Naturalistic Driving Methods & Analyses Symposium
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Site-Based Naturalistic Data Collection and Analysis

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Acknowledgement
TRB: SHRP 2 Safety Research Program
Project S09 Partners

S09 Objectives

- Design and develop a site-based video system to accurately capture multi-vehicle kinematics at intersections and highway segments
- Justify and prove the system concept in terms of SHRP2 research questions
- Demonstrate capabilities via a small field trial, including analysis demonstration

Talk Outline

- Background and applicability of site-based data collection
- System types and methods
- Intersection crash surrogates – accuracy requirements for analysis
- Research questions – direct and indirect analysis

Background and Applicability

- Sites of interest: intersections, freeways, ramps, curves, transitions, …
- Detailed vehicle kinematics for crash, near-crash, conflicts and normal driving
  - Counting and evaluating crashes is statistically weak
- Exposure, risk, highway factors, traffic factors
- Multi-vehicle kinematics - not easily available from vehicle-based collection
- Research to focus on “typical” as well as “problem” locations

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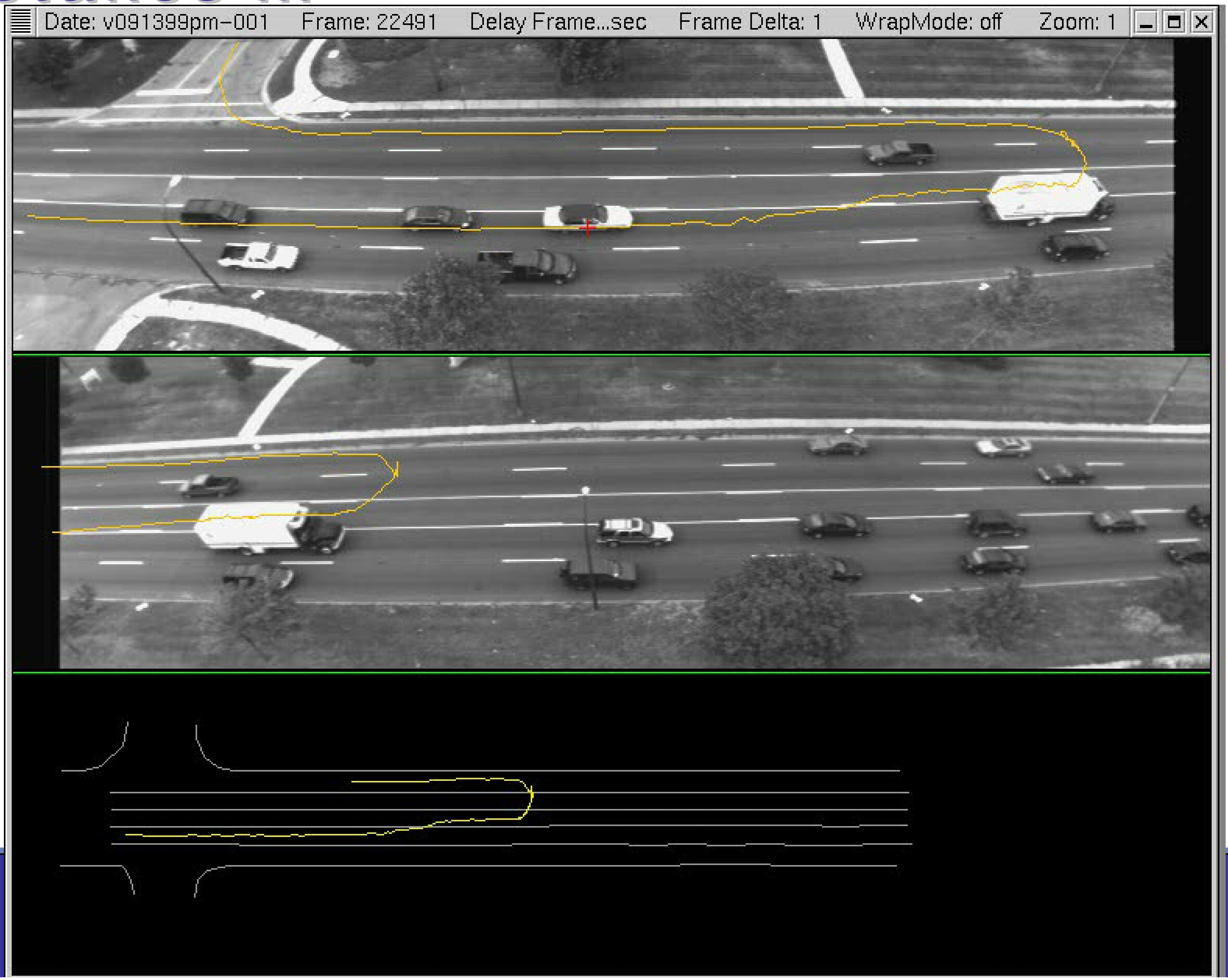
Background and Applicability

- Driver behavior: indirect, but aspects can be inferred from vehicle motions
  - decisions and timing
  - delayed reactions
  - risk taking
  - mistakes
  - control accuracy
- Human factors? possible - requires additional data
- Event extraction and classification, … need
  - source data
  - trigger (on-line or off-line)
  - analysis method
- Risk analysis: e.g. red-light running frequency as a function of approach speed

mistakes ...


