# Can traffic conflicts be used to estimate road safety? Research effort at UBC

**Emanuele Sacchi**

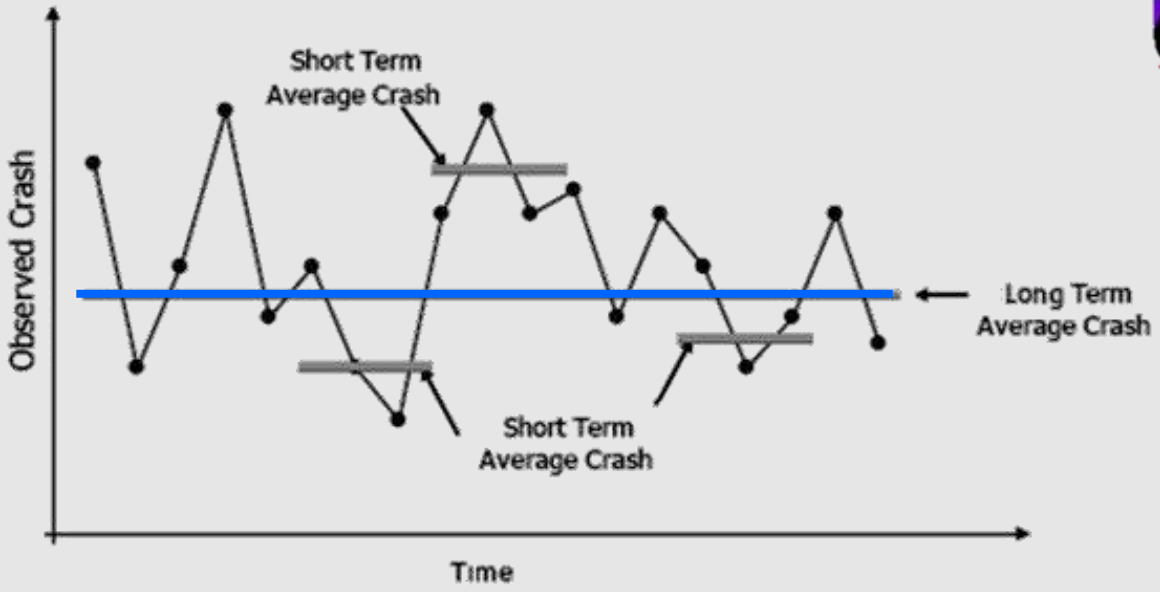
Postdoctoral Fellow

Department of Civil Engineering

# Introduction

- **A collision event is used as a fundamental indicator of safety**

**It results in injury or property damage**



# Introduction

***Estimate of Road Safety***

=

***Estimate of long-term average collision frequency of a road site, under a given set of geometric design and traffic volumes in a given time period (Hauer, 1997)***

**Example of road safety measures:**

**observed collisions over 3 years**

**predicted collision frequency from safety performance functions**

**posterior distribution of collision frequency from Bayesian methods**

**…**

# Collision Data

## Shortcomings

- ✓ **Collision records are in many cases incomplete and lack important details**
- ✓ **Collisions are rare events**

  **It is often necessary to observe collisions over a prolonged period to reach statistically valid results**

- ✓ **Confounding factors (regression to the mean, …)**
- ✓ **Reactive approach**

# Collision-based Safety Evaluations

- ✓ **Road safety studies based on collision data rely on solid statistical techniques which were developed over two decades of research**

- ✓ **Wide literature on Collision prediction models (Safety Performance Functions)**

**Mathematical form of CPMs/SPFs:**

- e.g., road segments

traffic exposure

$$E(Y) = e^{a_0} \cdot L^{a_1} \cdot V_1^{a_2} \cdot e^{\sum_{j=1}^{m} b_j x_j}$$

coefficients to be estimated through regression analysis

# Alternative Safety Measures

**Also known as “surrogate” measures**

**Definition**

**1. Must be based on an observable non-crash event that is physically related in a predictable and reliable way to collisions**

**AND**

**2. There exists a practical method for converting the non-crash events into a corresponding crash frequency**

# Traffic Conflicts

***"An observable situation in which two or more road users approach each other in space and time for such an extent that there is a risk of collision if their movements remain unchanged"***

- **Traffic conflict represents the most commonly used surrogate safety measure.**

- **Time-to-collision (TTC) indicator**

# TTC Estimation

Figure 22. Conflict observer in chair.

