Overview and Evaluation of the Automotive Collision Avoidance System Field Operational Test (ACAS FOT)

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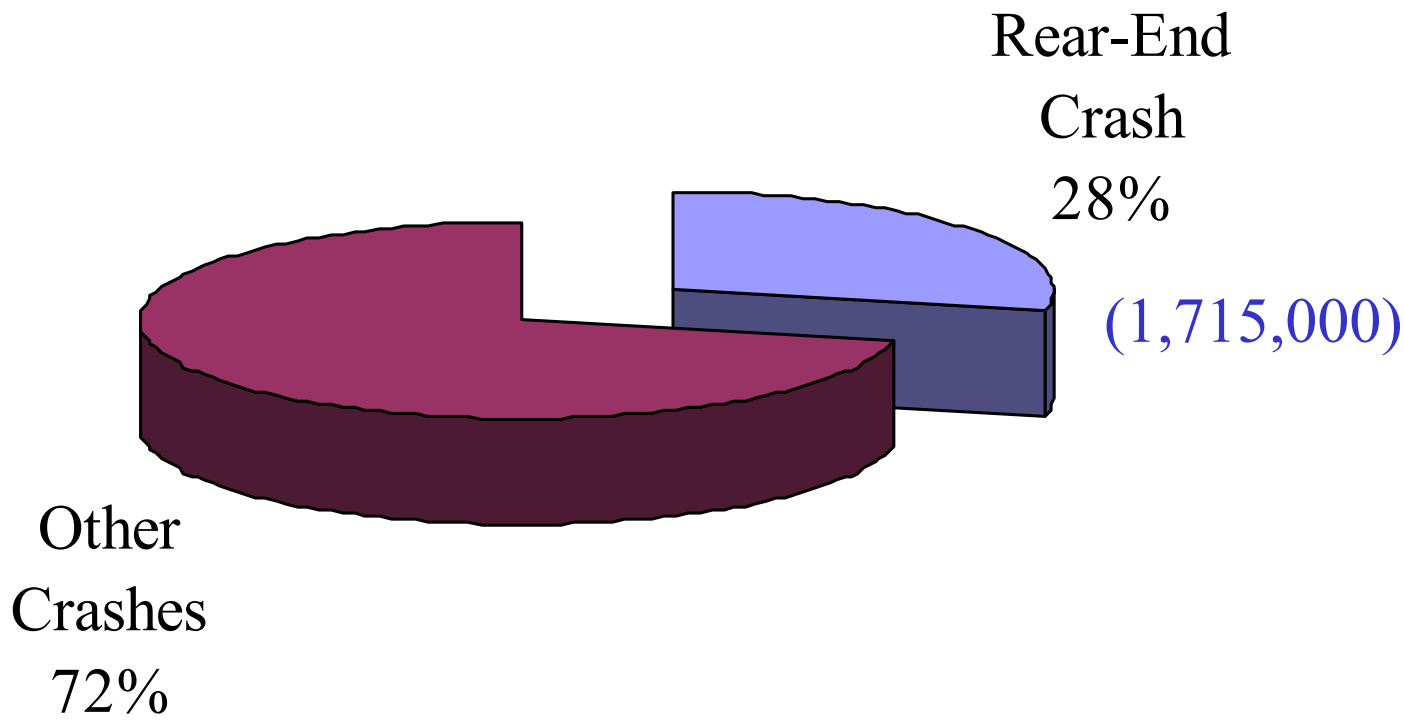
Outline

- **Program Overview:**
  - Program Phases
  - System Description
  - FOT Description
- **Evaluation Overview:**
  - Analysis Framework
  - Safety Benefits Estimation
  - Rare Events
  - Unintended Consequences