Date: v091399pm-001
Frame: 22491
Delay Frame...sec
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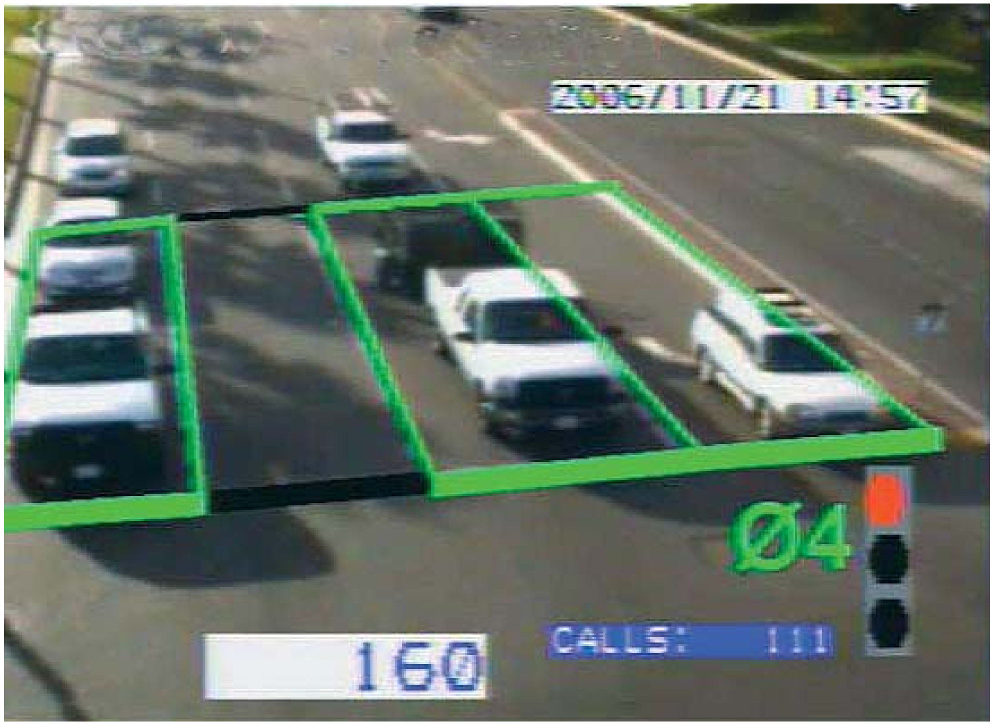
Video-based Tracking

- Background subtraction
- Motion analysis from frames to frame gradients
- Feature detection and tracking
- Stereo vision
- Shape from motion

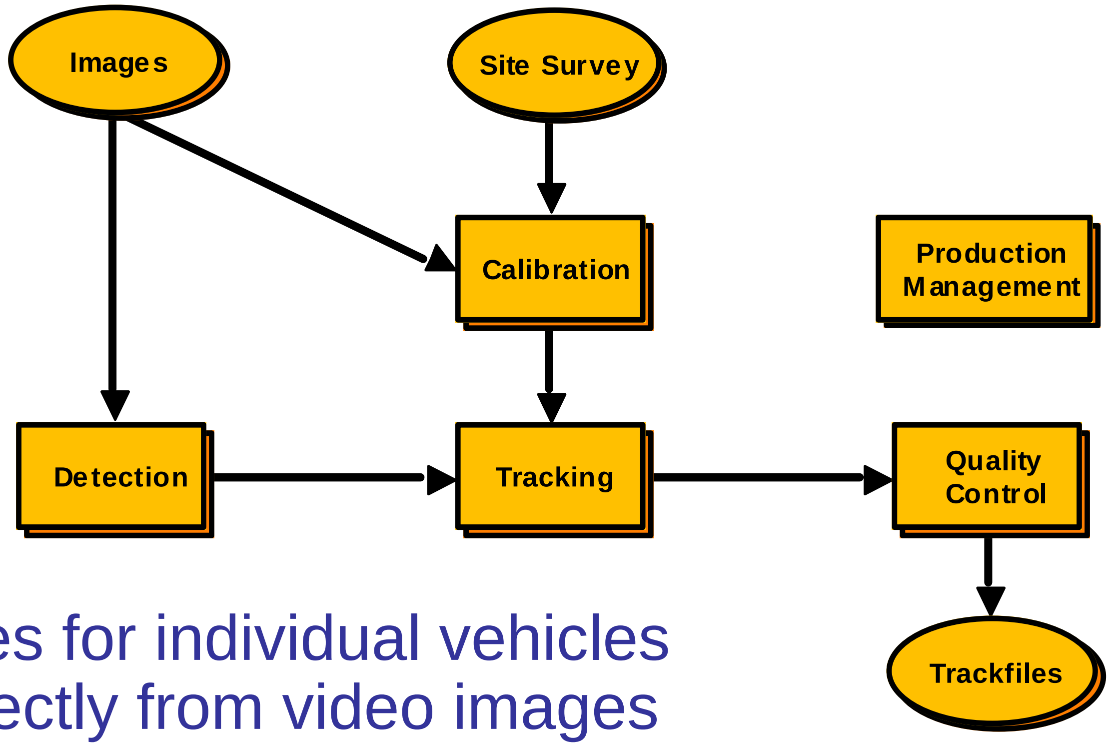
Commercial Example: Autoscope



- traffic management
- occupancy-based
- incidents

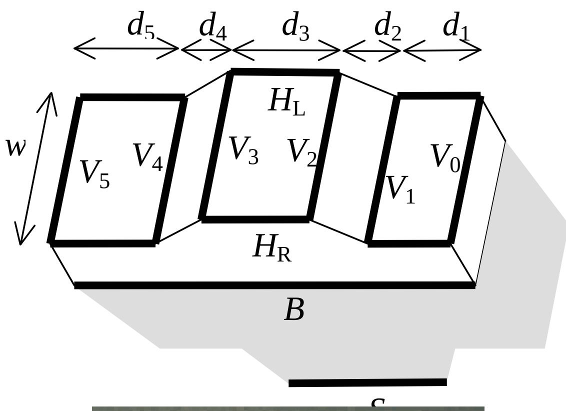
… not designed for or capable of vehicle tracking

