Video based vehicle tracking – lessons from SAVME and new opportunities in naturalistic data collection

Risk and countermeasure analysis from Site-Based Data Collection

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F-SHRP Safety Report …

"Future countermeasures will require a more rigorous and detailed understanding of the relationship of multiple factors responsible for collisions and casualties. In particular, the interrelationship of driver performance and behavior with roadway design and traffic conditions to affect the risk of collisions and casualties is largely an unknown area, despite the fact that driver behavior is widely believed to be responsible for most collisions."

Naturalistic Data Collection

- **Vehicle based**
  - **Driver state and actions**
    - Secondary behaviors
    - Distraction
    - Attention
    - Skill level
    - Control actions
  - **Vehicle states**
    - Detailed kinematics
    - Vehicle systems
    - Interactions
- **Site based**
  - **Highway state**
    - Geometry
    - Surface condition
    - Weather
    - Signals and signage
  - **Vehicle states**
    - Density and flow
    - Detailed kinematics
    - Interactions

Road Departure Crashes
a site-based perspective

SAMPLE RESEARCH QUESTIONS

- How do lane-edge-markings affect lane-keeping?
- How does driver behavior (speeding) affect lane-keeping?
- How do driver factors such as inattention or fatigue affect lane-keeping?
- Does lane-keeping vary with driver age, gender, or vehicle type?
- How do grade, curvature, and other road design factors affect lane-keeping performance?
- How do rumble strips change driver behavior?
- Do rumble strips on the right shoulder increase deviations into the lane on the left?
- What is the influence of surrounding traffic on lane-keeping?

Intersection Crashes
a site-based perspective

SAMPLE RESEARCH QUESTIONS

- What is the relative risk of different intersection maneuvers?
- How much do left and right-turn lanes and/or signal phases reduce collision risk?
- How do turn lanes change the pattern of conflicts at an intersection?
- What is the role of illegal maneuvers in collision risk at intersections?
- Does the relative risk of different intersection maneuvers vary with driver age and gender?
- Does driver behavior (speeding, aggressive driving) affect the collision risk of intersection maneuvers?
- What is the role of inattention in collision risk at intersections?
- How does the pattern of conflicts and collision risk vary with traffic volume?

SAVME Project

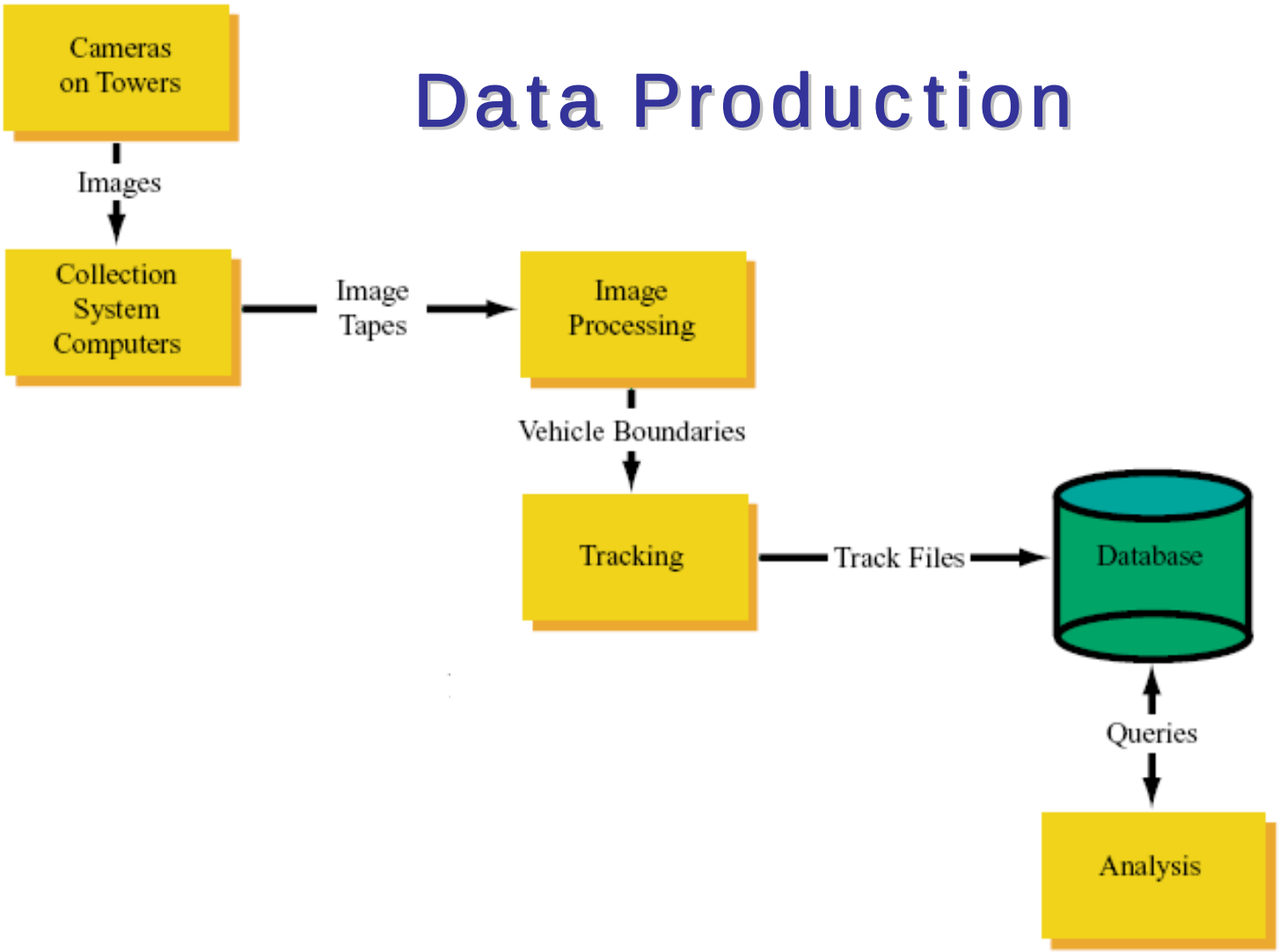
Sponsor: NHTSA, contributions from ERIM International, Nonlinear Dynamics Inc.

