Probability of Secondary Crash Occurrence on Freeways using Private Sector Speed Data

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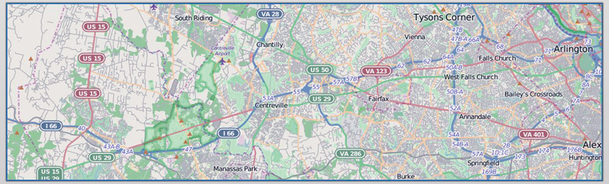
INTRODUCTION

- Secondary crashes occur near other incidents, either due to driver distraction from the primary incident, or when vehicles encounter an unexpected queue.
- Likelihood of secondary crashes is not well understood.
  - Previous studies used static spatial and/or temporal boundaries to classify secondary crashes.
  - Findings in the literature rarely considered both incident duration and empirical queue lengths.

OBJECTIVES

- Develop a methodology to classify crashes as secondary using incident durations and private sector travel time data.
- Determine the probability model of secondary crash occurrence based on the primary incident's duration, congestion levels, and traffic demand.

STUDY AREA



Incident Summary Statistics

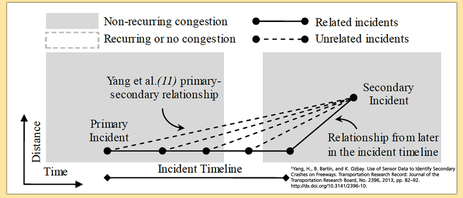
Incident Type	Duration (minutes)					Sample Size
	Mean	Median	Standard Dev.	Maximum	Minimum	
Collision	55.6	52	31.9	369	1	2466
Disabled Vehicle	26.7	18	27.4	518	1	5882
Fire	49.3	54	37.7	82	7	4
Vehicle Fire	53.5	43	41.5	214	7	46
Incident	23.7	18	23.8	190	1	374

METHODS AND FINDINGS

Previous approaches attempt to link a primary incident and secondary crashes through completely nonrecurring congestion in time and space.

Our approach relaxes these requirements, allowing less than 100% nonrecurring congestion, and allowing relationships from anywhere on the incident timeline.

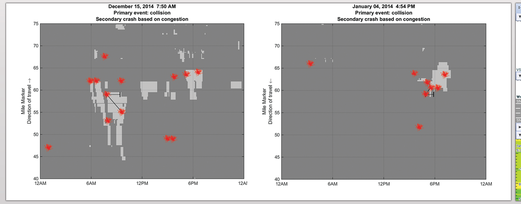
Visualizing Time-Space Incident Relationships



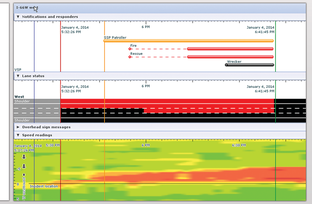
Comparison of Classification Approaches

Approach	Primary Incident Type	Prim.-Sec. Non-recurring Congestion	Proximity Crash Times Boundary	Number Secondary Crashes	Secondary Crashes as Percentage of Total Crashes
Yang et al.	Crashes-only	100%	Static	104	4.19%
	Any	100%	Static	200	8.05%
Goodall	Crashes-only	100%	Static	161	6.48%
	Any	100%	Static	267	10.75%
	Crashes-only	> 90%	Static	183	7.37%
	Any	> 90%	Static	306	12.32%
	Crashes-only	> 90%	Incident Duration	228	9.16%
	Any	> 90%	Incident Duration	342	13.79%

Incidents with <100% Congested Timeline

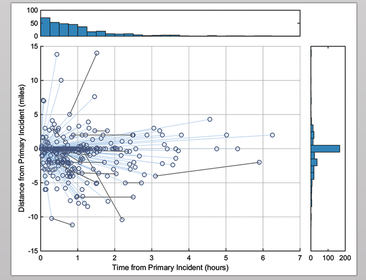


Primary Incident with Late-Forming Congestion

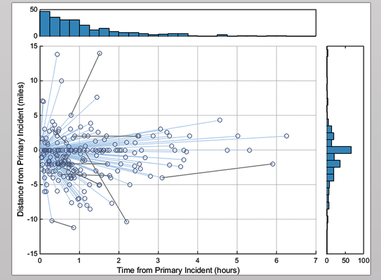


Secondary and Tertiary Crashes According to Time and Distance from Primary Incident

All Secondary Crashes



Queue Crashes Only



MODELING PROBABILITY OF SECONDARY CRASH

$$P(s) = \frac{e^{Y}}{1 + e^{Y}}$$

P(s) = probability of a secondary crash occurring

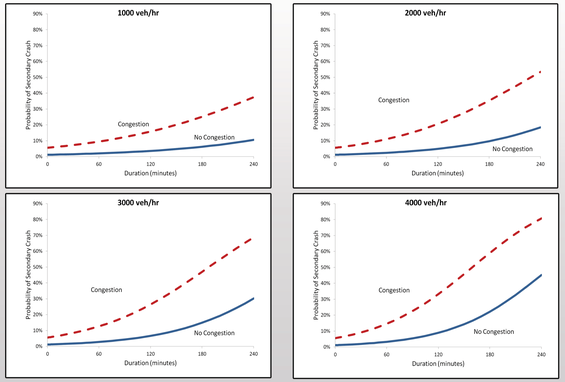
Y is defined as: For $\begin{cases} C = 0; Y + -4.459 + 0.006985t + 0.000162d \\ C = 1; Y + -2.836 + 0.006985t + 0.000162d \end{cases}$

C = 1 indicates presence of congestion (speed < 30% historical average)

t = incident duration in minutes

D = total number of vehicles that have encountered the incident or its queue

Estimated Probability of Secondary Crash at Various Demands



CONTRIBUTIONS

1. Secondary crash classification strategy that uses widely-available private sector travel time data.
2. Methodological improvements on previous secondary crash classification techniques, by using empirical queues, incident durations, and congestion.
3. A simple model of crash probability using the most relevant factors.
4. A rule-of-thumb estimate of increased secondary crash risk with time on-scene, which can be used by incident responders as a training tool.

CONCLUSIONS

- 9.2% of all vehicle crashes were secondary to another incident
- 6.2% of secondary crashes were tertiary to another primary incident
- Findings support a fast incident response, as the model predicts that the probability of secondary crash occurrence increases approximately one percentage point for every ad-ditional 2-3 minutes spent on-scene in high-volume scenarios.