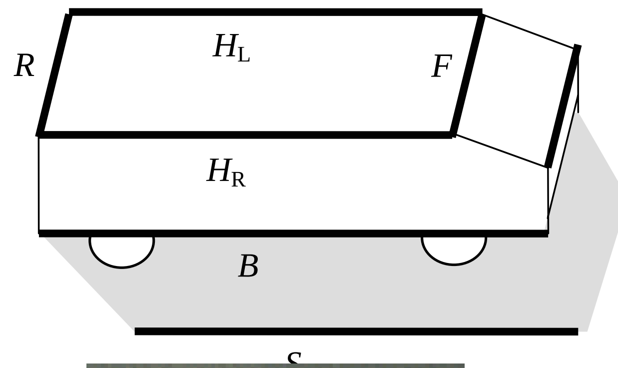
Example: SAVME

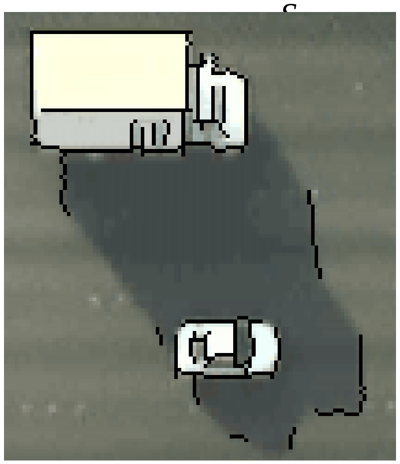


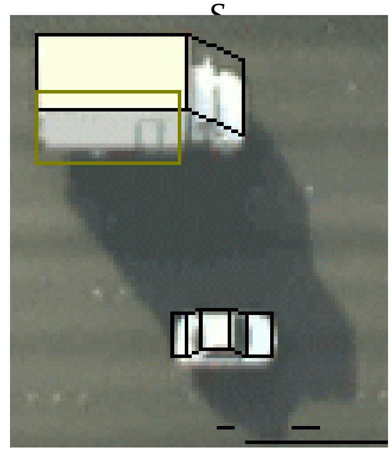
- Motion time histories for individual vehicles
- Optical tracking directly from video images
- Post-processing from video archive, with operator interface to resolve image processing errors
- High vantage point attempts to resolve motions as two dimensional and reduce occlusions

Example: NGSIM (CA PATH): wire-frame models and shadow representation









CICAS Intersection Motion Tracking

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Alternative Technologies

- Radar
- Scanning laser
- LIDAR
- Combination (e.g. radar plus video)
- how to choose? cost, reliability, accuracy
- how to determine accuracy needs?

Analysis Method: Conflict Metrics (Crash Surrogates) at Intersections

- **Crashes occur rarely so patterns only emerge over long time periods**
- **Crash surrogates and conflict measures can be used as indicators of intersection safety performance**
- **Trajectory data required:**
  - **reference point motion** $x(t), \dot{x}(t), \ddot{x}(t), y(t), \dot{y}(t), \ddot{y}(t)$
  - **bounding box**

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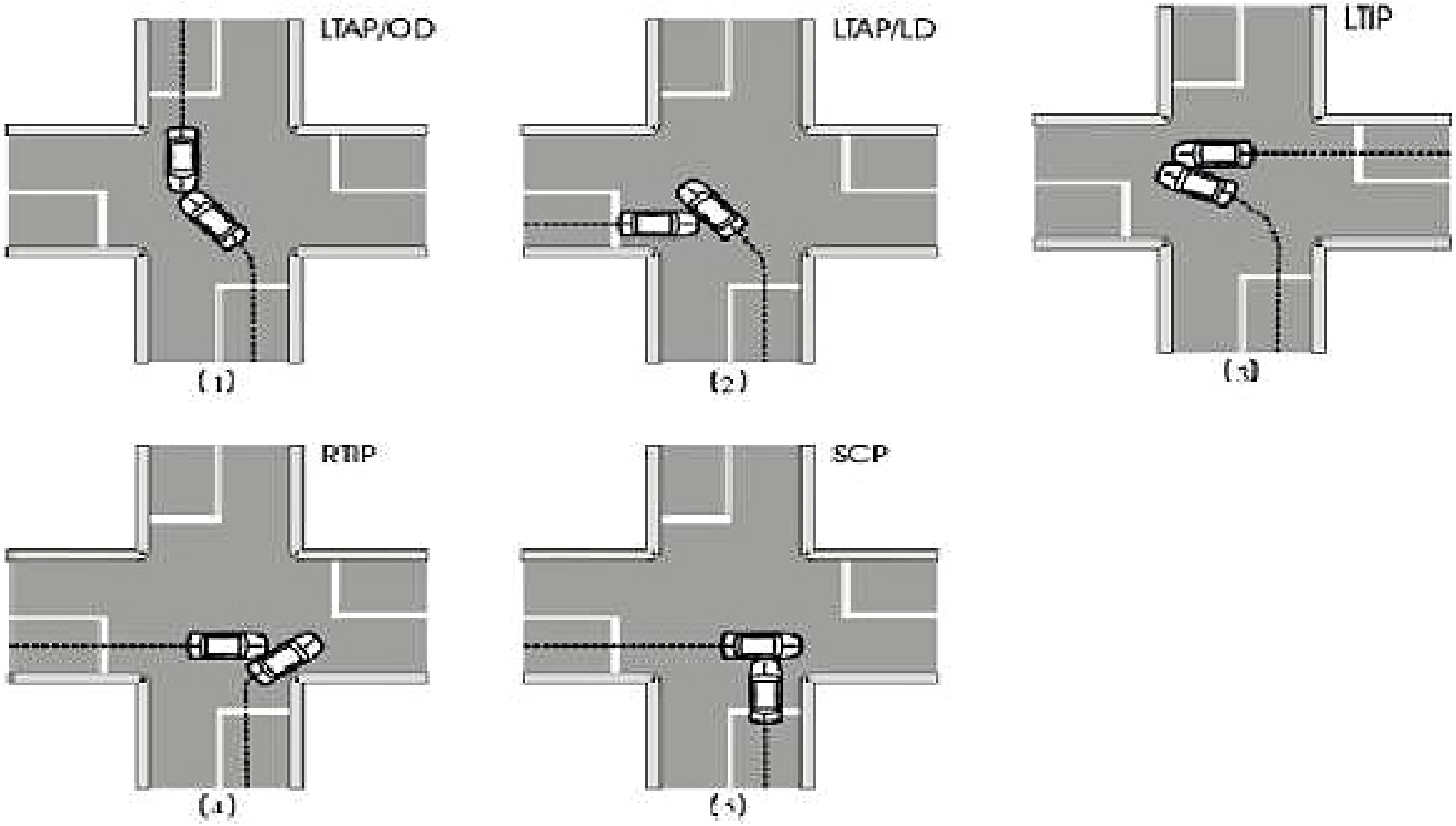
Surrogates for Intersection Collisions