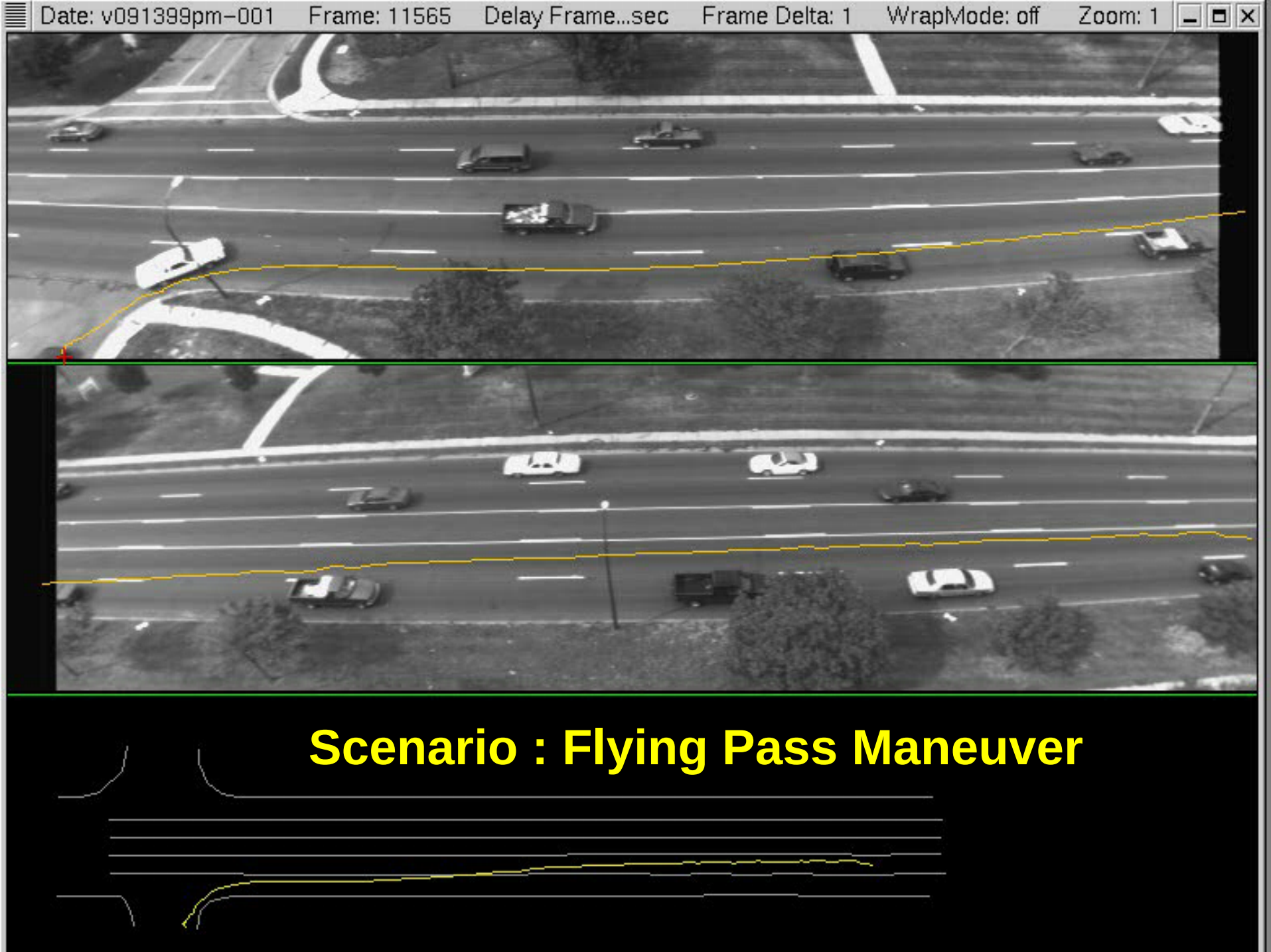
- Video data collection from dedicated 100 ft towers
- Completed in August 2000
- Delivered a database of 30,500 vehicle trajectories
- Validated tracking accuracy
- Sample scenario analyses
- Source data for later computational modeling

SAVME Data:

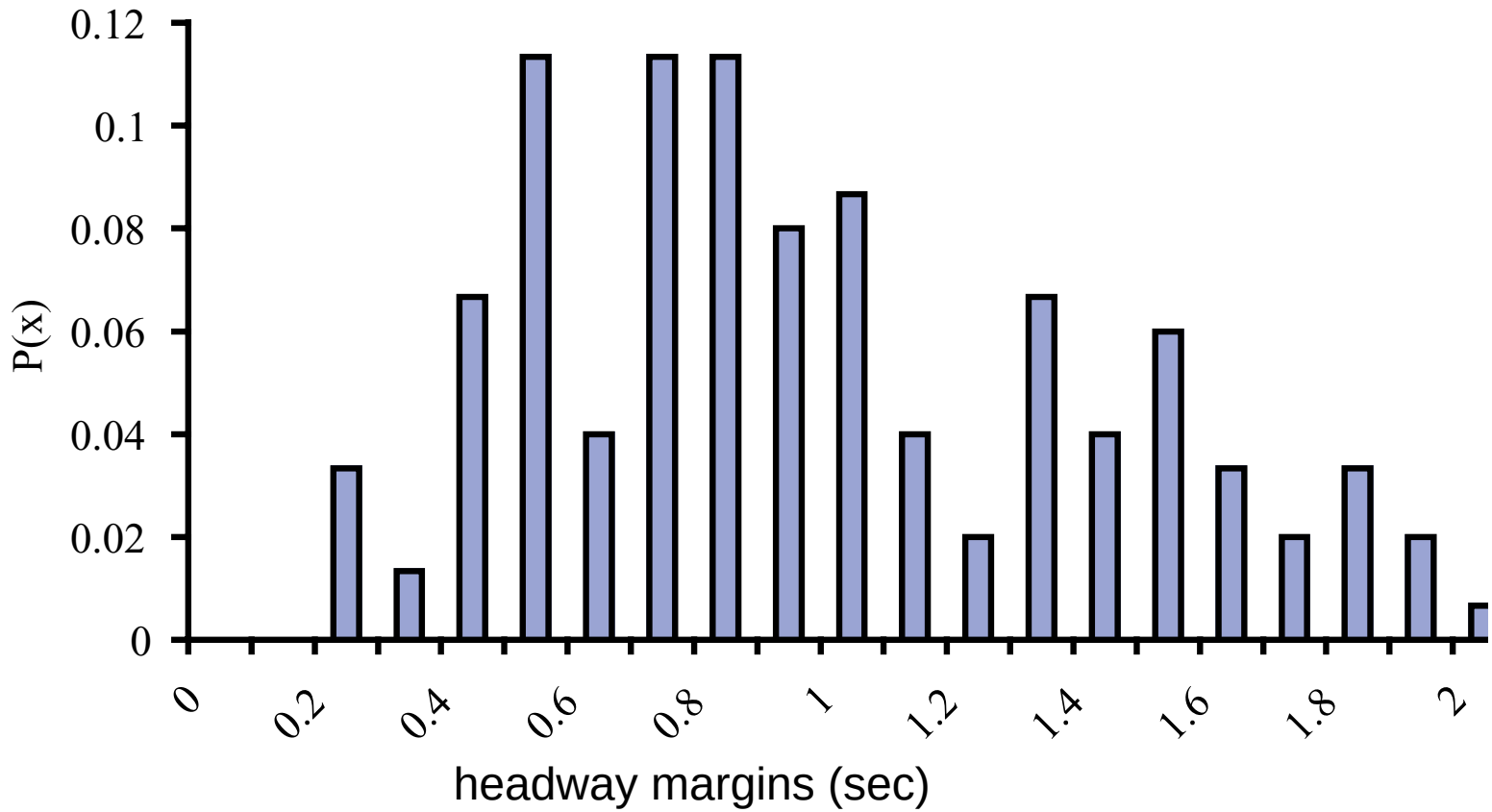
- Motion time histories for individual vehicles and vehicle clusters
- Inferred inter-vehicle kinematics: range, range-rate, azimuth angle - matching the same fundamental measures from on-board radar
- Database queries provide analyses of defined scenarios: case counts, histograms, measure distributions