Rear-End Crash Problem

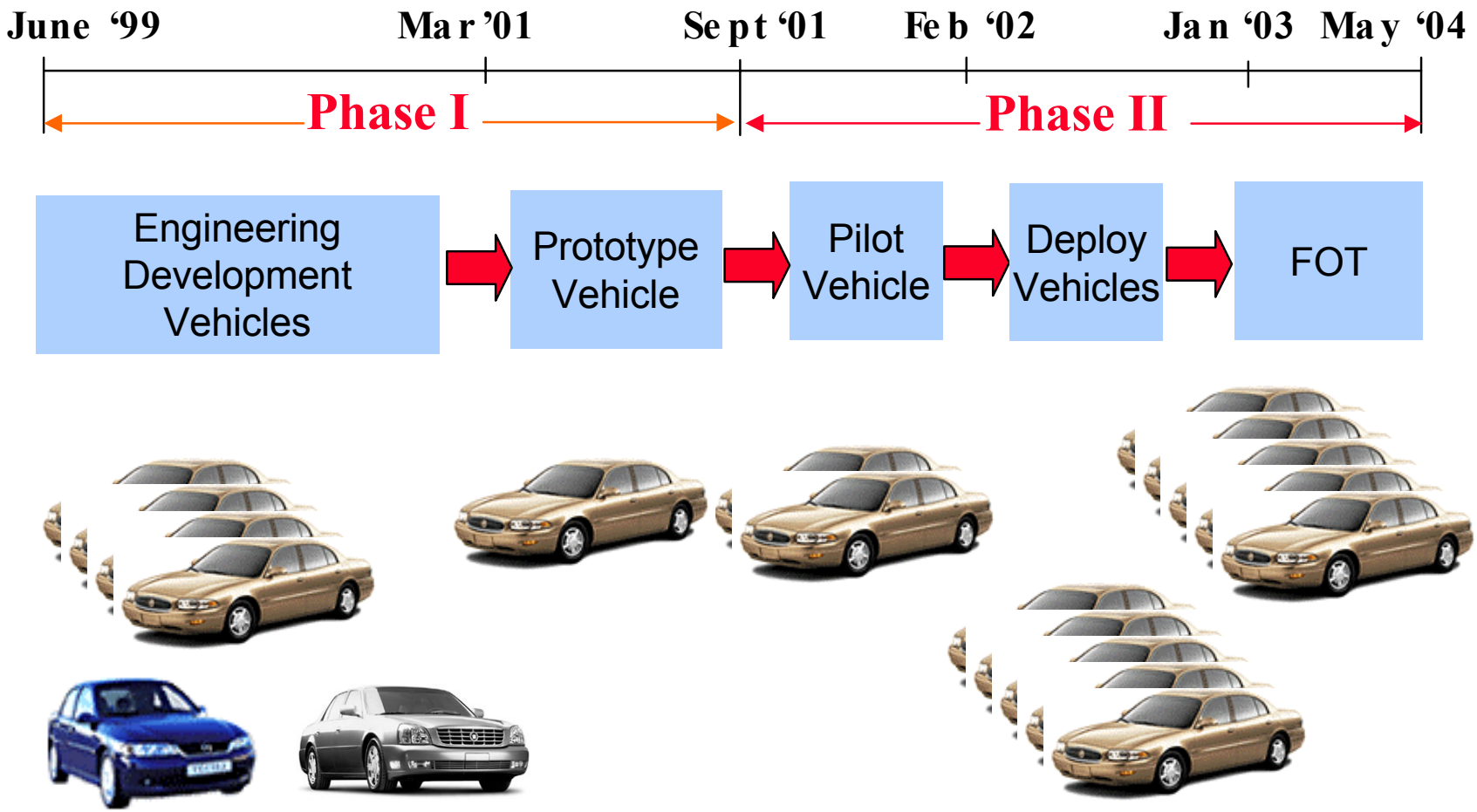


- 2003 General Estimates System data
- Light vehicle crash statistics
- Total 6,071,000 police-reported crashes

Automotive Collision Avoidance System Field Operational Test (ACAS FOT) Program

- **Sponsor**: U.S. DOT/***NHTSA***
- **Private Consortium**:
  - System Development and Build: ***GM/Delphi***
  - Conduct of Field Operational Test: ***UMTRI***
- **Independent Evaluator**: U.S. DOT/RITA/***Volpe Center***