Gap Time	Time lapse between completion of the encroachment by turning vehicle and the arrival time of crossing vehicle if they continue with same speed and path.
Encroachment time	Time duration during which the turning vehicle infringes upon the right-of-way of through vehicle.
Deceleration rate	Rate at which crossing vehicle must decelerate to avoid collision.
Proportion of stopping distance (PSD)	Ratio of distance available to maneuver to the distance remaining to the projected location of collision.
Post encroachment time (PET)	Time lapse between end of encroachment of turning vehicle and the time that the through vehicle actually arrives at the potential point of collision.
Initially attempted post-Encroachment Time (IAPT)	Time lapse between commencement of encroachment by turning vehicle plus the expected time for the through vehicle to reach the point of collision and the completion time of encroachment by turning vehicle.

Time to collision (TTC)	Expected time for two vehicles to collide if they remain at their present speed and on the same path.
Time exposed TTC	The length of time that all vehicles involved in conflicts spent under a designated TTC minimum threshold during a specified time period.
Time Integrated TTC	Integral of TTC profile of drivers to express the level of safety over the specified time period.
Time to Accident	Point at which the aversive action is taken. This measure, combined with the conflicting speed allows to determine the level of severity of a conflict
Signal encroachment time	Time lapse between the onset of red cycle and vehicle entering intersection
Signal transition deceleration time	Time lapse between the transition of signal (green to amber or amber to red) and deceleration onset.
Signal transition acceleration time	Time lapse between the transition of signal and acceleration onset
Lateral encroachment time	Time duration during which the “violating” vehicle infringes upon the right-of-way of through vehicle