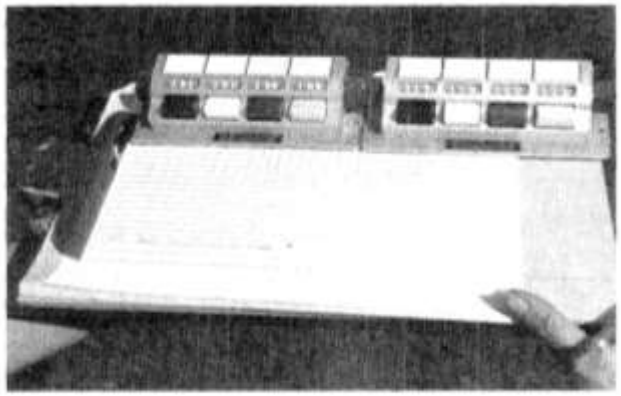
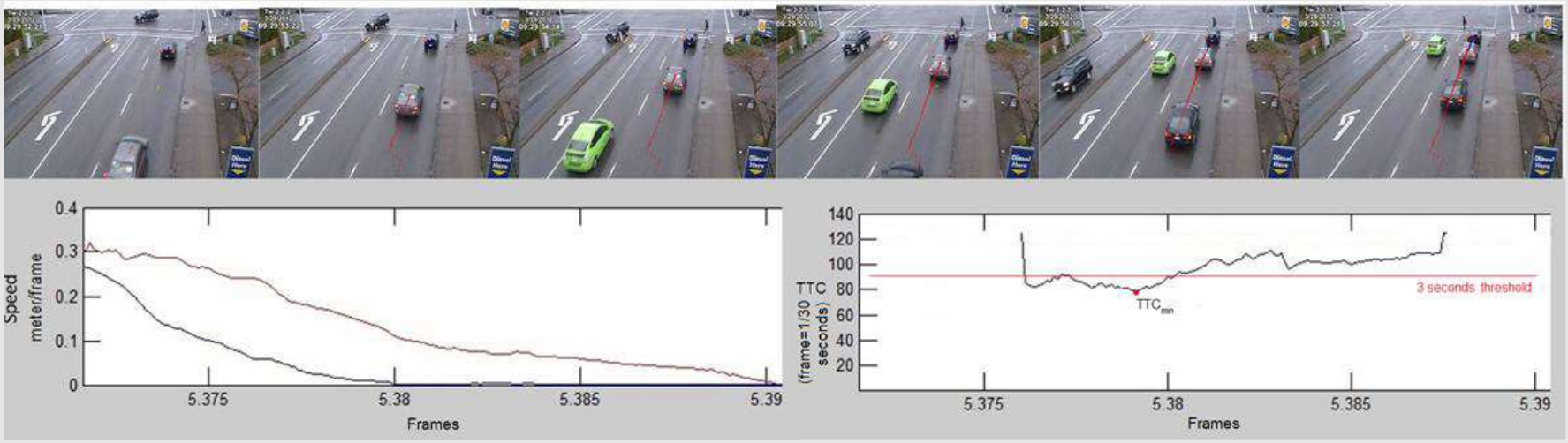


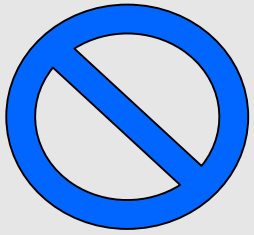
Figure 24. Traffic conflict count board.



# Can Traffic Conflicts Be Used To Estimate Road Safety?

**2. There exists a practical method for converting the non-crash events into a corresponding crash frequency**

- **The link between conflict reduction and potential collision reduction still needs to be clearly established**

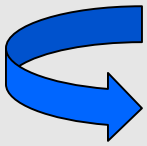


**The correlation between conflicts and collisions is weak, or can vary from site to site**

**Some very recent research has shown models which convert conflicts into collision frequency but results are not uniform**

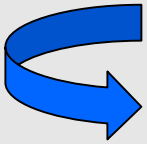
# Research Effort At UBC

1. **Comparison of collision-based evaluation with the results of a traffic conflict-based evaluation based on the same set of treatment intersections**



***Countermeasure: Smart channel***
***Case study: Penticton (BC)***

2. **Transferring the statistical techniques developed for collision-based safety evaluations to surrogates such as traffic conflicts**

