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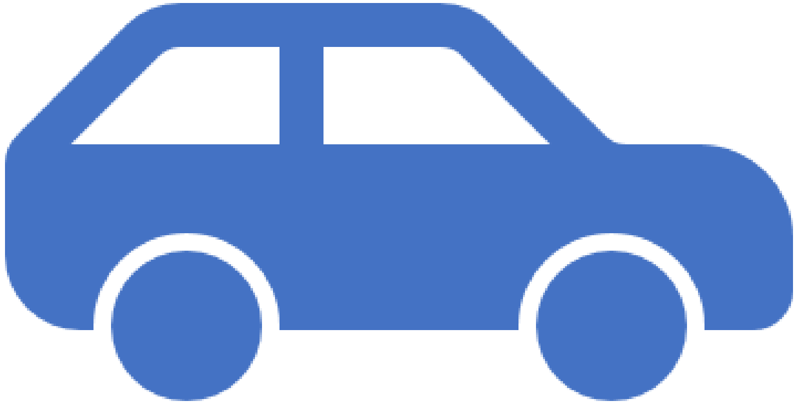

Issues in Developing and Applying Crash-Conflict Models

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Motivation

- Vision Zero – City of Toronto: Eliminate traffic-related fatalities and serious injuries, e.g., through:
  - Red Light Cameras
  - Automated Speed Enforcement
  - VRU measures such as
    - Leading Pedestrian Intervals,
    - bike lanes
    - Left turn hardening
  - Speed Limit Reduction
- Planning and evaluation process for innovative strategies may be challenging, as prior information may not exist.
- Challenge could be addressed with the use of surrogate measures, such as traffic conflicts.
- Statistical models relating crashes to conflicts are fundamental to this application.

Objectives/Research Approach

- Investigate key issues in the development and application of crash-conflict models for safety assessments
  - model specification
  - definition of conflicts
  - model transferability
  - use of models for estimating of crash modification factors (CMFs)
- Model specification and conflict definition Issues are addressed with a case study
  - four-legged signalized intersections in the City of Toronto.
  - traffic conflicts identified from time to collision (TTC) and post encroachment time (PET) generated from microsimulation
- Transferability of models to another jurisdiction investigated by estimating calibration factors and assessing goodness-of-fit.
- Application for CMF estimation investigated with hypothetical left turn protection treatment.

Surrogate Safety Measures

SURROGATE SAFETY MEASURE	DESCRIPTION
Time-to-Collision (TTC)	TTC is the necessary time for two vehicles to collide if they continue at the same speed and path.
Post-Encroachment Time (PET)	PET is the difference in time when the first vehicle leaves a position and the second vehicle subsequently arrives at that position.
Maximum Speed (MaxS)	Maximum speed recorded of either vehicle during the conflict.
First/Second VMinTTC	Speed of the first and second vehicle respectively observed at the TTC.