Data Production

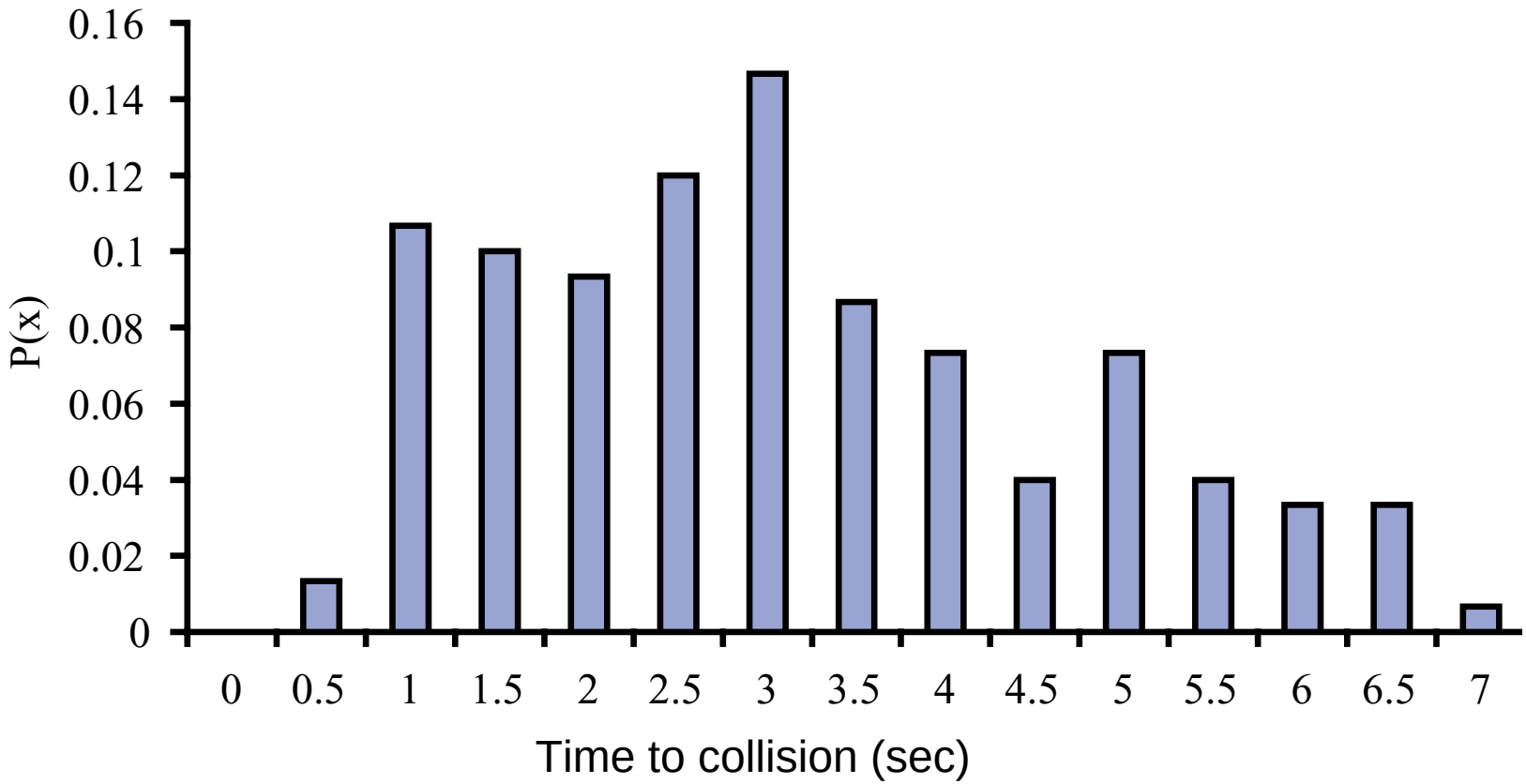


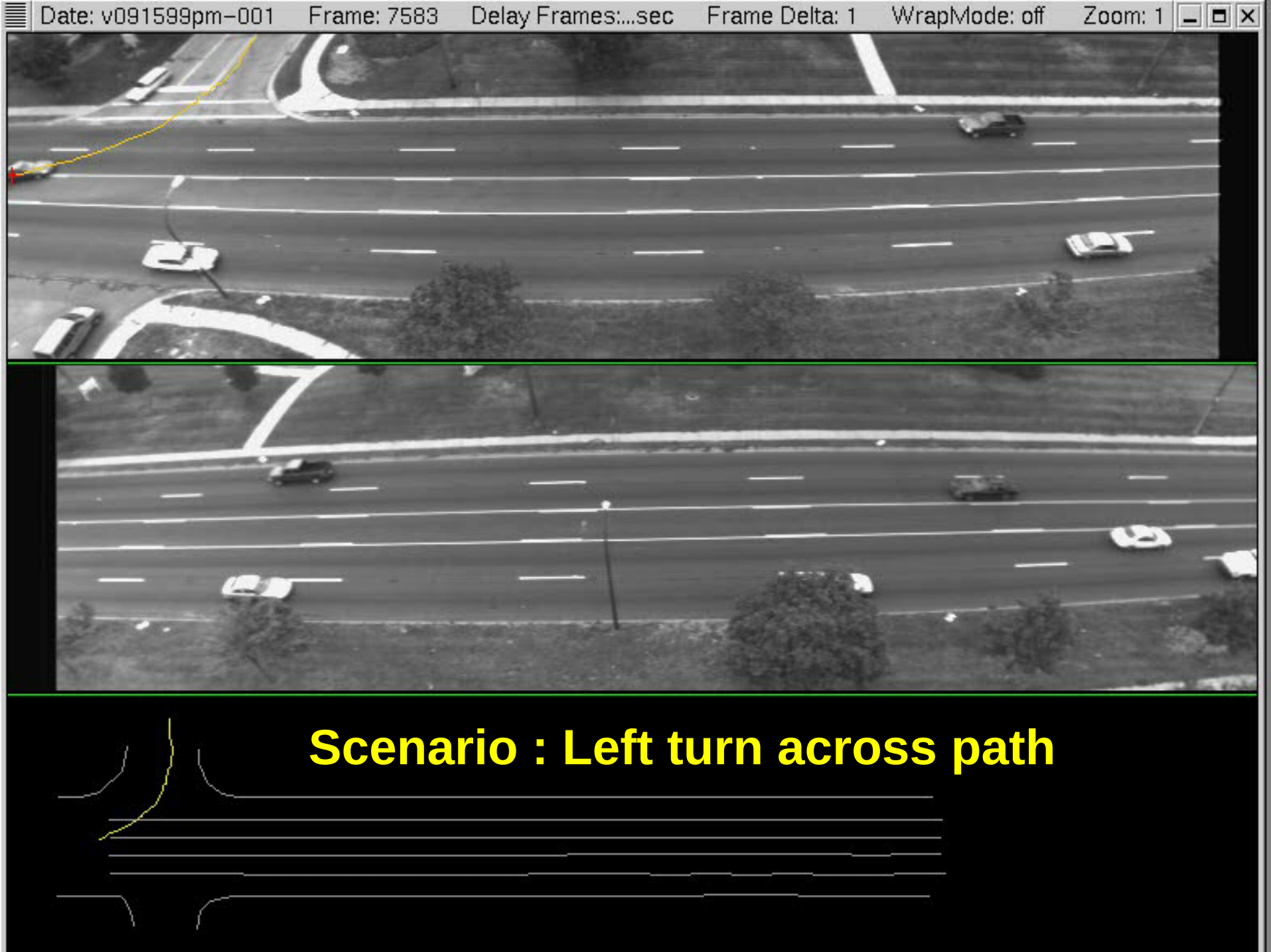

Date: v091399pm-001 Frame: 11565 Delay Frame...sec Frame Delta: 1 WrapMode: off Zoom: 1
Scenario : Flying Pass Maneuver