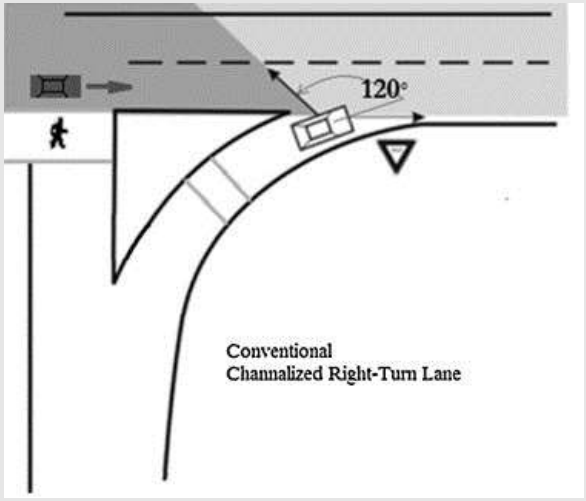


***Case study: Surrey (BC)***

# Smart Channels

**Channelized right turns**

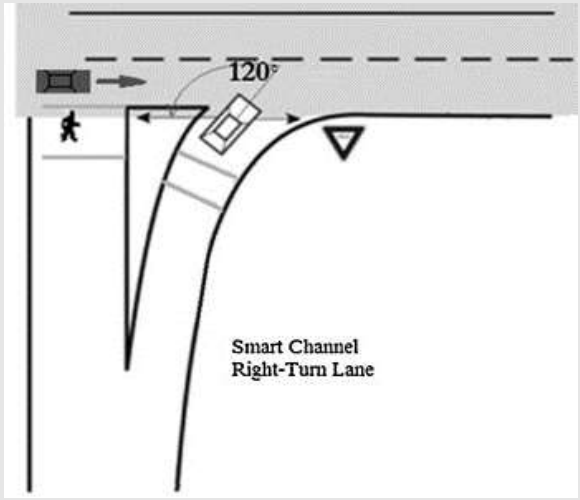
**implemented at intersections with high right-turn traffic volumes to reduce vehicle delay**




**"Smart" channel**

**alternative right-turn design more pedestrian-friendly**

**Drivers are provided with a better view of the traffic stream they are to merge with**



# Project Goals

**At first, a before-and-after evaluation using traffic conflicts was carried out for 3 smart channels in Penticton (Autey, Sayed et al., 2012)**

- **BA study using collision and traffic volume data for the same treated intersections and state-of-the-art statistical technique**
- **Compare the results of the collision-based evaluation and the conflict-based evaluation conducted earlier to validate traffic conflict technique**
- **Better understanding of the link between road safety (collisions) and conflicts**

# Review Of Data Sources


- **3 treated, 14 control and 6 comparison sites**

  a) comparison sites: site right-turn channel not improved

  b) control sites: nearby intersections comparable for geographic proximity and comparability to a treatment site.

- **Traffic volumes from 2007 to 2011**

- **Collision data (PDO and F+I) gathered in time frames of 1 and 4 months**

- **Months of implementation removed (summer 2010)**

# Full Bayesian Evaluation (I)

- **Collision reduction from OR**
- **OR = 1 no change; OR< 1 safety improvement**
- **OR= $\frac{A/C}{B/D}$**
- **Poisson-lognormal intervention model (advanced SPF)**

$$Y_{it}|\theta_{it} \sim \text{Poisson}\,(\theta_{it})$$

$$\ln\,(\theta_{it}) = \ln\,(\mu_{it}) + \varepsilon_i$$

$$\ln\,(\mu_{it}) = \alpha_0 + \alpha_1 T_i + \alpha_2 t + \alpha_3 [t - (t_{B,i} + 1)] I_{it} + \alpha_4 T_i t + \alpha_5 T_i [t - (t_{B,i} + 1)] I_{it} + \alpha_6 T_i I_{it} + \beta_1 \ln\,(V_{1,it}) + \beta_2 \ln\,(V_{2,it})$$

with

$$\varepsilon_i \sim \text{Normal}\,(0, \sigma_\varepsilon^2)$$

coefficients to be estimated with MCMC techniques

# Full Bayesian Evaluation (II)

**Account for confounding factors:**

- ✓ **Exposure effect**
- ✓ **Regression-to-the-mean phenomenon**
- ✓ **Unrelated effects**
- ✓ **Trend effects**

