Applying Traffic Engineering Tools to Resource Road Safety

FPInnovations Webinar

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Researcher – Roads and Infrastructure
Responding to members’ needs

BC Forests, Lands, Natural Resource Operations & Rural Development, industrial resource road operators

**NEED:**
Systematic and objective methodology to assess safety of resource roads

Road: quantification of safety
Vehicles: assess safe traffic capacity

Traffic Engineering
Traffic engineering components

**Vehicle Data**
- Collection methods
- Safety analysis
  - Now/future **safe capacity**
  - Traffic mitigation methods

**Road Data**
- Collection methods
- Analysis methods
- Cost issues
- Refinement of collection, analysis, and reporting
Overview of presentation

Theory:
  ▫ Need for field data collection, traffic microsimulation

Traffic data:
  ▫ Tools used, costs, limitations, post-processing

Microsimulation:
  ▫ How traffic field data fits, workflow, possible analyses

Conclusions:
  ▫ Benefits, questions, your insights, conversation
Calibrating your crash data to crash data database

“Safe Capacity”

“Level of service” based on measures of effectiveness
Theory: related fields

Requires crash data for CMFs and SPFs (not available)

“Safe Capacity” of resource roads

Better safety ≠ Better level of service
Theory: capacity

Capacity: hard to measure directly

Capacity analysis: considers a “prescribed” level of operation
Theory: level of service – multilane highway

*LOS*: “[quantitative] quality measure describing operational conditions within a traffic stream, generally in terms of such service measures as:

- speed/travel time
- Freedom to maneuver
- Traffic interruptions
- Comfort and convenience”

- HCM
Theory: LOS – multilane highway

Free flow speed

Operation at/above posted speed

Operation at posted speed, good maneuverability, good comfort

Operation at/near posted speed, maneuverability noticeably restricted

Operation speed starts to decline, reduced comfort

Operation at capacity, maneuverability very limited, poor comfort

Operation is in a flow breakdown

Always 6 LOS levels

first five are “operational”

sixth is a “fail”

Images from: http://www.mdta.maryland.gov/I95section100DELETE/i95-sect100_los.html
Theory: measures of effectiveness

- MOE metrics used by LOS
- MOE: many kinds
- Different MOE for various infrastructure

<table>
<thead>
<tr>
<th></th>
<th>Speed</th>
<th>Density</th>
<th>PTSF</th>
<th>Delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multilane Highway</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two Lane Highway</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Urban street</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intersection</td>
<td></td>
<td></td>
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<td>X</td>
</tr>
</tbody>
</table>

PTSF = percent time spent following
Theory: LOS – two-lane highway
## Theory: LOS – two-lane highway

### Exhibit 12-5. Example Service Volumes for Multilane Highways
*(See footnote for assumed values)*

<table>
<thead>
<tr>
<th>FFS (km/h)</th>
<th>Number of Lanes</th>
<th>Terrain</th>
<th>Service Volumes (veh/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>100</td>
<td>2</td>
<td>Level</td>
<td>1200</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rolling</td>
<td>1140</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mountainous</td>
<td>1040</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>Level</td>
<td>1800</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rolling</td>
<td>1710</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mountainous</td>
<td>1570</td>
</tr>
<tr>
<td>80</td>
<td>2</td>
<td>Level</td>
<td>960</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rolling</td>
<td>910</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mountainous</td>
<td>830</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Level</td>
<td>1440</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rolling</td>
<td>1370</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mountainous</td>
<td>1250</td>
</tr>
</tbody>
</table>

**Notes:**
- Assumptions: highway with 100-km/h FFS has 5 access points/km; highway with 80-km/h FFS has 15 access points/km; lane width = 3.6 m; shoulder width > 1.8 m; divided highway; PHF = 0.88; 5 percent trucks; and regular commuters.
Theory: LOS – interrupted flow

