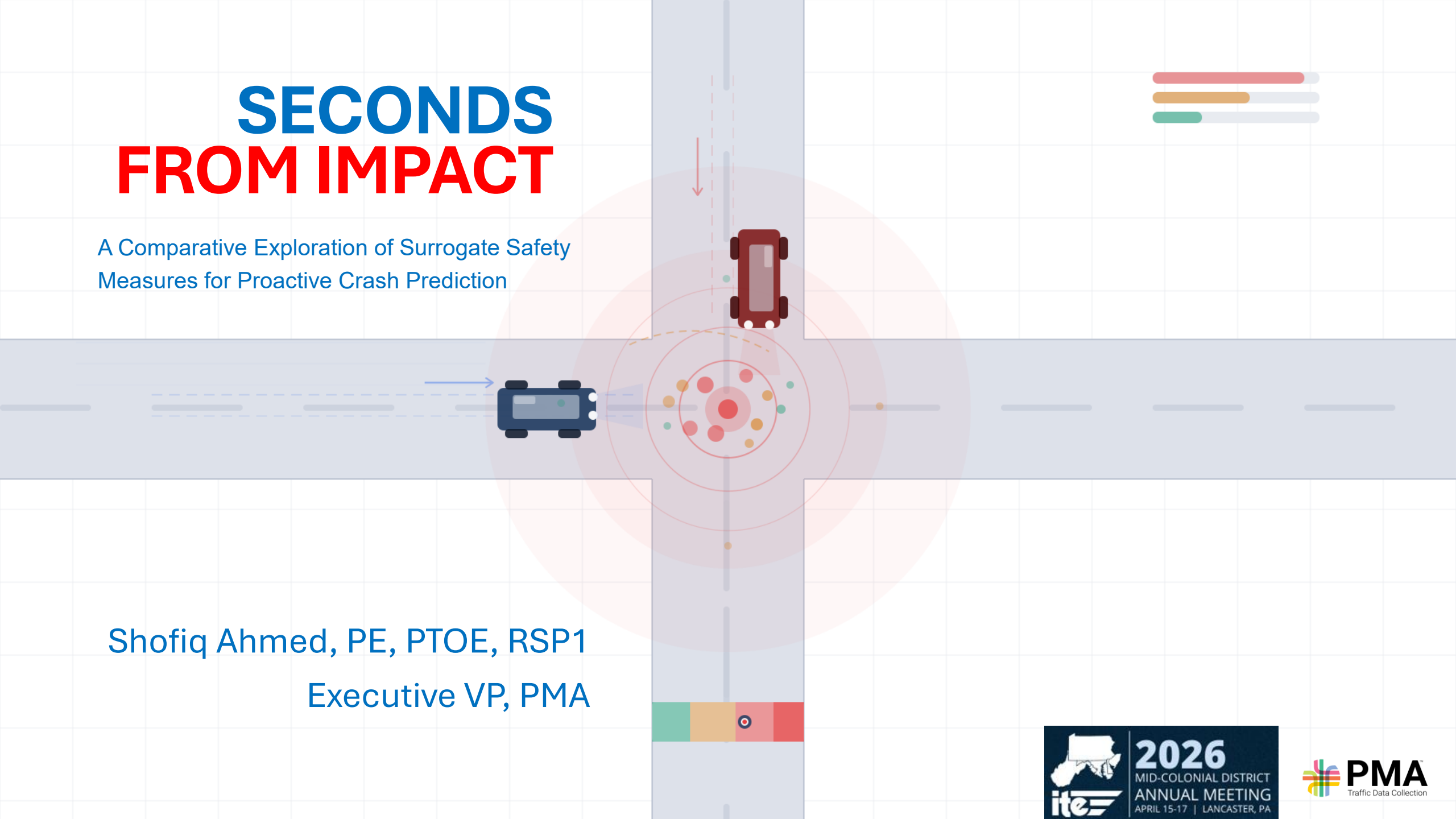


SECONDS FROM IMPACT

A Comparative Exploration of Surrogate Safety
Measures for Proactive Crash Prediction



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Outline

- Near Miss Analysis
- Performance Metrics
- Strength/Weakness
- Engineering Opinion

Near Miss Analysis

From Observation to Measurement

1967-68

**Perkins & Harris
(GM Research
Labs)**

Traffic Conflicts
Technique (TCT)
first formalized.

1972

**Hayward
(Penn State)**

TTC introduced as
objective danger
measure.

1984

**ICTCT
International**

Formal conflict
definition adopted
globally.

1987

**Hydén
(Lund Univ.)**

Swedish TCT
methodology
standardized.

