/ & w/o CHART
- No. of lane changes within peak period
- Length of a segment
- No. of incidents during peak period

Number of lane changes at Incident scene

Lane changes to incident Ratio

Number of potential incidents reduced by CHART operations due to effective removal of vehicles
Part B: Potential Incidents

- Potentially reduced Incidents due to CHART Operations

<table>
<thead>
<tr>
<th>Road Name</th>
<th>I-495/95</th>
<th>I-95</th>
<th>I-270</th>
<th>I-695</th>
<th>I-70</th>
<th>I-83</th>
<th>MD-295</th>
<th>US-50</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mileage</td>
<td>41</td>
<td>63</td>
<td>32</td>
<td>44</td>
<td>13</td>
<td>34</td>
<td>30</td>
<td>42</td>
<td>849</td>
</tr>
<tr>
<td>2018</td>
<td>173</td>
<td>231</td>
<td>57</td>
<td>184</td>
<td>74</td>
<td>33</td>
<td>28</td>
<td>69</td>
<td>849</td>
</tr>
<tr>
<td>2017</td>
<td>229</td>
<td>212</td>
<td>62</td>
<td>207</td>
<td>79</td>
<td>45</td>
<td>23</td>
<td>98</td>
<td>955</td>
</tr>
<tr>
<td>2016</td>
<td>228</td>
<td>264</td>
<td>58</td>
<td>223</td>
<td>88</td>
<td>47</td>
<td>29</td>
<td>94</td>
<td>1,031</td>
</tr>
<tr>
<td>2015</td>
<td>185</td>
<td>213</td>
<td>45</td>
<td>161</td>
<td>60</td>
<td>34</td>
<td>24</td>
<td>75</td>
<td>797</td>
</tr>
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<td>2014</td>
<td>203</td>
<td>231</td>
<td>48</td>
<td>149</td>
<td>72</td>
<td>44</td>
<td>30</td>
<td>71</td>
<td>848</td>
</tr>
</tbody>
</table>
Thank you

Questions?
Visit http://chartinput.umd.edu
or Email at gang@umd.edu or hmkim@umd.edu