Database query : Headway time margins



Database query : TTC Metric on Flying Passes

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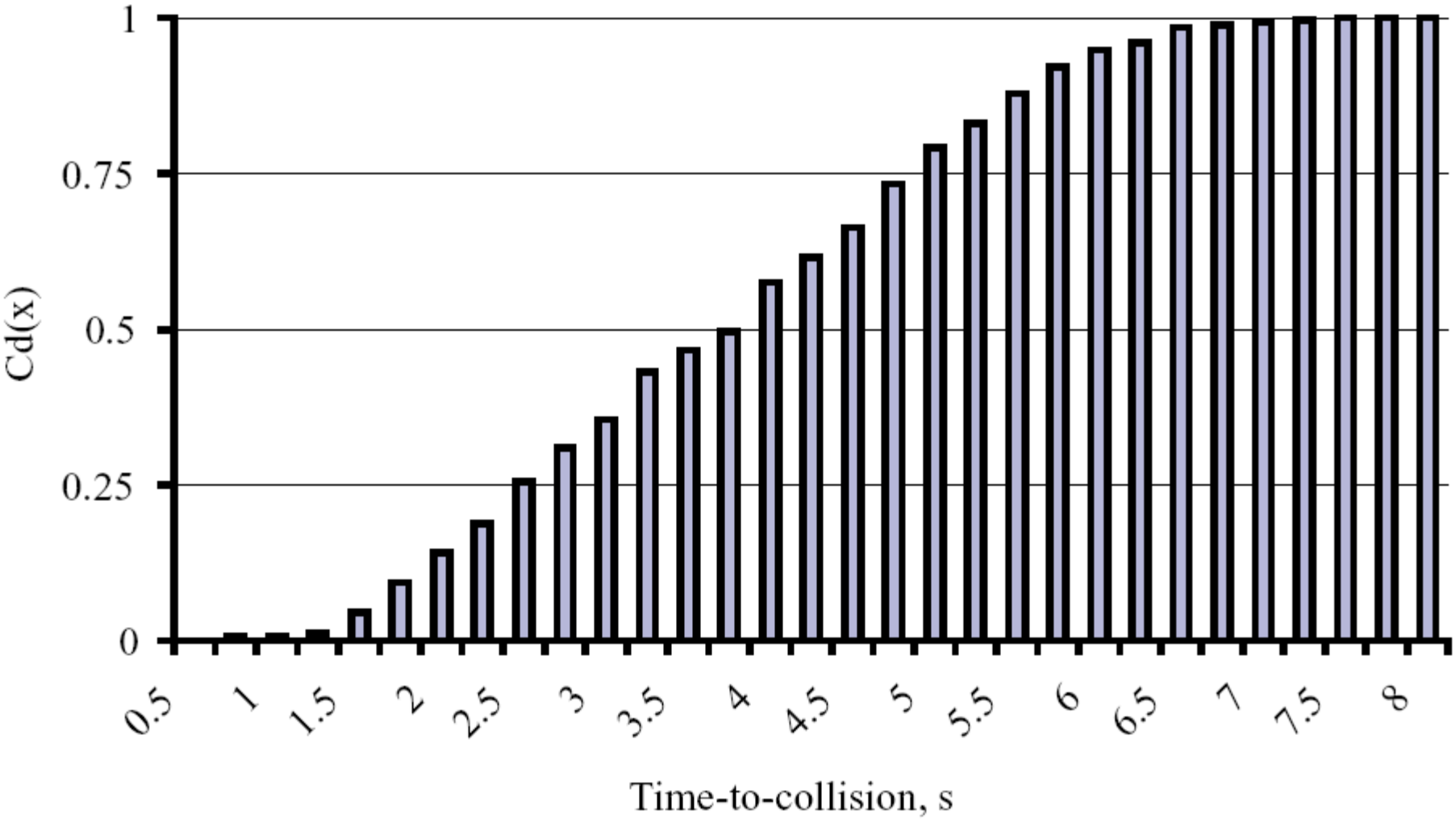
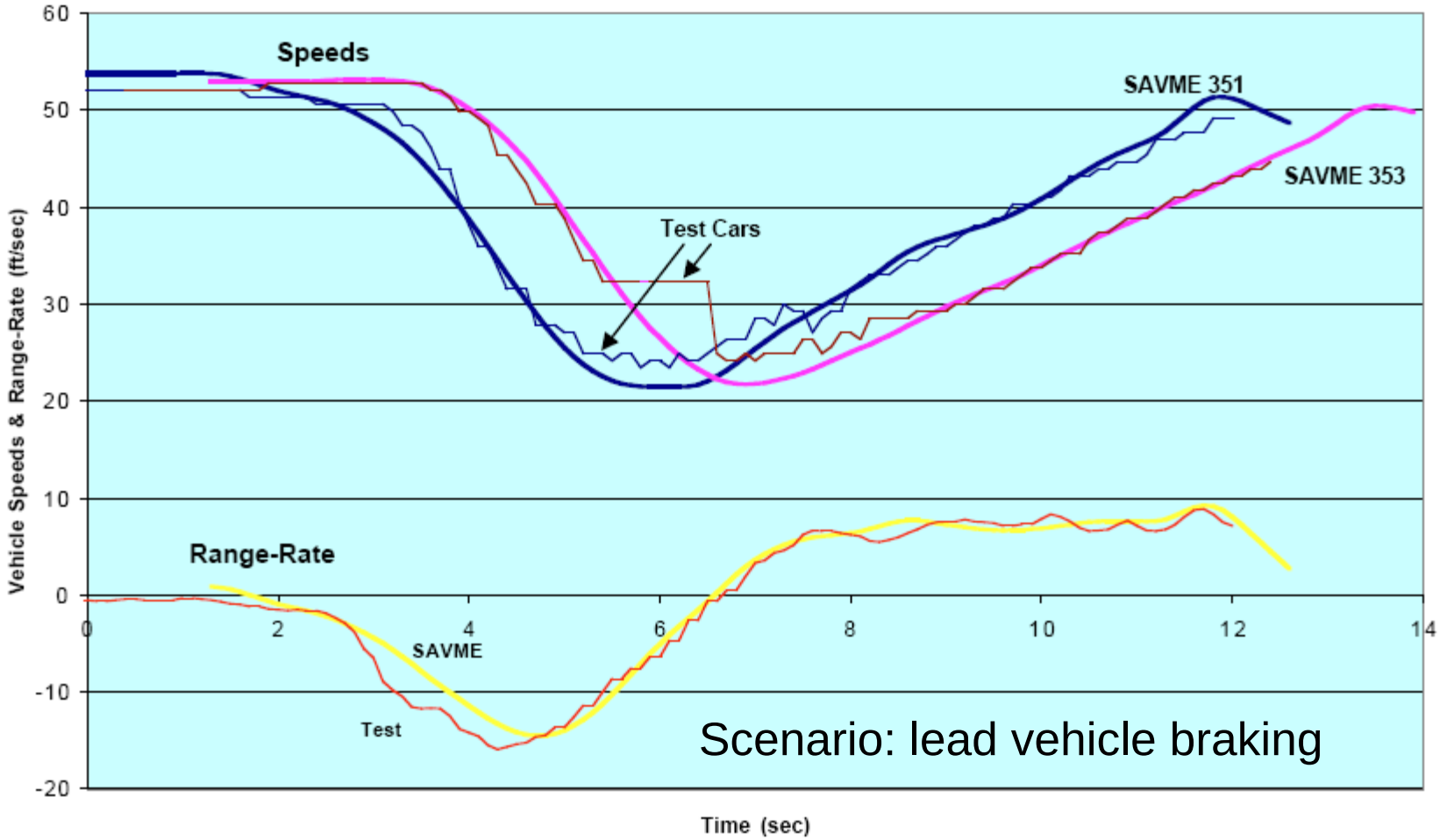
Scenario : Left turn across path