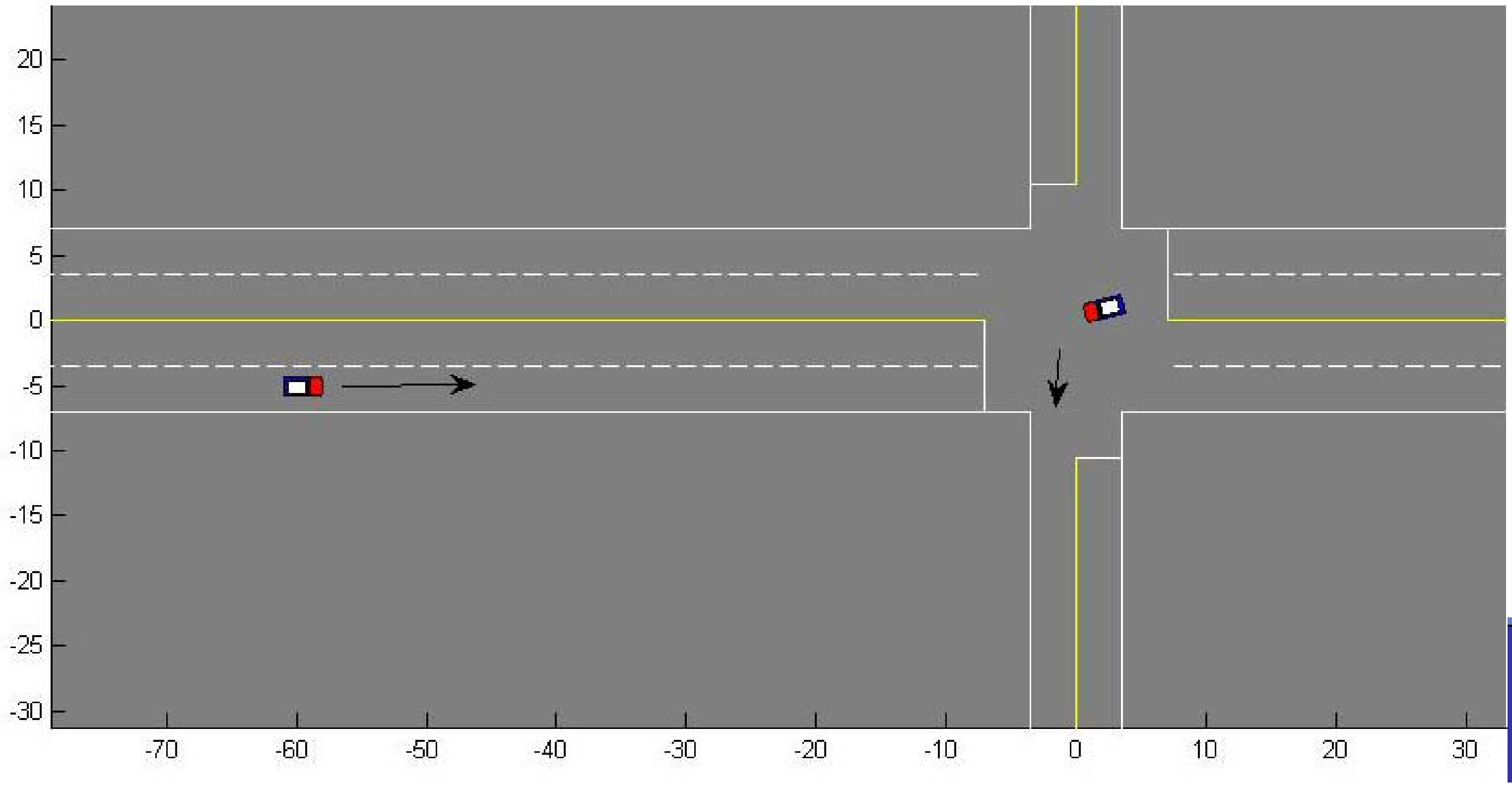
Intersection Crash Kinematics



From: Najm, Smith, and Smith, 2001

Accuracy Requirements

- simulated path crossing (baseline accurately "known"
- measurement errors applied



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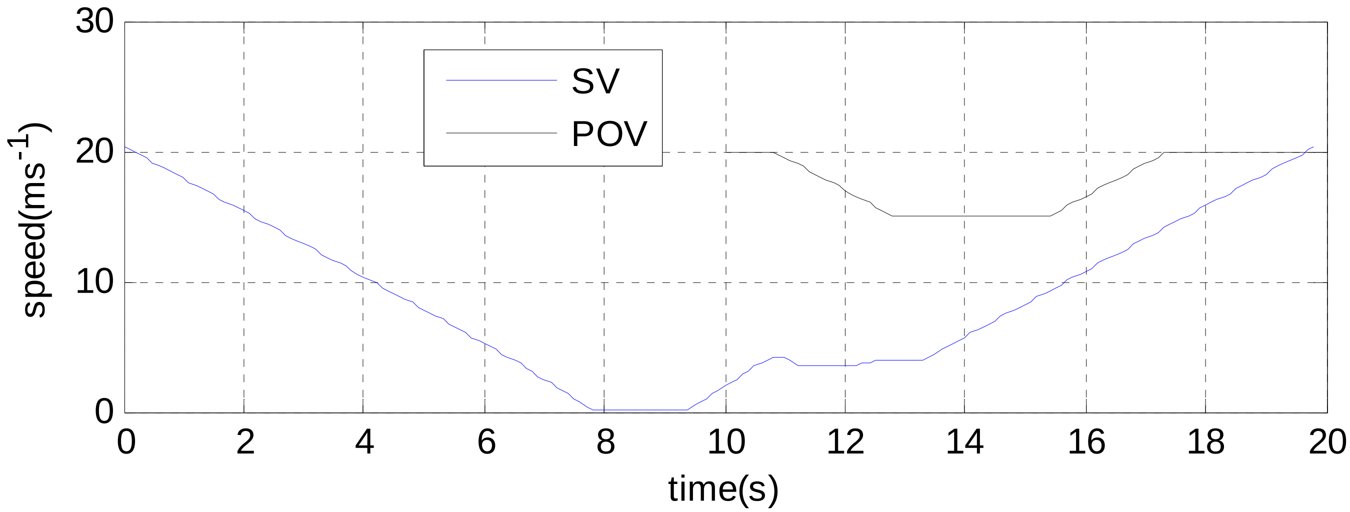
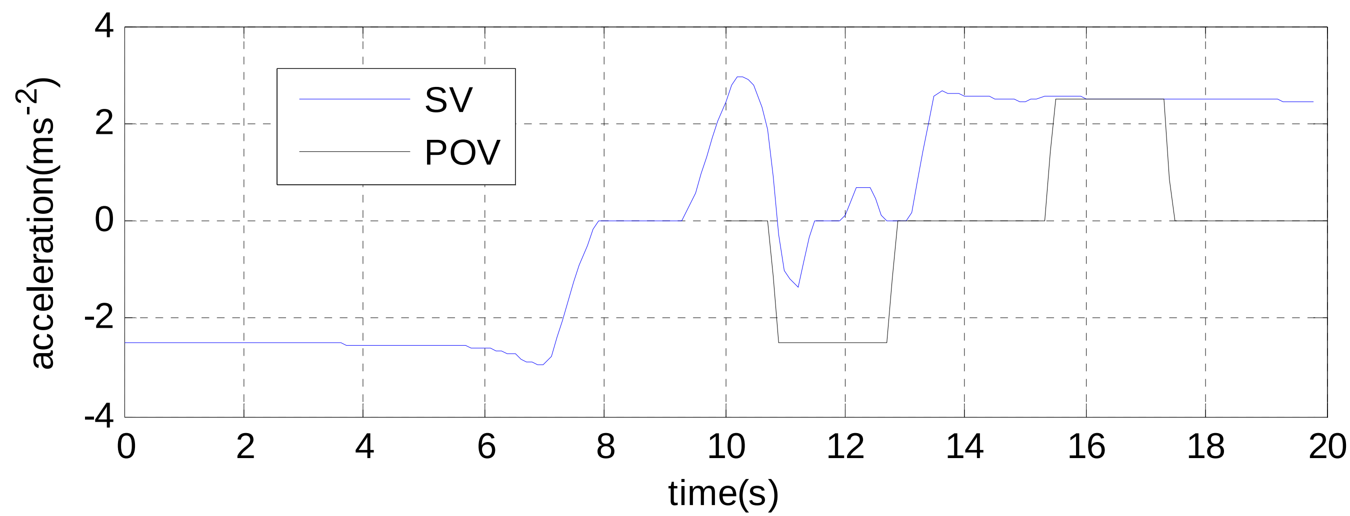
LTAP/OD - baseline case





