Safety Evaluation of Cable Barrier Installations on BC Highways

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CARSP 2018 June 10-13 Victoria, BC
Background

A High Tension Cable Barrier is a barrier that consists of 3 or 4-strand high tension cables that is designed to contain and redirect vehicles that leave the road.

- Cross-median and off-road collisions result in serious injuries and death
- Off-road and crossover head-on collisions ≈ 42% of all serious collisions. i.e. injury + fatal on provincial highways
Median Cable Barrier: Reported Benefits

- Texas - prevented 98% cross-over crashes
- Wyoming - reduced fatal (44%) and serious (12%) collisions
- Washington - reduced fatal and serious collisions by 72%
- Florida - contained light trucks (79.9%) and heavy trucks (64.3%) collisions
- Severity ↓, Overall collisions ↑ (24%) for MCB (HSM)
Highway 1 – Median Installation
Cable Barrier After a Collision

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Rockwell Drive – Roadside Installation

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Study Overview

- Researched safety benefits and existing studies
- Gathered collision history for cable barrier locations
Methodology

• Data Collection
  - Treatment Sites: 3 Median Cable Barrier and 2 Roadside Cable Barrier sites
  - Reference Sites: RAU4, RFD4
  - Before and after collision and traffic volume data (6 years)

• Analysis
  - Simple before and after
  - Empirical Bayes
Median Cable Barrier Sites

Highway 99 South of Richmond

Highway 99 South of White Rock

Highway 1 East of Chilliwack
Roadside Cable Barrier Sites

Highway 97 North of Osoyoos Lake

Highway 97 South of Penticton
# Evaluation Sites

<table>
<thead>
<tr>
<th>Section ID</th>
<th>Evaluation Group</th>
<th>Road Class</th>
<th>Hwy #</th>
<th>L (km)</th>
<th>Barrier Type</th>
<th>Installation Date</th>
<th>Before Period Start</th>
<th>ADT (Before)</th>
<th>After Period Start</th>
<th>ADT (After)</th>
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Simple Before and After

**Median Cable Barrier Sections**

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<th>Before</th>
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<td>Total_SC</td>
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<tr>
<td>Truck_SC</td>
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<tr>
<td>ORL+ HO_SC</td>
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<td>20</td>
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<tr>
<td>Trucks_SC (HO+ORL)</td>
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<td>2</td>
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**Roadside Cable Barrier Sections**

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
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</thead>
<tbody>
<tr>
<td>Total_SC</td>
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<td>Truck_SC</td>
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<tr>
<td>ORR_SC</td>
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<tr>
<td>Trucks_SC (ORR)</td>
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## Simple Before and After

<table>
<thead>
<tr>
<th>Barrier Type</th>
<th>SC</th>
<th>Truck SC</th>
<th>ORL+ HO SC</th>
<th>ORR</th>
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<tbody>
<tr>
<td></td>
<td>CF*</td>
<td>CR**</td>
<td>CF</td>
<td>CR</td>
</tr>
<tr>
<td>MCB</td>
<td>10.0%</td>
<td>-6.4%</td>
<td>-26.1%</td>
<td>-37.1%</td>
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<tr>
<td>RCB</td>
<td>-75.0%</td>
<td>-76.4%</td>
<td>-100.0%</td>
<td>-100.0%</td>
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</table>

* CF = Collision Frequency

** CR = Collision Rate
Empirical Bayes Method

\[ O.R. = \frac{D}{\hat{B}} \]

\[ E(O.R.) = \frac{O.R.}{(1 + \frac{Var(\hat{B})}{\hat{B}^2})} \]

Where:

\( \hat{B} \) = EB safety estimate of collisions in the treatment group had no treatment taken place during post improvement period,

\( D \) = Observed number of collisions in the treatment group during post improvement period.

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Empirical Bayes Method

\[
EB_i = \gamma_i \cdot \mu_i + (1 - \gamma_i) \cdot y_i
\]

\[
Var(EB_i) = \gamma_i \cdot (1 - \gamma_i) \cdot \mu_i + (1 - \gamma_i)^2 \cdot y_i
\]

\[
\gamma_i = \frac{1}{1 + \frac{\mu_i}{k}}
\]

Where:

\( y_i \) = Observed collisions in the before period for location \( i \)

\( \gamma_i \) = Weight assigned to the predicted value for location \( I \)

\( k \) = Dispersion parameter of the negative binomial model

\( \mu_i \) = Expected annual mean collision frequency (Collisions/ year) on location \( i \)
Empirical Bayes Method

\[ \hat{B} = (EB_i)_a = (EB_i)_b \times \frac{(\mu_i)_a}{(\mu_i)_b} \]

\[ Var(\hat{B}) = Var(EB_i)_a = Var(EB_i)_b \times \left[ \frac{(\mu_i)_a}{(\mu_i)_b} \right]^2 \]

Where:

\((EB_i)_a\) = EB safety estimate of treated site \(i\) in the “after” period had no treatment taken place.