ACAS FOT Program Scope



System Description

- **Forward Crash Warning (FCW)**:
  - Provide drivers with visual and audible alerts to help them avoid or reduce the severity of rear-end crashes.
  - Enabled when vehicle speed exceeds 25 mph.
- **Adaptive Cruise Control (ACC)**:
  - Maintain *selected cruise speed* if no lead vehicle is impeding the forward motion of the host vehicle.
  - Maintain *selected headway* (1 – 2 seconds) if lead vehicle is traveling below selected cruise speed.
  - Driver use of ACC is optional
  - ACC uses throttle & brake control up to 0.3g

Driver-Vehicle Interface – Head Up Display

ACC ON

FCW ON

Flash at
4 Hz

Imminent

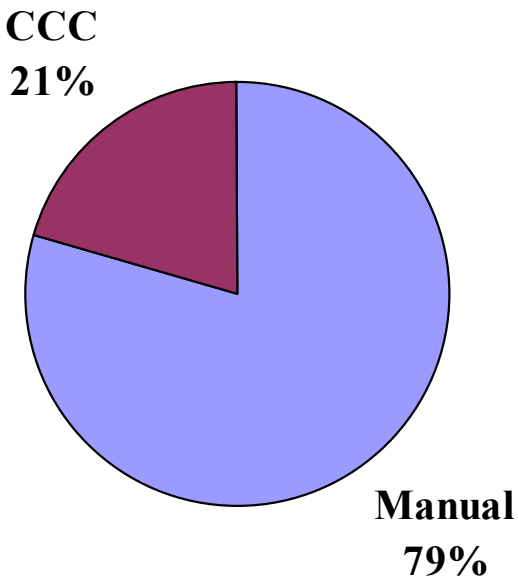
Steering Wheel Controls

FOT Experimental Design

Algorithm	Total Subjects	Age Groups		
		20 - 30	40 - 50	60 - 70
A	15	5	5	5
B	15	5	5	5
C	66	22	22	22

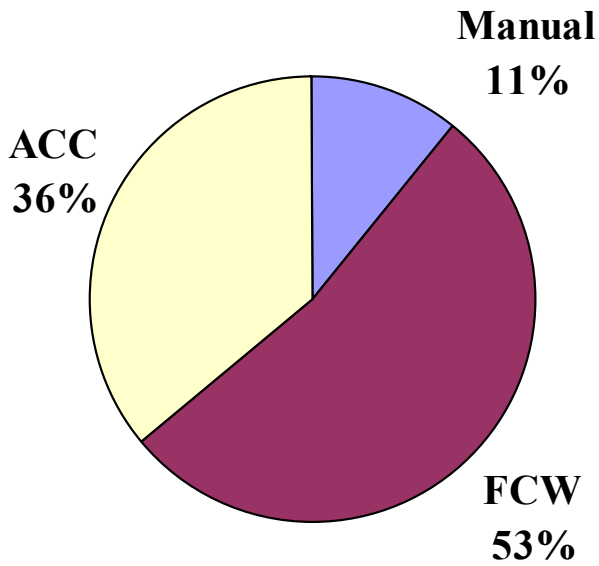
- 10 ACAS-equipped 2002 Buick LeSabres used
- Participants used vehicle as personal car unsupervised and unrestricted
- 4-week test period per subject:
  - 1 week baseline
  - 3 weeks with ACAS enabled