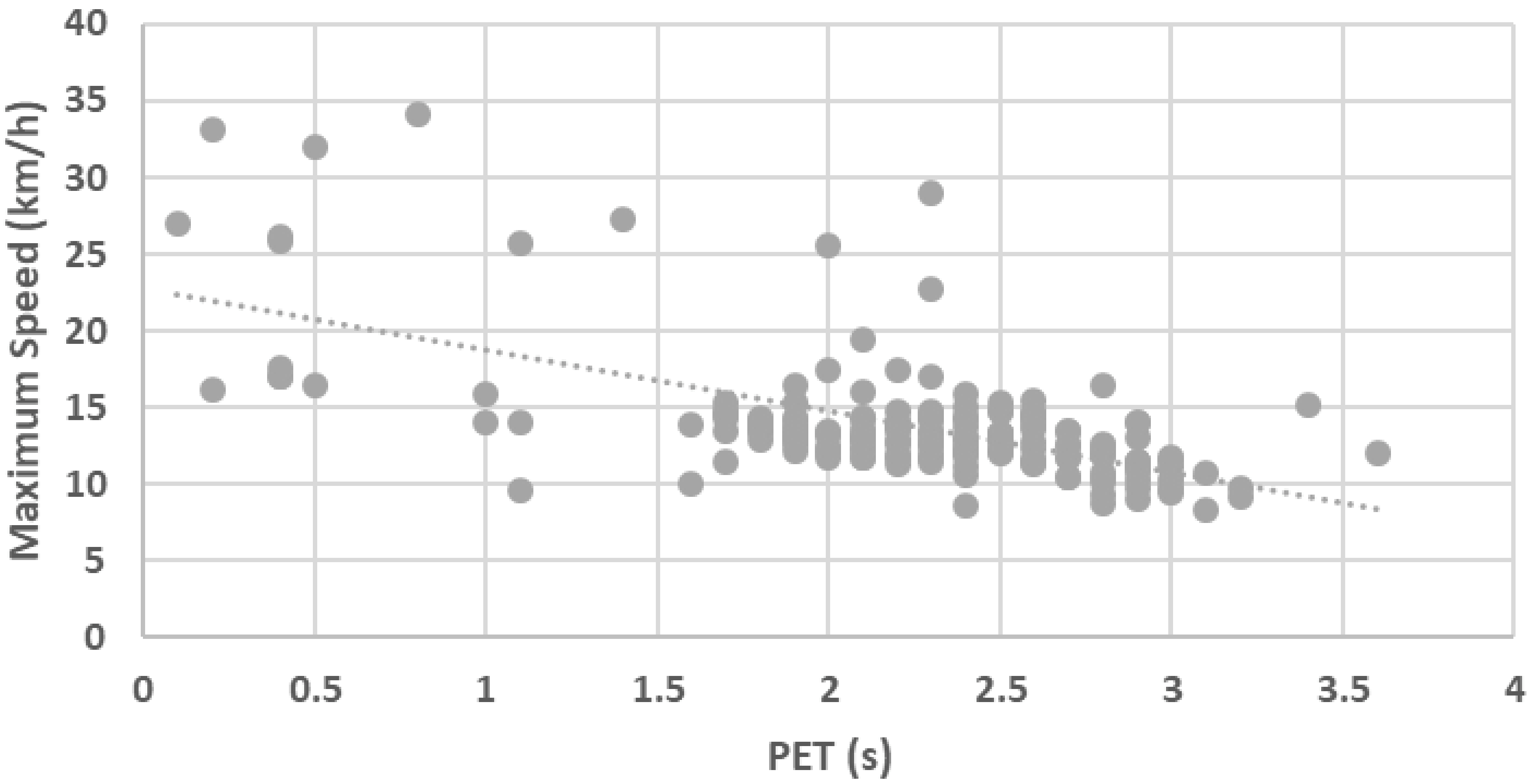
Methodology

Synchro and VISTRO	Design each Intersection (91 four-legged signalized intersections)
VISSIM	Simulation of Intersections
SSAM	Estimation of Traffic Conflicts
SAS	Crash Prediction Modelling (5 years crashes; Generalized linear modeling
The Calibrator	Transferability of CPMs to another Canadian jurisdiction

Peak Hour Conflict Statistics

Conflict Threshold	Conflicts	Average Speed	Maximum Speed
PET 5 sec	179.09	26.75	32.70
PET 2.5 sec	108.83	26.36	32.23
TTC 1 sec	17.80	28.96	33.85
TTC 0.5 sec	3.30	34.11	37.66

Maximum Speed vs. PET for a Sample Intersection



Crash - Conflict Relationship	PET 2.5 sec					TTC 0.5 sec				
	Crash - Conflict	Total - Total		Injury - Total		Crash - Conflict	Total - Total		Injury - Total	
Crash - Conflict Model	Coefficient	Estimate	$Pr > \chi^2$	Estimate	$Pr > \chi^2$	Coefficient	Estimate	$Pr > \chi^2$	Estimate	$Pr > \chi^2$
	α	0.7501	0.1761	-0.1559	0.774	α	2.5225	<.0001	1.1488	<.0001
	β_1	0.4333	0.0003	0.3254	0.0056	β_1	0.2447	0.0002	0.2141	0.0011
	K	0.246		0.2048		K	0.2467		0.1975	
Crash - Conflict and Average Speed Model	Coefficient	Estimate	$Pr > \chi^2$	Estimate	$Pr > \chi^2$	Coefficient	Estimate	$Pr > \chi^2$	Estimate	$Pr > \chi^2$
	α	-3.0989	0.0337	-4.4347	0.0027	α	1.0874	0.0341	-0.2026	0.7429
	β_1	0.67	<.0001	0.5754	<.0001	β_1	0.2492	<.0001	0.2176	0.0007
	β_2	0.8467	0.0048	0.9595	0.0021	β_2	0.4066	0.005	0.3832	0.0276
	K	0.2271		0.1809		K	0.2315		0.1857	
Crash - Conflict and Maximum Speed Model	Coefficient	Estimate	$Pr > \chi^2$	Estimate	$Pr > \chi^2$	Coefficient	Estimate	$Pr > \chi^2$	Estimate	$Pr > \chi^2$
	α	-2.5079	0.0976	-4.1153	0.0071	α	1.134	0.0302	-0.1767	0.776
	β_1	0.6188	<.0001	0.5393	<.0001	β_1	0.2428	0.0001	0.2112	0.001
	β_2	0.6951	0.0216	0.8596	0.0059	β_2	0.3841	0.0078	0.3669	0.0316
	K	0.2331		0.1855		K	0.233		0.1864	