Database query : TTC for LTAP/OD (330 cases)

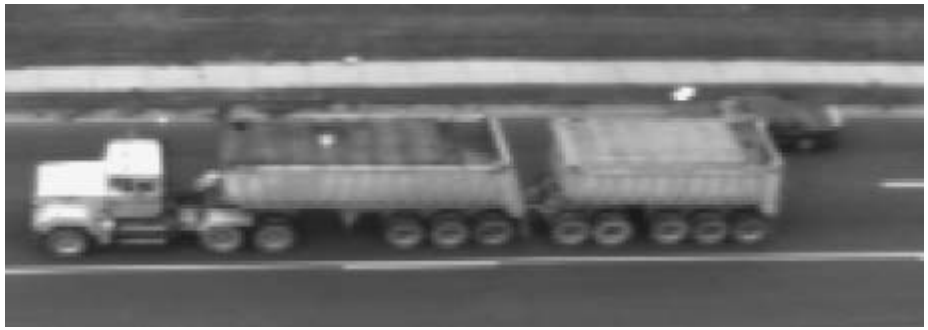


Test vehicles provide validation



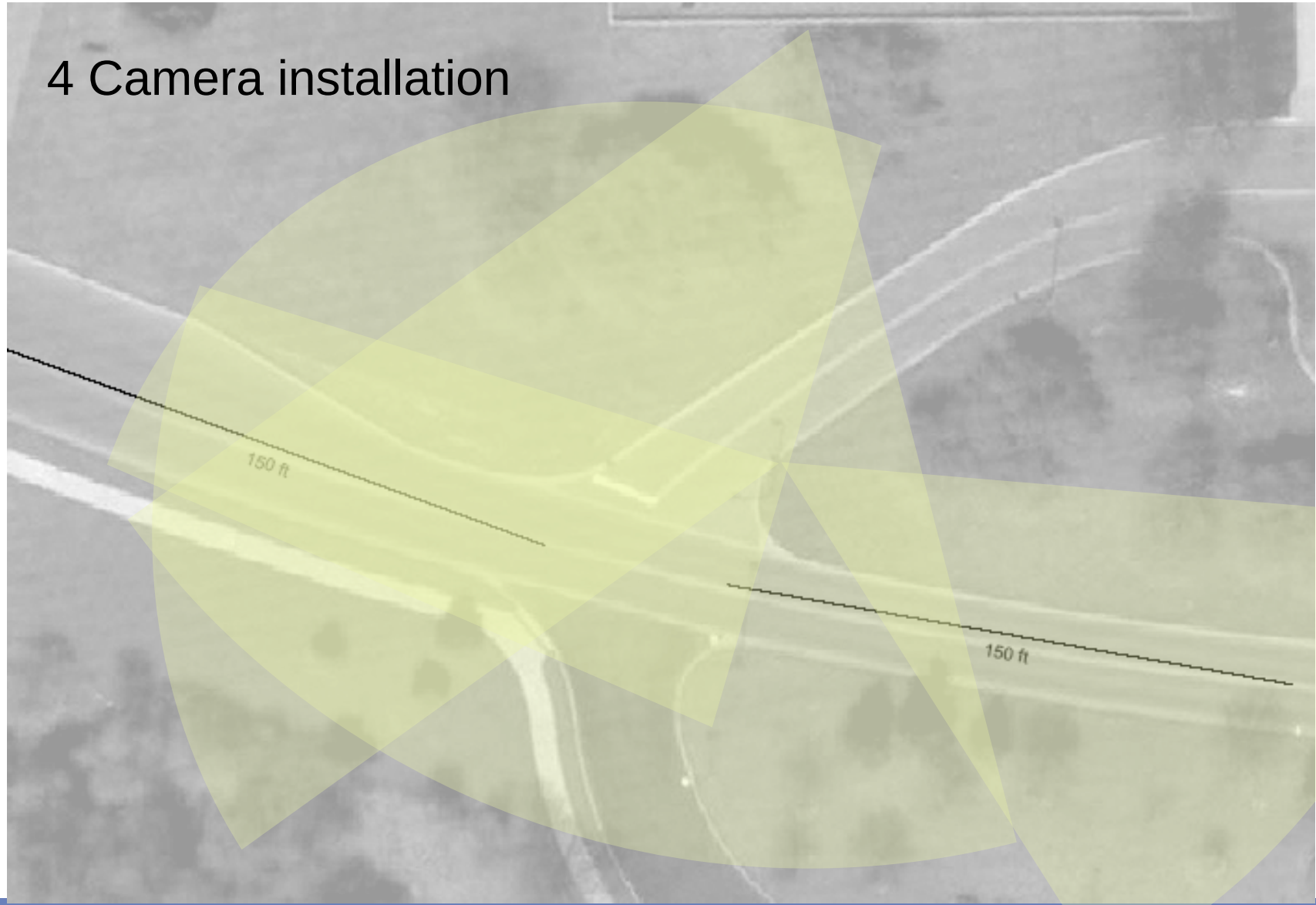
SAVME limitations motivate recent work at UMTRI (2005-2006)