FOT Exposure



ACAS Disabled

Total Distance Traveled
36,000 Km



ACAS Enabled

Total Distance Traveled
122,000 Km

Independent Evaluation

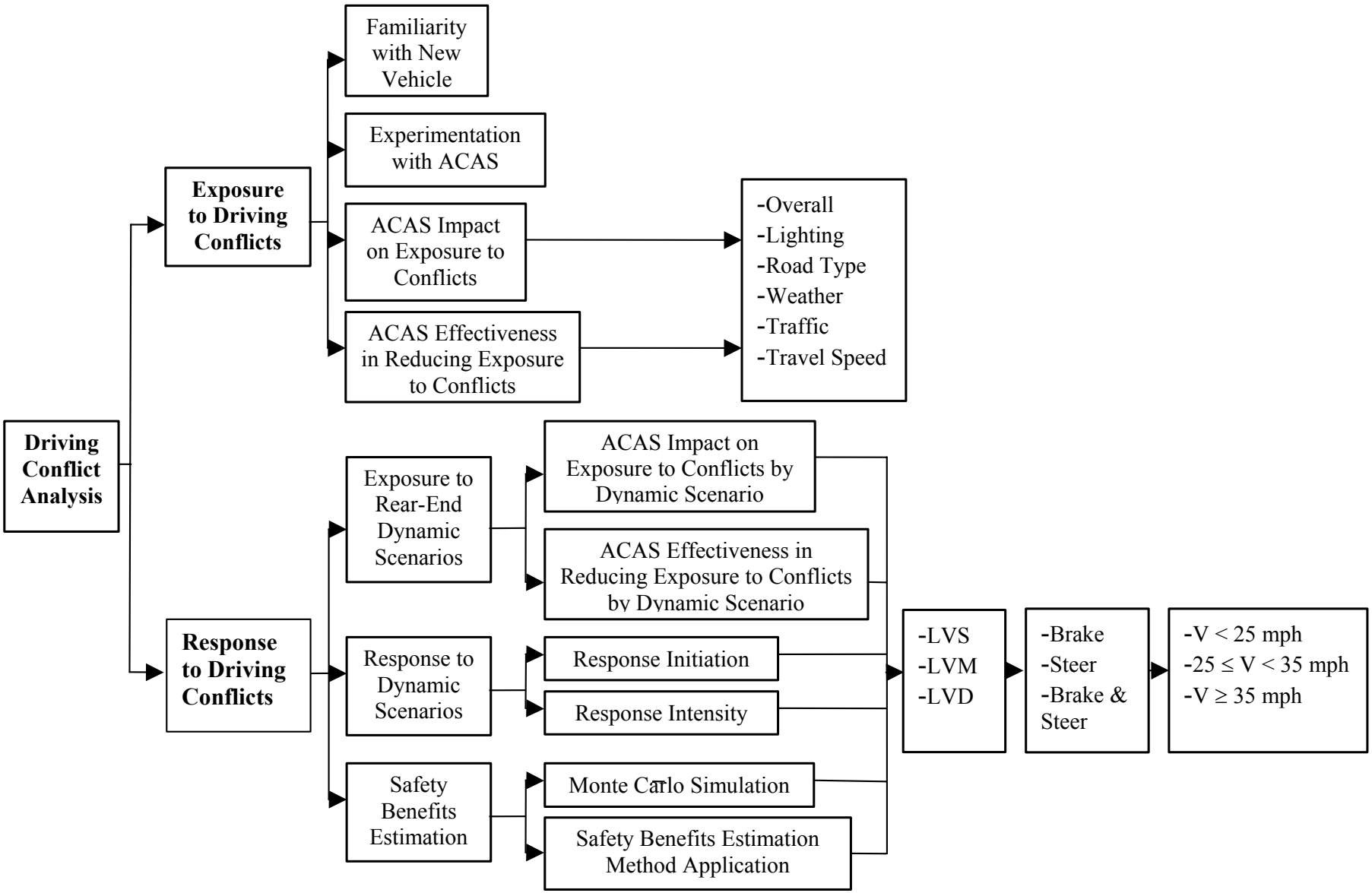
Goals:

- Estimate Safety Benefits
- Determine Driver Acceptance
- Characterize System Capability

Safety Impact

1. **Driving Conflict Analysis** – Global level examination of all FOT driving conflicts to develop quantitative estimates of overall safety benefits of ACAS.
2. **Near Crash Analysis** – Detailed Examination of the most severe near crashes to assess the usefulness of ACAS in preventing crashes.
3. **Driver Impact Analysis** – Examination of driver performance data to identify positive or unintended negative effects of ACAS on driving performance and behavior.