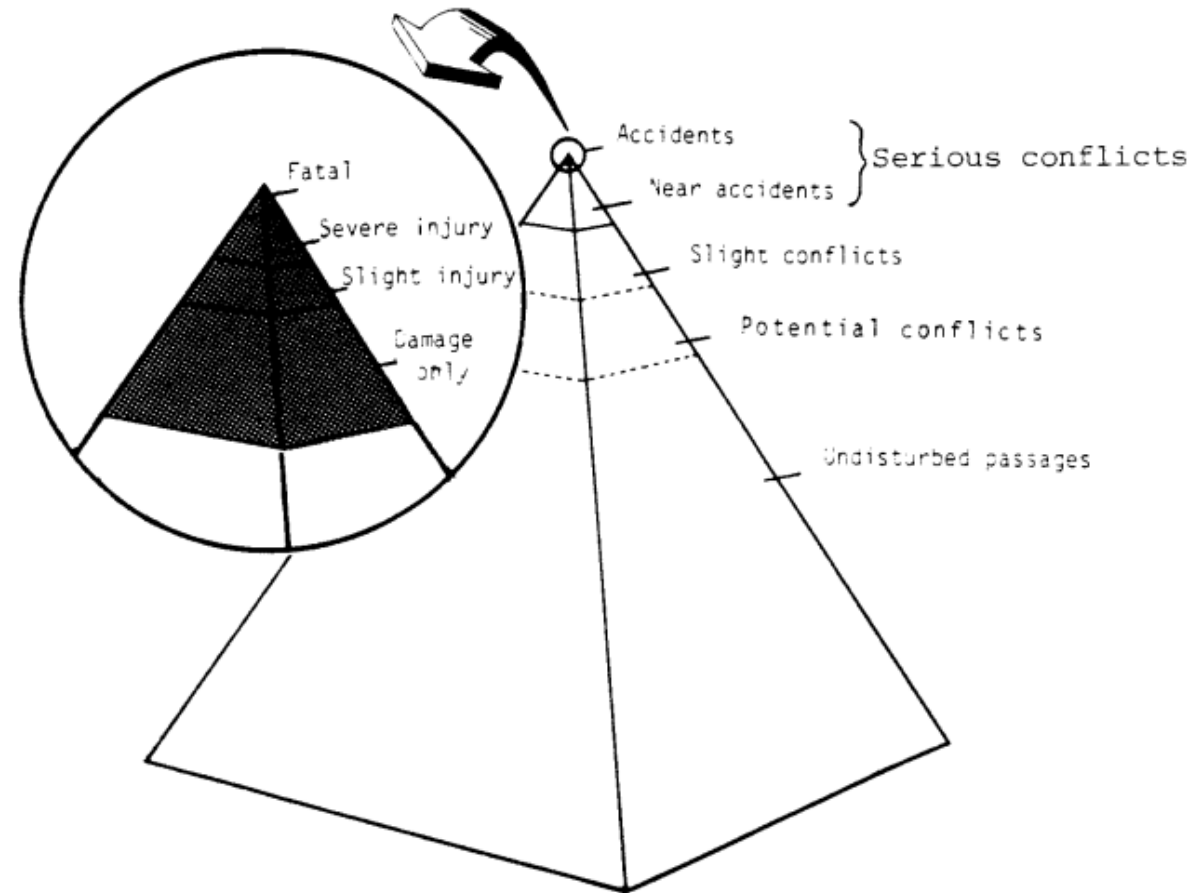
2008

FHWA SSAM

Software tool for
simulation-based
conflict analysis.

“The traffic conflict technique emerged from a fundamental recognition: crashes are too rare, too lagging, and too costly to be the primary tool for proactive safety engineering.”

Hydén Safety Pyramid



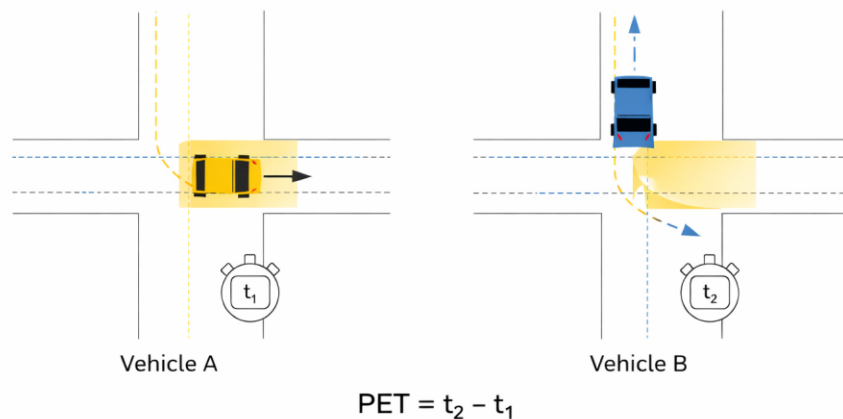
Performance Metrics

Time to Collision (TTC)