- Expandable and deployable
- Low maintenance
- Robust to weather and traffic occlusions
- Fully automated track capture



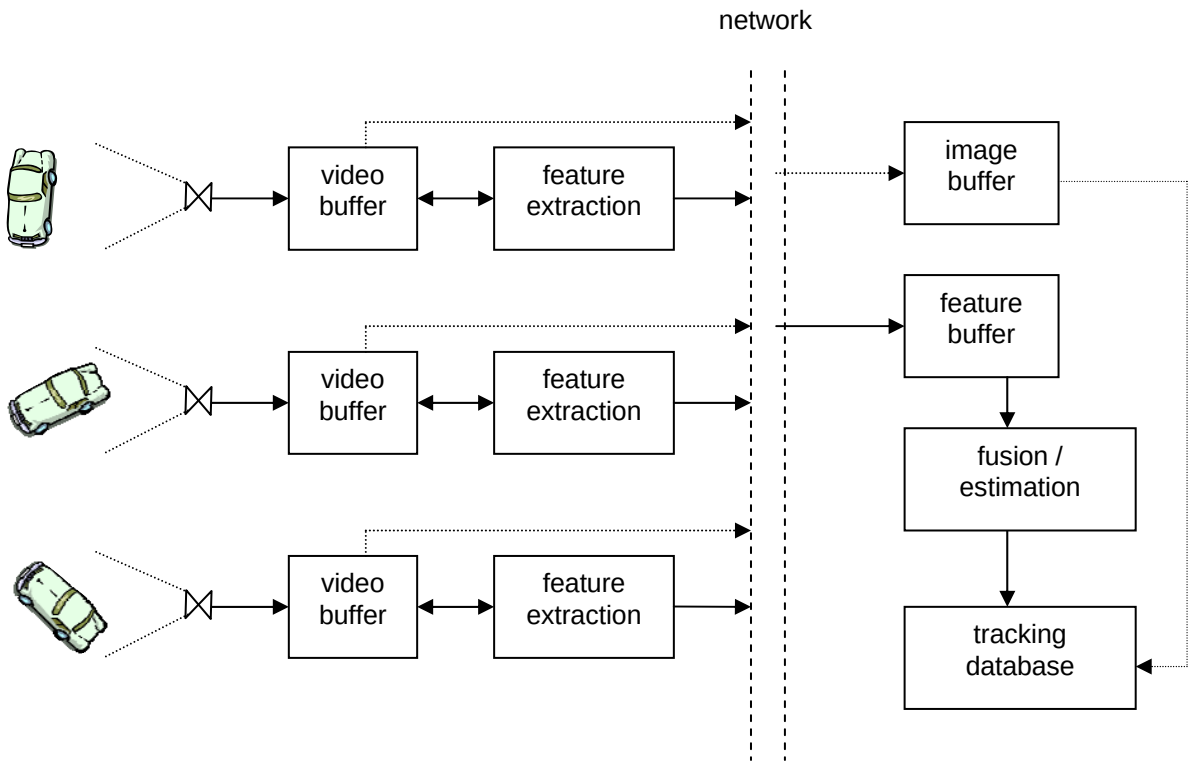
- Low intrusion (visually, passive / low emission sensors, …) – video is still the best option
- Compact data – limited or no video file storage (single stream of uncompressed monochrome video requires ~ 30Gb/hr)
- …
- while maintaining kinematic accuracy and capacity for large volume data capture

4 Camera installation



Data Architecture

- Features extracted locally
- Images sampled for validation
- Network not overloaded with image data
- Distributed data processing - scalable
- Pilot limited to post-processing stored video …



Feature extraction, registration and motion analysis

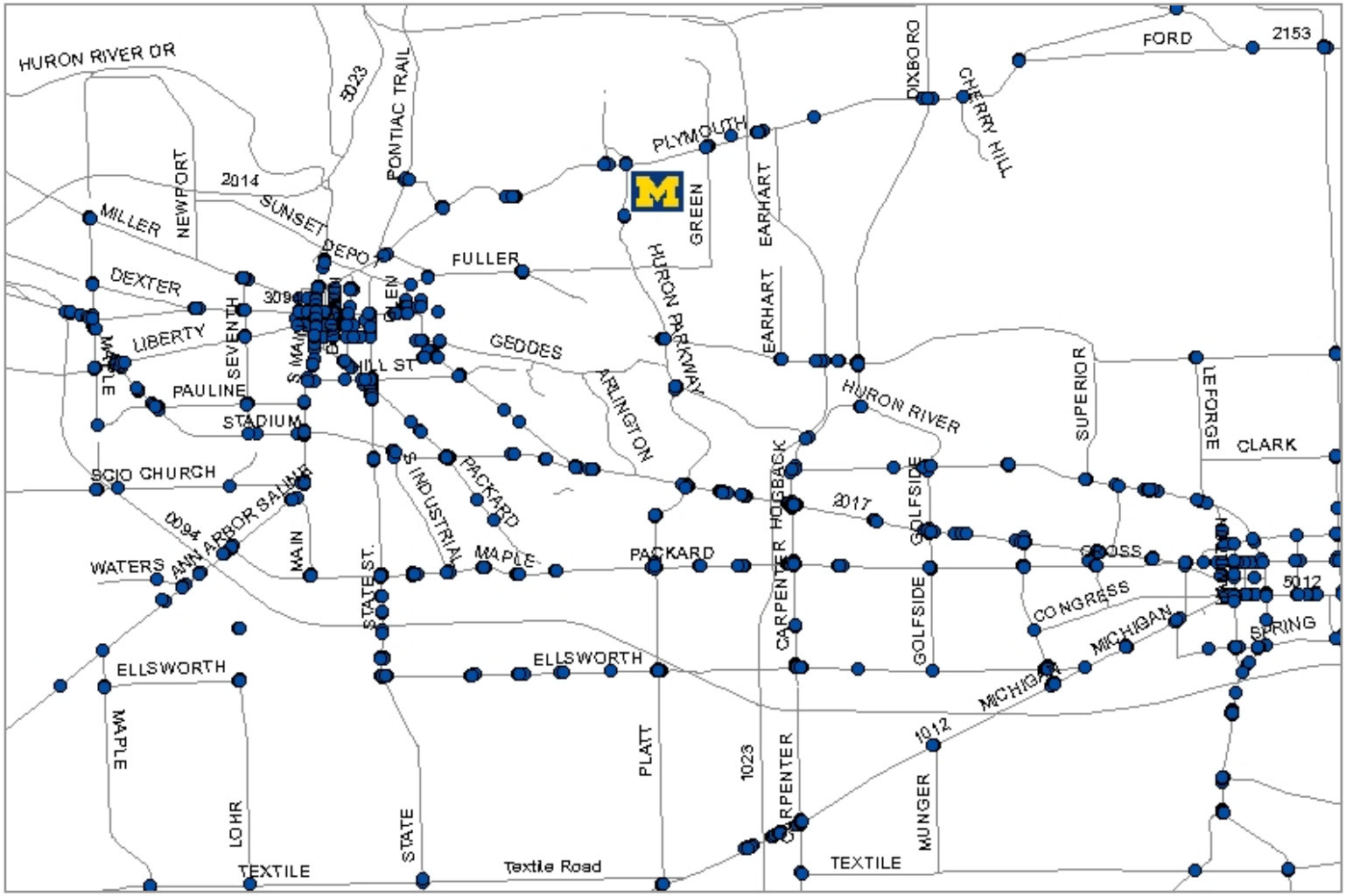
- Full automation of image processing
- Integrated motion analysis
- Feature registration in world coordinates
- 70+% availability