<table>
<thead>
<tr>
<th>Urban Street Class</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range of free-flow speeds (FFS)</td>
<td>90 to 70 km/h</td>
<td>70 to 55 km/h</td>
<td>55 to 50 km/h</td>
<td>55 to 40 km/h</td>
</tr>
<tr>
<td>Typical FFS</td>
<td>80 km/h</td>
<td>65 km/h</td>
<td>55 km/h</td>
<td>45 km/h</td>
</tr>
<tr>
<td>LOS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>&gt; 72</td>
<td>&gt; 59</td>
<td>&gt; 50</td>
<td>&gt; 41</td>
</tr>
<tr>
<td>B</td>
<td>&gt; 56–72</td>
<td>&gt; 50</td>
<td>&gt; 50–59</td>
<td>&gt; 32–41</td>
</tr>
<tr>
<td>C</td>
<td>&gt; 40–56</td>
<td>&gt; 40–59</td>
<td>&gt; 32–59</td>
<td>&gt; 23–32</td>
</tr>
<tr>
<td>D</td>
<td>&gt; 32–40</td>
<td>&gt; 30–40</td>
<td>&gt; 23–32</td>
<td>&gt; 18–23</td>
</tr>
<tr>
<td>E</td>
<td>&gt; 26–32</td>
<td>&gt; 26–32</td>
<td>&gt; 18–23</td>
<td>&gt; 14–18</td>
</tr>
<tr>
<td>F</td>
<td>≤ 26</td>
<td>≤ 26</td>
<td>≤ 26</td>
<td>≤ 14</td>
</tr>
</tbody>
</table>

**EXHIBIT 15-2. URBAN STREET LOS BY CLASS**

**Average Travel Speed (km/h)**

<table>
<thead>
<tr>
<th>Urban Street Class</th>
<th>Default (signals/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0.5</td>
</tr>
<tr>
<td>II</td>
<td>2</td>
</tr>
<tr>
<td>III</td>
<td>4</td>
</tr>
<tr>
<td>IV</td>
<td>6</td>
</tr>
</tbody>
</table>
Theory: what about a resource road?

- Does not deal with weather, large grades, passing lanes, narrow bridges...
- Points to traffic simulation for more complex situations

Measuring traffic characteristics (MOE) → Simulation

"As is" Analysis → "What if" Analysis
**Theory: traffic metrics related to safety**

- Roads with radio-controlled one lane sections:
  - Number of pullout occurrences
  - Total time spent stopped at pullouts (delay)
  - Number of pullout overcrowding events

- General metrics for any road:
  - Percent time spent following
  - Number of passing occurrences
  - Average speed and variance
  - Vehicle type classification
  - Average traffic volumes per hour

**How to get all this data... economically?**
Traffic data: magnetic counters

- Relatively inexpensive ($400)
- TrafX is industry standard
- Not always reliable

- Count
Traffic data: radar

- On straight part of road, facing particular angle, clear shot
- $5000 +

- Spot speed
- Direction
- Vehicle length
Traffic data: radar post-processing

Insights:
- Traffic flow patterns over time of day
- Distribution of spot speed for vehicle length categories
- Headway distribution/percent vehicle following (1 second time resolution)
- ...
Traffic data: radar post-processing

- **Summer**: 84.5 km/h
  - 70 km/h

- **Winter**: 86 km/h
  - 72 km/h
Traffic data: motion cameras

- Tested four motion cameras ($150 - $700):
  - produced timekeeping
  - unreliable in capturing fast vehicles or vehicles that are following other
Traffic data: motion cameras post-processing

**Summer**

Avg. time in pullout: **74 s**

**Winter**

Avg. time in pullout: **116 s**
Traffic data: video cameras

- Camera + SD card + waterproofing + battery (as low as $300)

- Capture all traffic reliably with relatively little time drift
Traffic data: video post-processing

- Speeds for types of vehicle over a road segment
- Bus was passed by two cars
- Passing is observable
Traffic data: video post-processing
Traffic data: video post-processing
Traffic data: video post-processing