- Time remaining until two vehicles collide assuming constant speed and path — no evasive action taken
 - Above 1.5 seconds — safe separation, no conflict
 - Between 0.5 and 1.5 seconds — elevated conflict, evasive action likely
 - At or below 0.5 seconds — immediate danger, physically unavoidable under most conditions
 - Average human perception-reaction time is 1.5 seconds, which is exactly why 1.5s is the upper threshold
-
- [ttc_animated_explainer.html](#)

Post Encroachment Time (PET)

- Time gap between the moment the first road user clears the conflict zone and the moment the second road user enters that same point
- $PET = \text{Time vehicle 2 arrives at conflict point} - \text{Time vehicle 1 departed that point}$
- Above 2.0 seconds — normal interaction, adequate separation
- Between 1.0 and 2.0 seconds — moderate conflict, warrants monitoring
- At or below 1.0 second — severe conflict, correlates with crash history
- Below 0.7 seconds — serious conflict



Deceleration Rate to Avoid Crash (DRAC)

- The minimum constant deceleration rate a following vehicle must apply to avoid a crash with the vehicle ahead, given current speeds and the gap between them
- $DRAC = (\text{Relative Speed}^2) \div (2 \times \text{Gap Distance})$
- Below 3.4 m/s^2 — comfortable braking, well within normal driver capability
- Between 3.4 and 6.0 m/s^2 — firm braking, within capability but demanding
- Between 6.0 and 8.0 m/s^2 — emergency braking, at the edge of human reaction and vehicle performance
- Above 8.0 m/s^2 — physically unavoidable under most real-world conditions

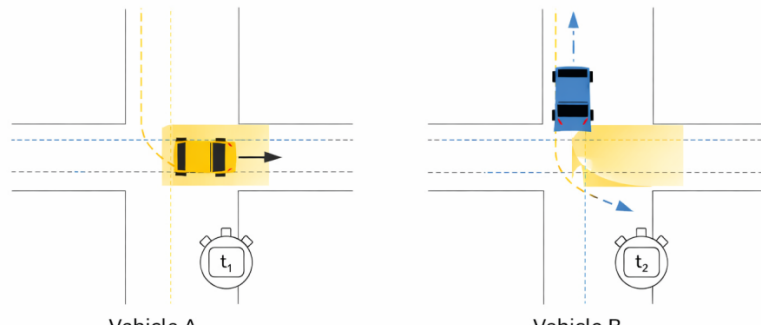
Severity Index (SI)

- A composite measure that combines multiple conflict indicators into a single score representing both the likelihood and the potential consequence of a crash
- Two conflicts can have identical TTC/PET values but completely different injury outcomes depending on speed, vehicle mass, and angle of approach
- It's a ranking based system – usually measured on a scale of 1-5

Strength/Weakness

Comparative Evaluation Matrix

Metric	Best Use Case	Key Strength	Key Limitation	Data Need
TTC	Rear-end & following	Real-time, continuous measure	Only valid on active collision course	Trajectory + speed
PET	Crossing & angle conflicts	Works after evasion; captures near-miss gap	Requires two clear timestamps; static conflict area	Video timestamps
DRAC	Deceleration analysis	Physics-based; links to crash probability	Assumes constant speed of lead vehicle	Speed + gap distance
SI	Network ranking	Composite — enables site comparison	Aggregation can mask individual severity	Multiple SSM inputs



Engineering Opinion

Field Evidence

Incidents	TTC	PET	SI	DRAC
1.	0.5911	2.2	2	16.049
2.	0.2332	2.4	2.857	379.6098
3.	0.7669	N/A	1.9444	6.1159
4.	0.1784	1.7	3.3333	732.3384
5.	0.1809	2	2.8571	898.5231
6.	1.0733	3	0.9524	6.2828
7.	0.0937	N/A	2.8571	74.0026
8.	0.4468	N/A	2.8571	70.9739
9.	0.3503	1.7	3.3333	349.3794

Recommendation

- Combine metrics before recommending action.
- Technology is not matured enough yet. This is not the time to make the process simple and focusing heavily on the cost.
- Use of at least TTC/PET along with the DRAC is recommended.

Thank you

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