Intersection Crashes … detailed pre-crash and conflict kinematic analysis

e.g. around 30 intersections crashes per year

(Washtenaw County, 20 worst cases, 6 year average = 32.1)

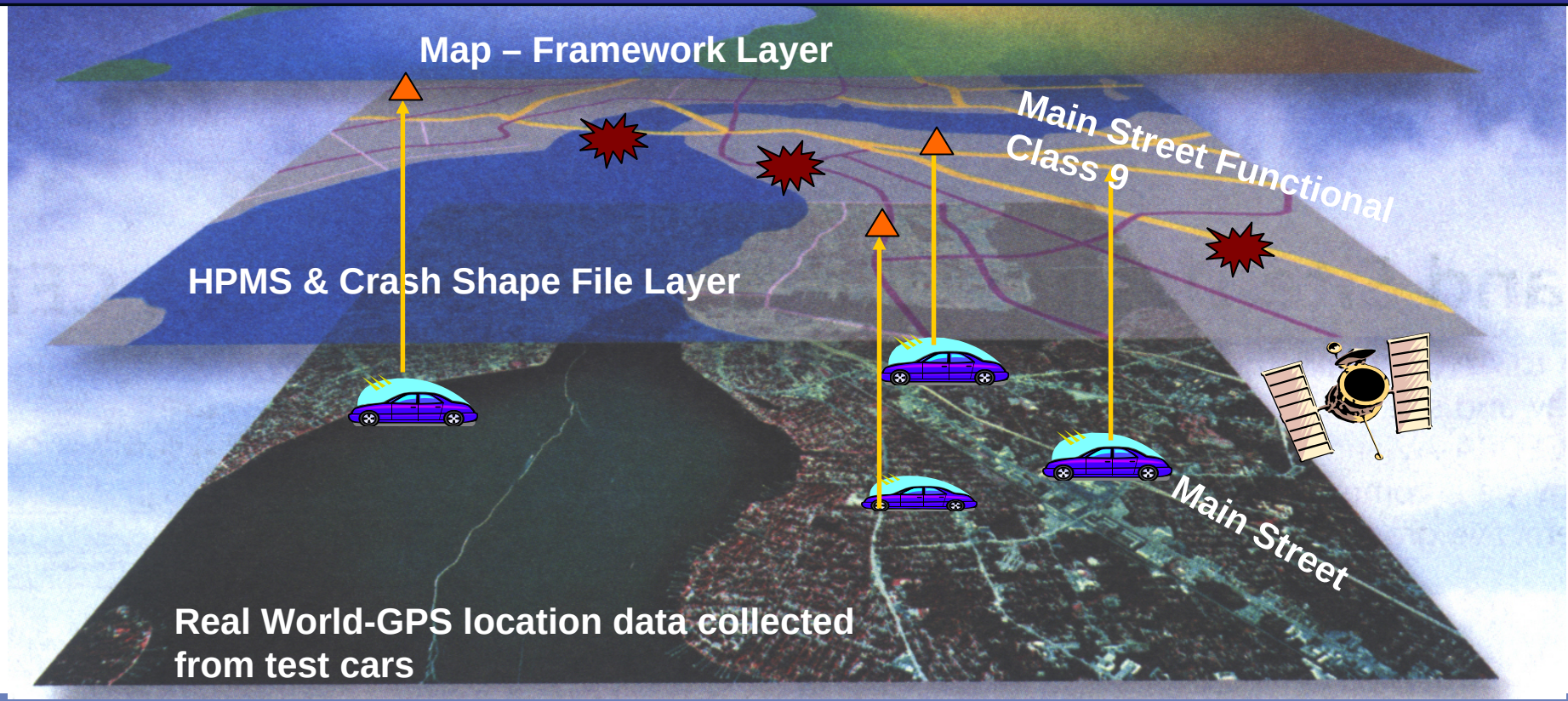
Washtenaw County 2004 Intersection Crashes (300 ft)



- **Crash locations (HPMS road and intersection data are also a part of this map point layer.)**

GIS - Joining Detailed Vehicle and Site-based Data Provides New Opportunities to Understand Crashes and Conflicts

-GPS Data from test vehicles (Lat Long Positions)
- Map layer (Michigan GeoRef)
- HPMS Data Layer (Michigan HPMS Data)



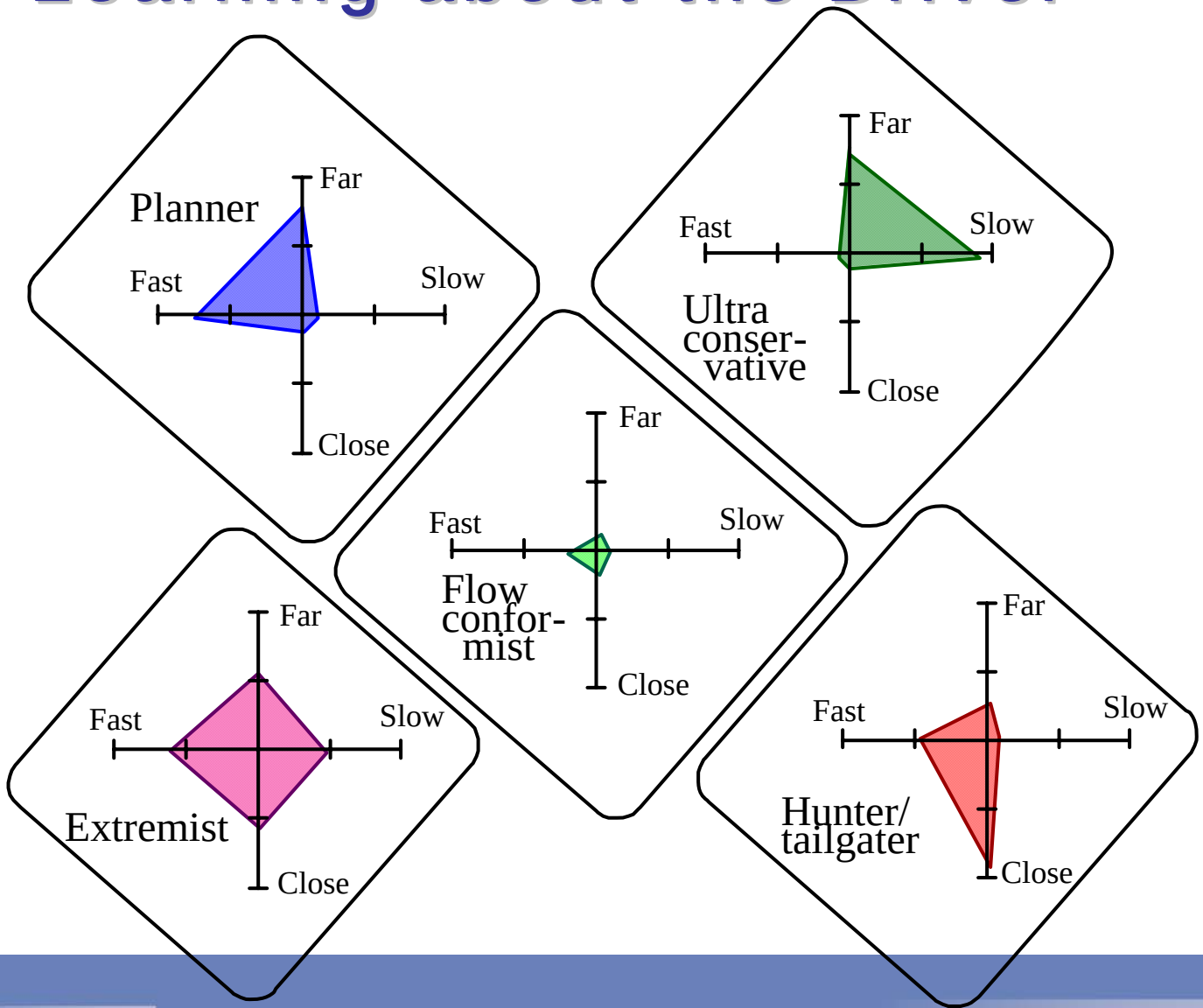
Washtenaw County Curve Speed Warning Imminent Alerts