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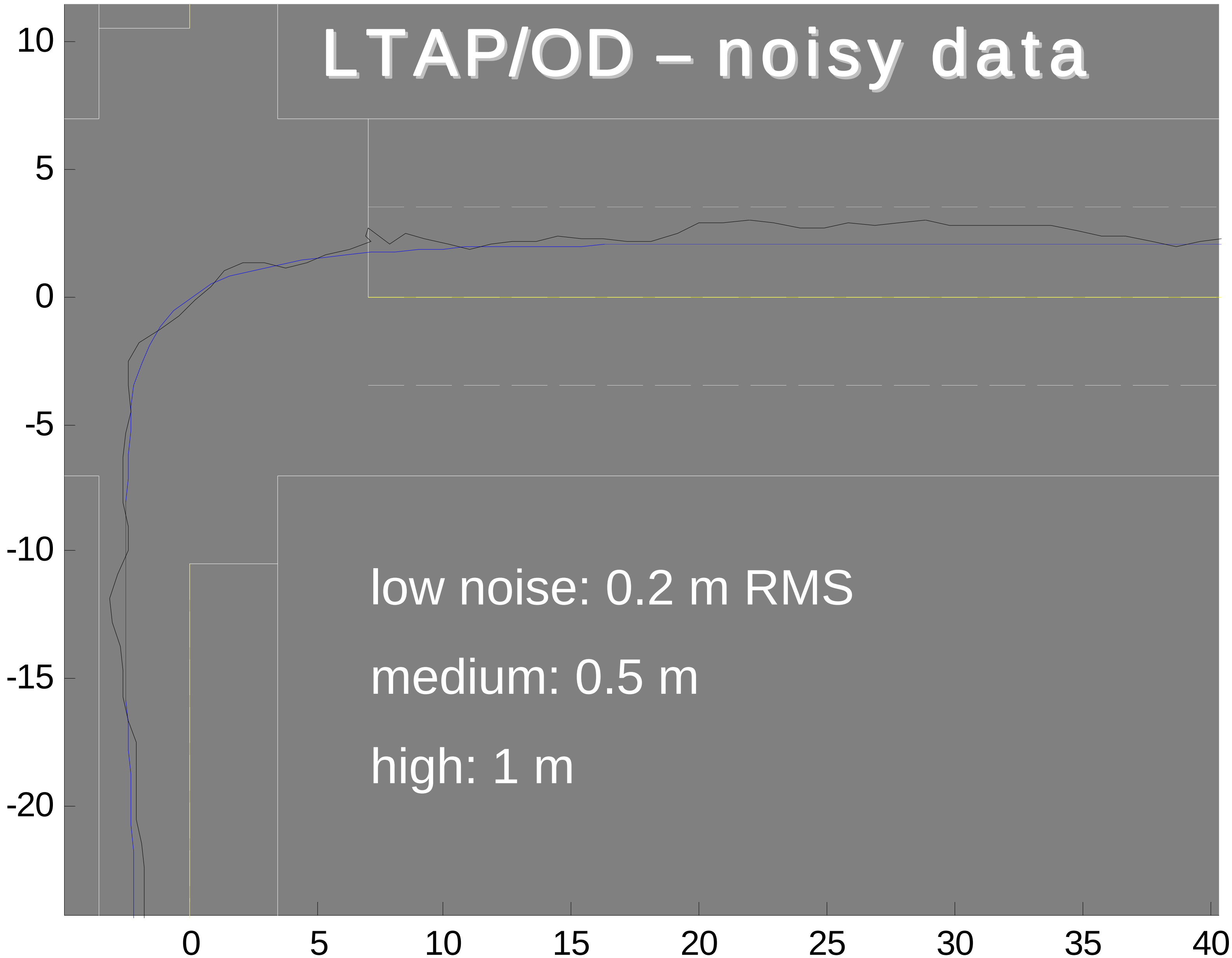