Crash – Conflict Models (PET ≤ 2.5 sec) (TTC ≤ 0.5 sec)

$$Crashes/year = e^{\alpha} * (Conflicts)^{\beta_1}$$

$$Crashes/year = e^{\alpha} * (Conflicts)^{\beta_1} * (Average\ Speed)^{\beta_2}$$

$$Crashes/year = e^{\alpha} * (Conflicts)^{\beta_1} * (Maximum\ Speed)^{\beta_2}$$

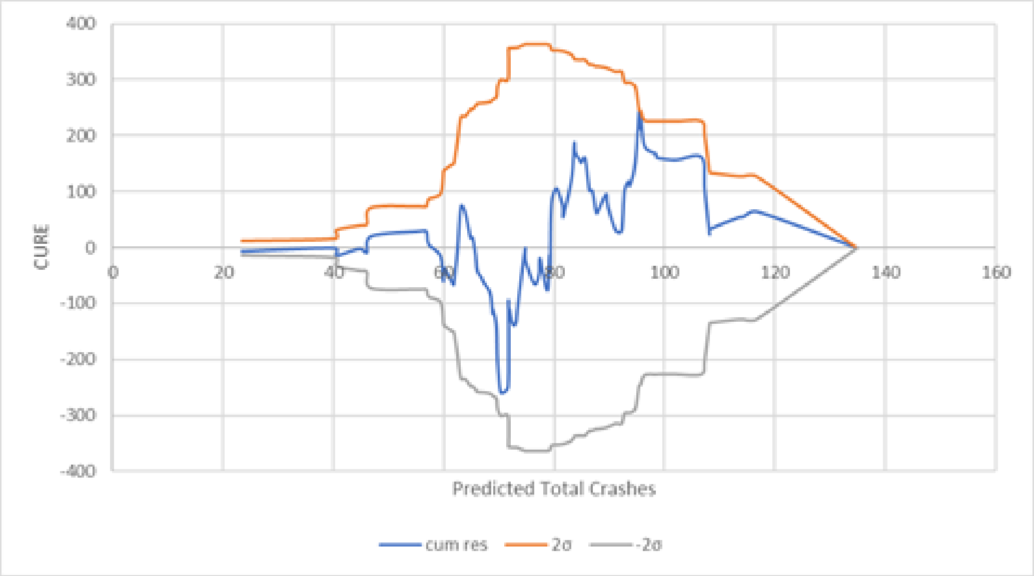
PET 2.5 sec				
Crash - Conflict	Total - Total		Injury - Total	
Coefficient	Estimate	$\mathbf{Pr} > \chi^2$	Estimate	$\mathbf{Pr} > \chi^2$
$\boldsymbol{\alpha}$	2.3469	<.0001	1.0107	<.0001
$\boldsymbol{\beta_1}$	0.1084	0.0525	0.1023	0.0587
$\boldsymbol{\beta_2}$	0.1729	0.0198	0.1197	0.0876
RS	365		480	
K	0.2397		0.2011	