- CSW Imminent Alerts

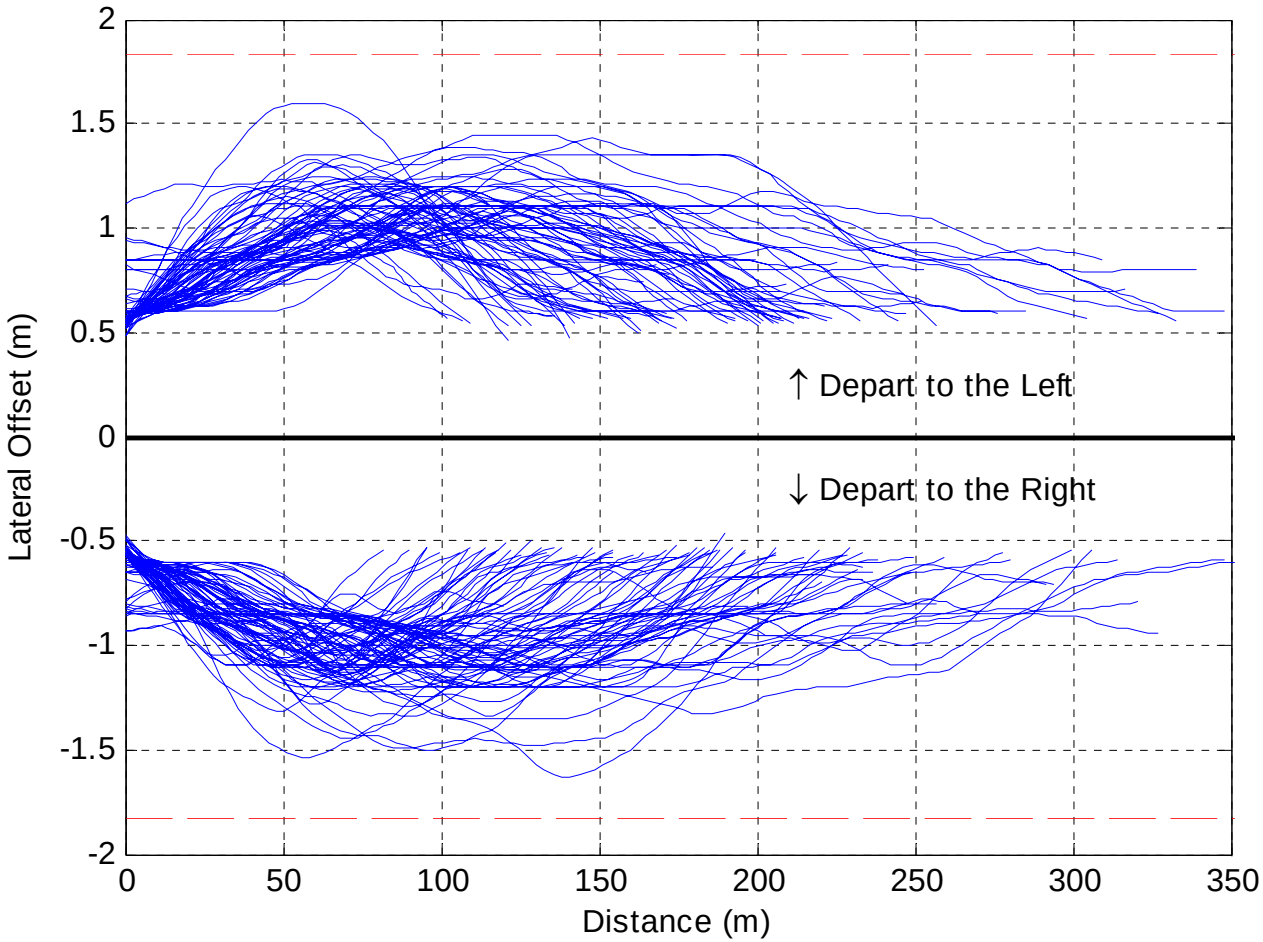
Learning about the Highway

- Detailed kinematics for crash, pre-crash *and* conflict
- Vehicle and site-based analysis can be joined via GIS to better understand highway factors
- Counting and evaluating crashes alone is statistically weak compared to the analysis of conflicts
- Research needed to better understand risk factors – major SHRP II objective
- Site-based data *essential* for intersection analysis & contributes to road departure analysis
- Vehicle-based data is *essential* for road departure analysis & contributes to intersection analysis
- To avoid bias, research should focus on "typical" as well as "problem" intersections

Learning about the Driver



Kinematic analysis of lane departures (ACAS)



- 2256 lane crossings in total.
- On average 23 occurrences per driver, 0.48 occurrence per trip.
- Occurrence rate: 33 per thousand miles traveled.

Freeway/artery mileage: 66,700 miles; total mileage covered by the fleet: 137,000 miles.

Learning about the Driver

While site based data collection cannot directly monitor drivers' activities within the vehicle,..

- **Major aspects of driver behavior can be inferred from vehicle motions – decisions and timing, delayed reactions, risk taking, control accuracy, …**
- **Multi-vehicle interactions resulting from those actions can be extracted, visualized and understood**
- **Site based acquisition provides an ideal data resource for modeling the driver-vehicle system interacting with other vehicles and the highway**