\((EB_i)_b\) = EB safety estimate of treated site \(i\) in the “before” period.

\((\mu_i)_a\) = Expected mean collision frequency given by the SPF for a treated site
Safety Performance Functions (SPFs) Development

- Mathematical models
- 3 Evaluation groups (2 MCB + 1 RCB)
- 3 Collisions types
  - All serious collisions
  - Truck serious collisions
  - Off road serious collisions

- 9 Safety Performance Functions
A general functional form is:

\[ \mu_i = a_0 \cdot AADT^{a_1} \cdot L^{a_2} \]

**Where:**

- \( y \): Expected Collision Frequency per n years
- \( AADT \): Annual Average Daily Traffic
- \( L \): Section Length
Safety Evaluation Summary

- Median Cable Barrier
  - Reduction of 21.7% in all Serious Collisions
  - Reduction of 53.8% in Truck Serious Collisions
  - Reduction of 34.8% in ORL+HO Serious Collisions
Safety Evaluation Summary

- Roadside Cable Barrier
  - Reduction of 74.7% in all Serious Collisions
  - Reduction of 100% in Truck Serious Collisions
  - Reduction of 100% in ORR Serious Collisions
Safety Evaluation Summary

<table>
<thead>
<tr>
<th>Group ID</th>
<th>Hwy #</th>
<th>Barrier Type</th>
<th>Length (km)</th>
<th>Serious Collisions</th>
<th>Truck SC</th>
<th>ORL+ HO SC</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Change (%)</td>
<td>p-value</td>
<td>Change (%)</td>
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<td>1</td>
<td>1</td>
<td>MCB</td>
<td>5.8</td>
<td>-21.7% ± 11.6%</td>
<td>0.06</td>
<td>-53.8% ± 13.2%</td>
</tr>
<tr>
<td>2</td>
<td>99</td>
<td>MCB</td>
<td>46.5</td>
<td>-74.7% ± 28.0%</td>
<td>0.01</td>
<td>-100% ± 0.0%</td>
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Impact of After-Implementation Period

No. of Evaluation Years

1  2  3  4  5

Change in Safety Effect Over Time

- Change in Safety Effect  - LL  - UL

*All Serious Collisions – Median Cable Barrier

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Impact of After-Implementation Period

*All Serious Collisions – Median Cable Barrier

Change in Safety Effect Over Time
### Proposed Collision Modification Factors

**CMF Recommended Values for MCB**

<table>
<thead>
<tr>
<th>Collision Type</th>
<th>Severity Type</th>
<th>CMF</th>
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<tbody>
<tr>
<td>Median, Cross-median</td>
<td>Fatal, and All Injuries</td>
<td>0.72</td>
</tr>
<tr>
<td>Head On, Cross-median</td>
<td>All</td>
<td>0.52</td>
</tr>
<tr>
<td>All</td>
<td>Fatal, and All Injuries</td>
<td>0.76</td>
</tr>
<tr>
<td>Trucks</td>
<td>Fatal, and All Injuries</td>
<td>0.46</td>
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Summary & Conclusions

- Cable barriers have performed successfully in BC
- Placement of the system is key to maximizing the performance
- The safety effect stabilized after the first implementation year with some fluctuations over 2-5 years
- The findings of this study were compared to other Collision Modification Factors (CMFs) in the literature
- A recommendation was given on the best values to be used
Questions???!
Highway 1 – Median Installation
Cable Barriers: *Cost*

- Cost of installation is comparable to other barrier types.
- Cost is dependent on installation length & site conditions.
- Median installation cost for Highway 1 near Chilliwack was $116/linear meter (3 km installation length).
Cable Barrier After a Collision

Highway 1 – At Lickman Overpass

24/09/2011
Cable Barrier After a Collision

Highway 1 – Chilliwack