- Change detection
- Training data
Traffic data: video post-processing
Traffic data: video post-processing
Microsimulation: data collection needs

Finlay FSR (60KM)  Florence FSR (8KM)  Bamfield Main (7KM)

Various tools:
- Roadside sensors
- GPS mapping
- Interviews
- GPS on trucks

Left out ~ 1 week
Need input and validation data

Interior BC
Industrial traffic
One lane sections

Coastal BC
Recreational traffic
Four one lane bridges

Coastal BC
Mixed traffic
One lane section
“[Traffic] Micosimulation models are dynamic, stochastic, discrete time modelling techniques that simulate the movement of individual vehicles based on car-following, lane changing and gap acceptance algorithms that are updated several times every seconds. These vehicle-to-vehicle interactions provide the basis for calculating delays”

Microsimulation: process

1. **Verification:**
   - Making sure there are no logic errors in the model (using general observation/knowledge)

2. **Calibration:**
   - Iterating model parameters so that output variable matches the field observations

3. **Validation:**
   - Use field data that was not used during calibration as a final check of road model

4. **Output:**
   - Run many simulations to create average and variance for metrics of interest
Microsimulation: tool developed

- pullout rules / conditions
- radio calls – supports % without radios
- slowing down/pulling over for loaded vehicles
- counting statistics unique to resource roads
- defining behaviors of various vehicles
- scripts that automate building Aimsun models

API was developed to accommodate radio pullout use.
Microsimulation: entire workflow

Traffic data and Field mapping
↓
Cleaning/preparing all data
↓
Aimsun scripts to automate building models
↓
Calibrate simulation
↓
Make change and generate output metrics of interest
Microsimulation: entire workflow

Traffic data and Field mapping

Cleaning/preparing all data

Aimsun scripts to automate building models

Calibrate simulation

Make change and generate output metrics of interest

Main input:
Traffic count, vehicle classification

Other inputs:
grades, hills, GPS from trucks

Calibration to observed:
travel time, pullout use, passing frequency
Microsimulation: output examples
Microsimulation: output examples

Scenario A: circled section is a single lane

Scenario B: circled section becomes two lanes

<table>
<thead>
<tr>
<th>Stop time (s)</th>
<th>Travel time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 hour simulation</td>
<td>1 hour simulation</td>
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</tbody>
</table>

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Microsimulation: qualitative aspects

Workshops: key safety traffic metrics (MOE)
- Percent time spent following
- Average/proportion of time in pullouts
- Number of pullout overcrowding occurrences

LOS: what are the thresholds for
BAD, OK, GOOD for each MOE?
Conclusions: benefits

Analysis of field data only
- Speed profiles of different vehicle types
- Improving road asset database (widths, pullouts, etc)
- Confirmation of users (road use agreements)

Using field data to drive traffic microsimulation
- Test effects of different scheduling
- Test effect of road improvements
- Test effects of increased traffic volumes

<table>
<thead>
<tr>
<th>Safety</th>
<th>Finance</th>
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</thead>
<tbody>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>X</td>
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</tbody>
</table>
Conclusions: future

Work this year in BC

- Florence calibration in progress: UBC; methodology being finalized
- Bamfield study now has all field work done
  - Video post-processing will be tested
  - Calibration to follow – with passing
  - Looking at detailed vehicle classification

Further in the future...

- The API tool will work for anyone with an Aimsun license
  - Does not yet support platoons.. future?
- Video post-processing – lots could be done.. future?
- Motion cameras – keep eye on..
- Comparing traffic metrics between study locations may yield interesting results
Cooperators

This year we are working closely with UBC in building simulations on Bamfield road with the help of Island Timberlands

BC FLNRO
NR Canada
Aimsun
UBC – Radio Science Lab
Island Timberlands

FPIInnovations:
Al Bradley
Dawson Markle
Mithun Shetty
Glen Legere
Blane Grann

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