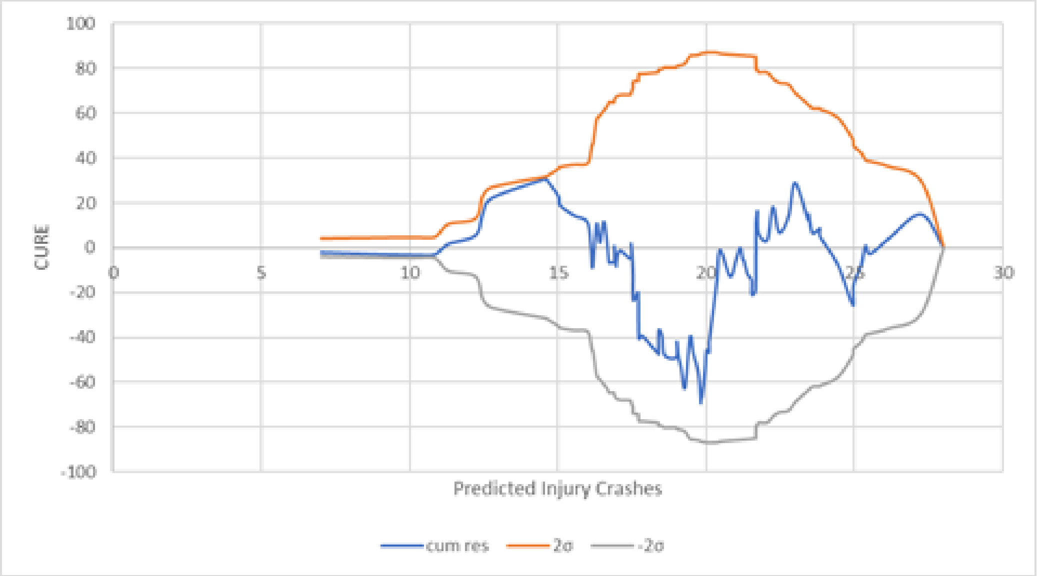
Link Function and Risk Score Approach (PET ≤ 2.5 sec)

$$Risk\ Score = \frac{Speed\ of\ First\ Vehicle + Speed\ of\ Second\ Vehicle}{PET}$$

$$Crashes = e^{\alpha} * (Conflicts < x)^{\beta_1} * (Conflicts > x)^{\beta_2} * Years$$