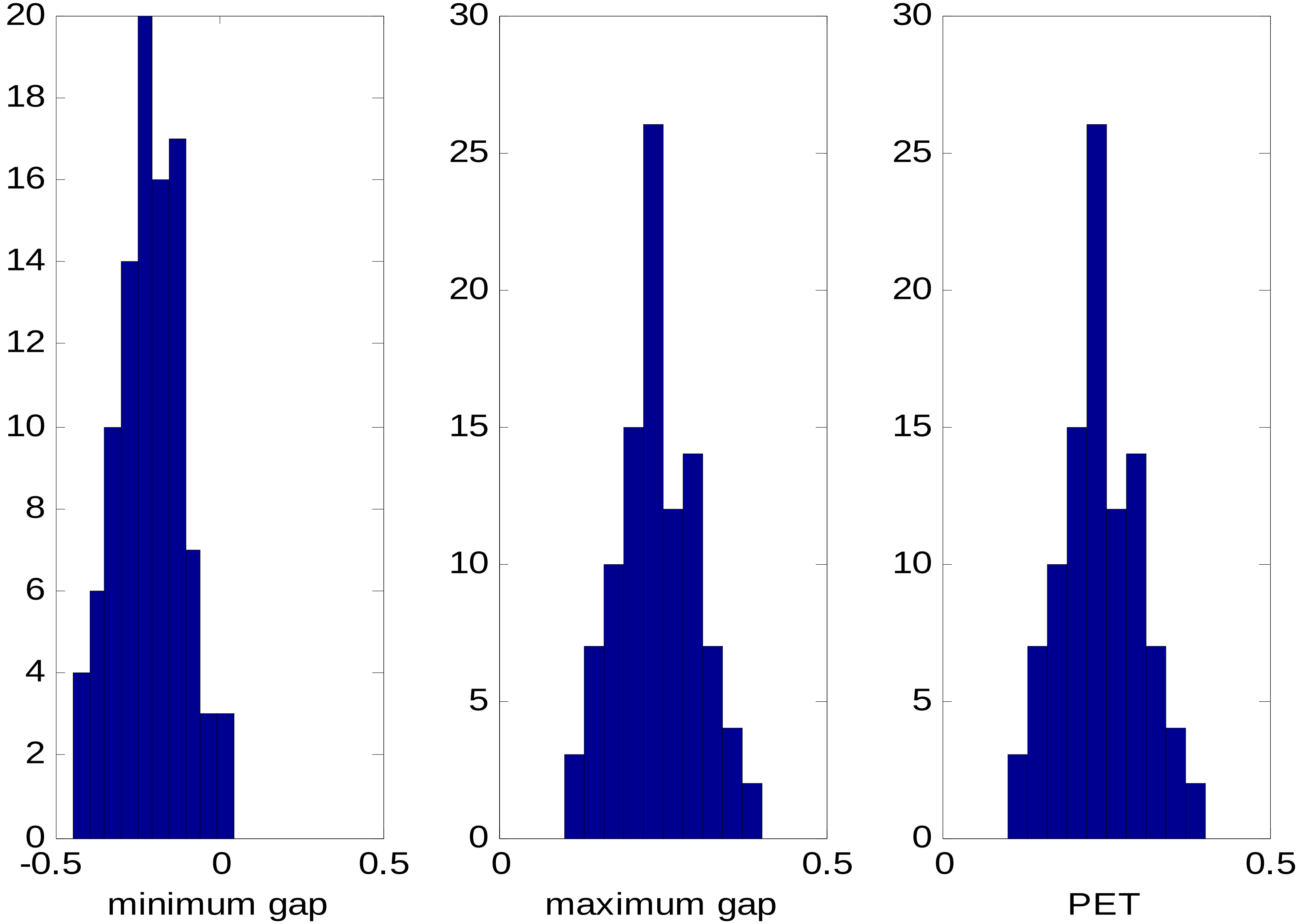
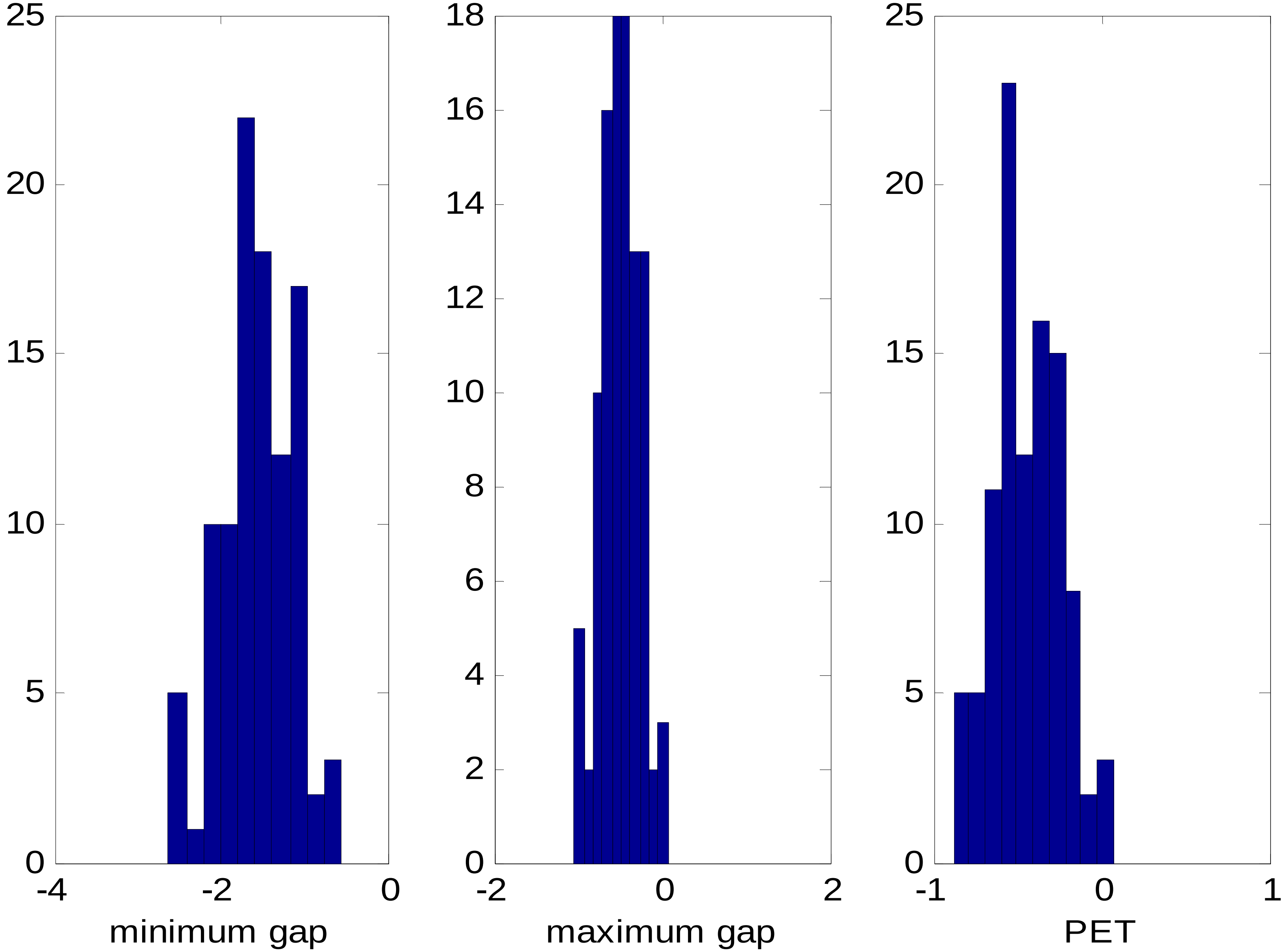