**Type of models developed:**

- ✓ **Univariate Analysis**
- ✓ **Multivariate Analysis**
- ✓ **Analysis with Matched Pair Sites**

**"Best" models selected for comparison**

# Results Comparison

- **Collisions versus traffic conflicts reduction**

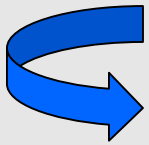
| Intersection/severity | Traffic conflicts (average hourly conflicts) | Collisions (on 4-month basis) |
|---|---|---|
| T1 – Channel/Green | 33% | 36.4%[a] |
| T2 – Channel/Warren | 57% | 65.1%[a] |
| T3 – Channel/Duncan | 55% | 55.1%[a] |
| Overall | 51% | 55.6%[a] |
| | | |
| Total severity | Conflict severity: 41% | PDO: 67.5%[b] |
| | | F + I: 47.6%[b] |

a PLNI model with matched pairs.

b MPLNI model.

# Discussion

- ✓ **The similarity of overall and location-specific reductions in conflicts and collisions was remarkable**



**This provides strong support for using traffic conflicts in BA studies**

- ✓ **Proportionality constant ≈ 1**

- ✓ **Limits of the evaluation (TTC<3 s, other conflict indicators, other safety countermeasures …)**

# Second Project: Goals

**Transferring the statistical techniques developed for collision-based safety evaluations to surrogates such as traffic conflicts**

**We introduced traffic conflicts in place of collision data in the statistical models used for road safety evaluations**

# Data (rear-end conflicts)

- **Automatic extraction of conflicts from 8 video cameras for 2 signalized intersections in Surrey**
- **Data was gathered only during daytime hours (approximately 7 AM to 8 PM) in two different days**
- **Traffic conflicts were defined by using the TTC conflict indicator**

# Conflicts-based SPFs

$$Y_{it}|\theta_{it} \sim \text{Poisson}\,(\theta_{it})$$

$$\ln\,(\theta_{it}) = \ln\,(\mu_{it}) + \varepsilon_i$$

Hourly traffic volume

Length of count of conflicts

$$\mu_t = \exp(\beta_0) \cdot V_t^{\beta_1} \cdot \exp(\beta_2 L_t)$$

coefficients to be estimated through regression analysis

# Estimated Model Parameters

| Distribution | Variable | Parameter | Mean | Standard Deviation |
|---|---|---|---|---|
| Poisson-Gamma | Intercept | $\beta_0$ | -6.756 | 1.17 |
| | Traffic volume | $\beta_1$ | 1.25 | 0.171 |
| | Length | $\beta_2$ | 0.006 | 0.002 |
| | Overdispersion | $\kappa$ | 1.718 | 0.196 |
| | Dispersion | $1/\kappa$ | 0.589 | 0.066 |
| | Deviance information criteria | DIC | Value= 1096.98 | |
| Poisson-Lognormal | Intercept | $\beta_0$ | -5.59 | 1.115 |
| | Traffic volume | $\beta_1$ | 1.198 | 0.169 |
| | Length | $\beta_2$ | 0.005 | 0.003 |
| | extra-Poisson variation | $\sigma_\varepsilon$ | 0.803 | 0.051 |
| | Deviance information criteria | DIC | Value=1105.19 | |

# Model validation

- ✓ **Global goodness-of-fit tests based on Bayesian p-values were performed**

$$\text{Bayes p-value} = \Pr\left[T(Y_{t,rep}, \beta) \geq T(Y_{t,}, \beta) | Y_t\right]$$

**probability that the simulated (replicated) data set, $Y_{t,rep}$, could be more extreme than the observed one, $Y_t$**

**$T_1$: global measure of lack of fit (i.e., sums-of-squares residuals)**

**$T_2$: fit in the upper tail of the distribution (i.e., max value)**

| Poisson-Gamma Model | Bayesian p-value | |
|---|---|---|
| | $T_1$ | $T_2$ |
| Surrey - data set I | 0.392 | 0.760 |

# Conclusions

- ✓ **Conflict-based SPFs were successfully developed using Bayesian statistical techniques**
- ✓ **The results demonstrated that the Poisson-Gamma model always outperformed the Log-Normal**
- ✓ **The number of conflicts involving lane changes or braking at intersections increases more rapidly than traffic volume**
- ✓ **A first framework toward the development of a promising field of conflict-based evaluations alternative to collision-based ones was provided**

# Questions