X = Specified Risk Score Threshold





Cumulative Residual Plots for Models Based on a PET threshold of 2.5 sec

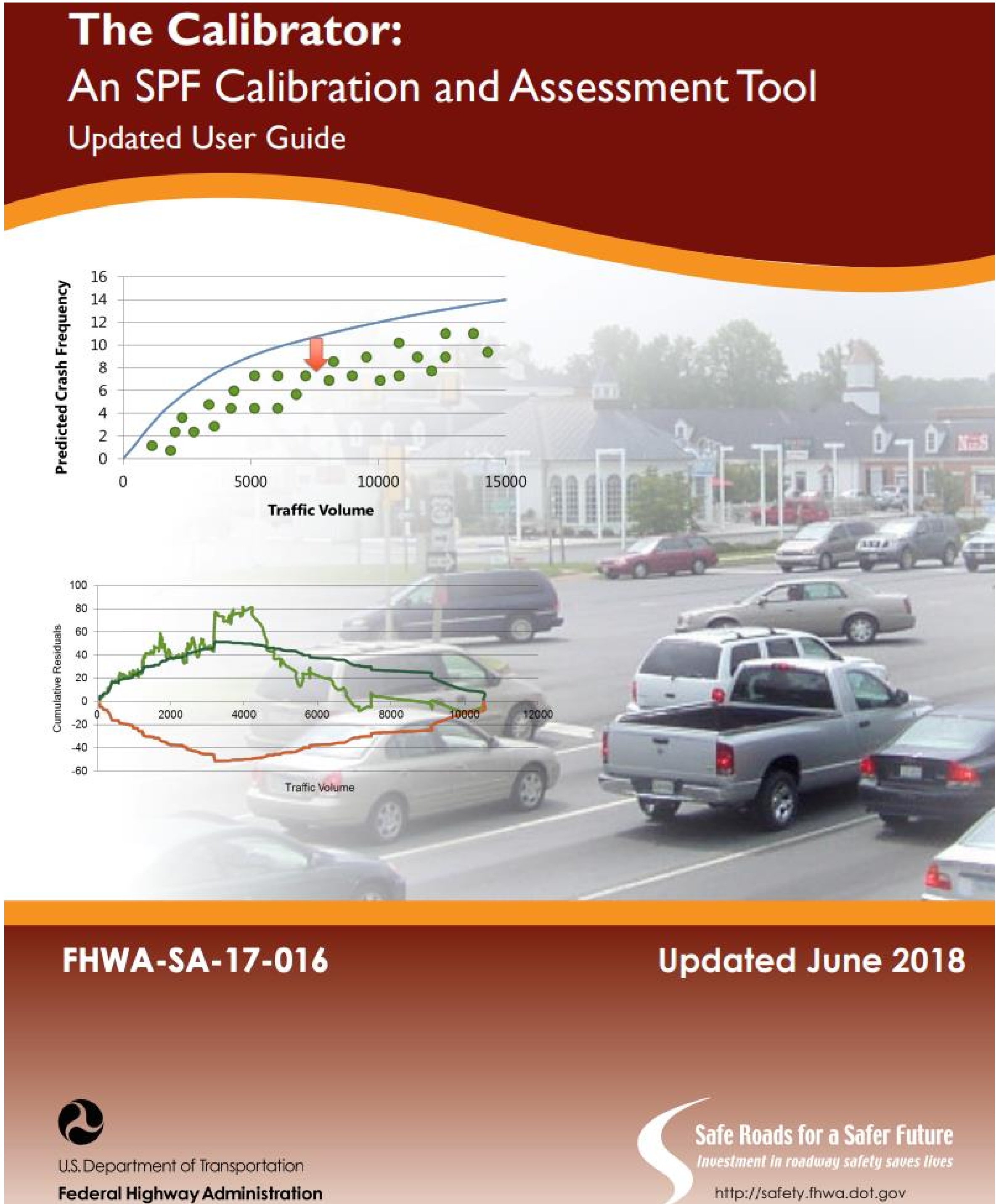
Key Findings from Models

- Models that incorporate the PET threshold tend to be slightly better.
- Models with the 2.5 sec. PET threshold tend to be better than those with the 5 sec. threshold.

- The addition of the speed results in a better model.
- The average speed variable tends to perform better than the maximum speed variable.
- Most speed-based models indicate a stronger effect of speed for injury crashes than for total crashes.

- Risk Score approach produced insignificant models with TTC threshold
- Coefficient for PET conflicts classed as more severe by risk score is larger than that for less severe ones.

York Region –Transferability results
(using FHWA Calibrator Software)
https://safety.fhwa.dot.gov/rsdp/downloads/fhwasa17016updated0618.pdf



York Region –Transferability results (using FHWA Calibrator Software)

Transferability Results – Injury Crash Models (PET < 2.5 sec)

Crash - Conflict	Injury - Total			Preferred Values
	Conflict Model	Conflict- Average Speed	Conflict Maximum Speed	
Crashes Observed	162	162	162	-
Crashes Predicted	220.1	204.75	209.91	-
Calibration Factor	0.74	0.79	0.77	Around 1
V(C)	0.03	0.04	0.04	Small
CV(C)	0.25	0.26	0.26	Less than 0.15
Modified R^2	0.29	0.3	0.28	Large
MAD	7.25	7.02	7.08	Small
Dispersion	0.43	0.46	0.46	Small
Max Cure Deviation	29.04	25.11	25.98	Small
% Cure Deviation	0.00%	7.69%	0.00%	Less than 5%
AIC	-558.74	-558.13	-558.11	Small
BIC	-558.18	-557.57	-557.54	Small

Application of Hypothetical Safety Treatment

10 City of Toronto Intersections

Change Left Turn Phase from Permissive to Permissive-Protected

Estimated CMFs with Application of Hypothetical Left Turn Treatment

- Phasing of the intersections was modified in Synchro
- Simulation was performed in VISSIM ➔ conflicts generated
- Crash - Conflict and Average Speed models with a PET of 5 sec.

were used to estimate crashes before and after treatment and CMFs.

	Total Crashes	Injury Crashes
Average predicted crashes/year before treatment	14.36	3.47
Average predicted crashes/year after treatment	12.26	2.98
Average CMF	0.85	0.86
Minimum value of CMF	0.67	0.71
Maximum value of CMF	0.96	0.96

- Separate CMFs could be estimated for each intersection
- Average CMFs were consistent with CMFs from crash-based before-after studies

Questions