LTAP/OD – noisy data
low noise: 0.2 m RMS
medium: 0.5 m
high: 1 m
10
5
0
-5
-10
-15
-20
0
5
10
15
20
25
30
35
40

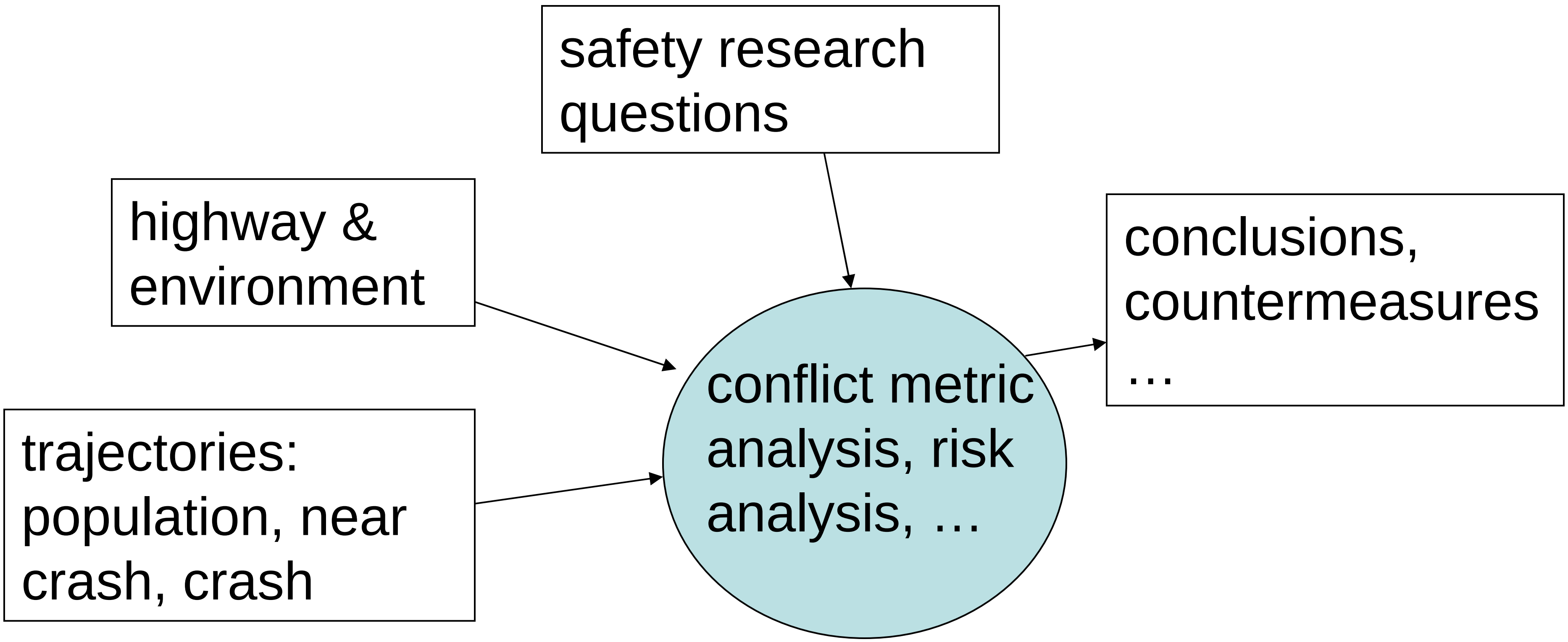
low noise LTAP/OD



medium noise LTAP/OD



“Classic” Research Questions



how far does this go for product design and development (e.g. active safety on cars)?

Conclusions

- Turning and merging conflict metrics are sensitive to trajectory errors: noise-to-signal ratios become large for near crash scenarios
- Smoothing and filtering do not necessarily remove these problems
- Design influenced by detailed “what if” analysis – naturalistic data is part of the story, predictive tools are critical

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