Driving Conflict Analysis



Driving Conflict Type and Intensity

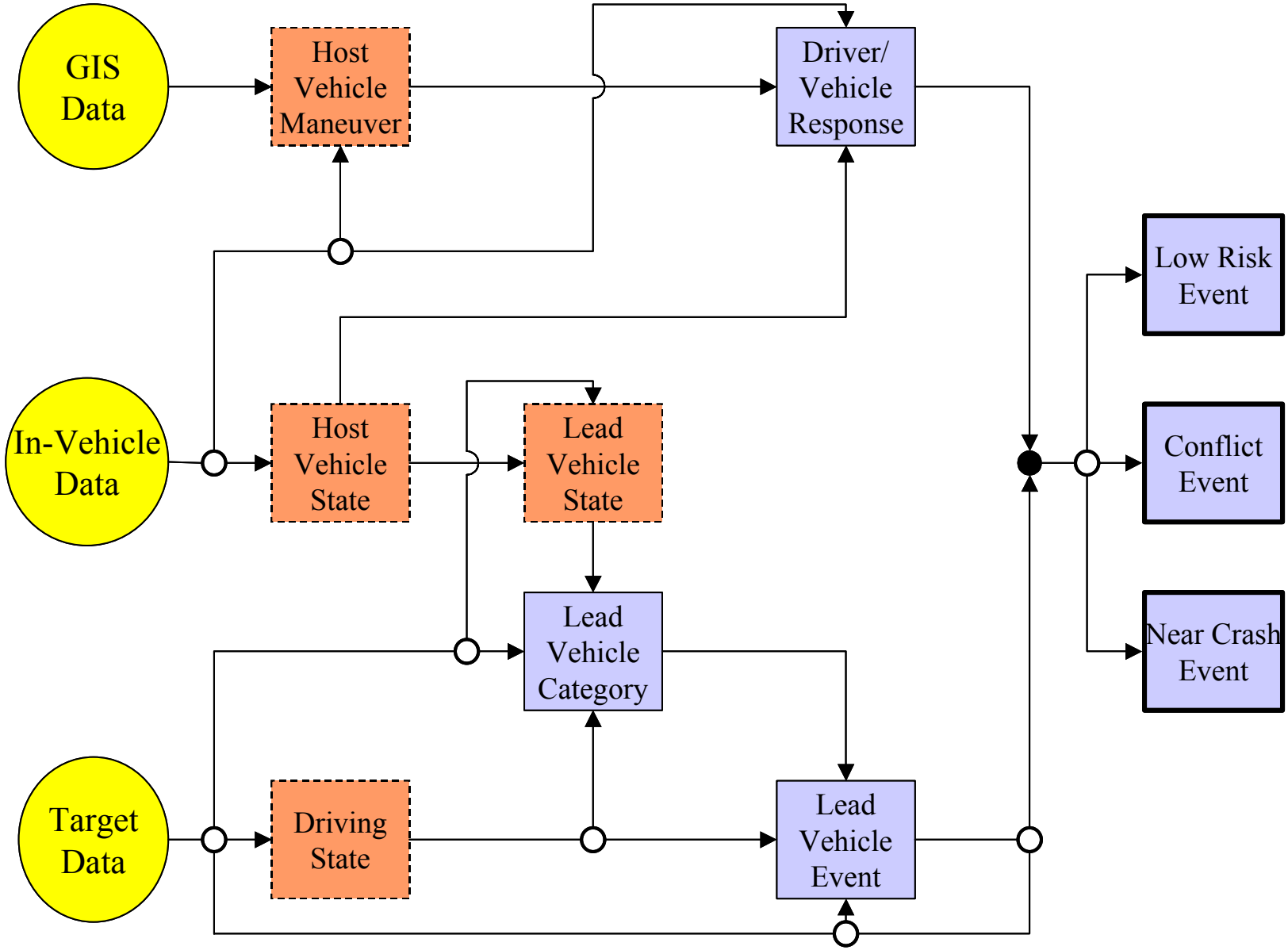
Driving Conflict Type

- *Conflicts*: CAMP data from last-second response studies at *comfortable* braking or steering level.
- *Near crashes*: CAMP data from last-second response studies at *hard* braking or steering level.

Driving Conflict Intensity

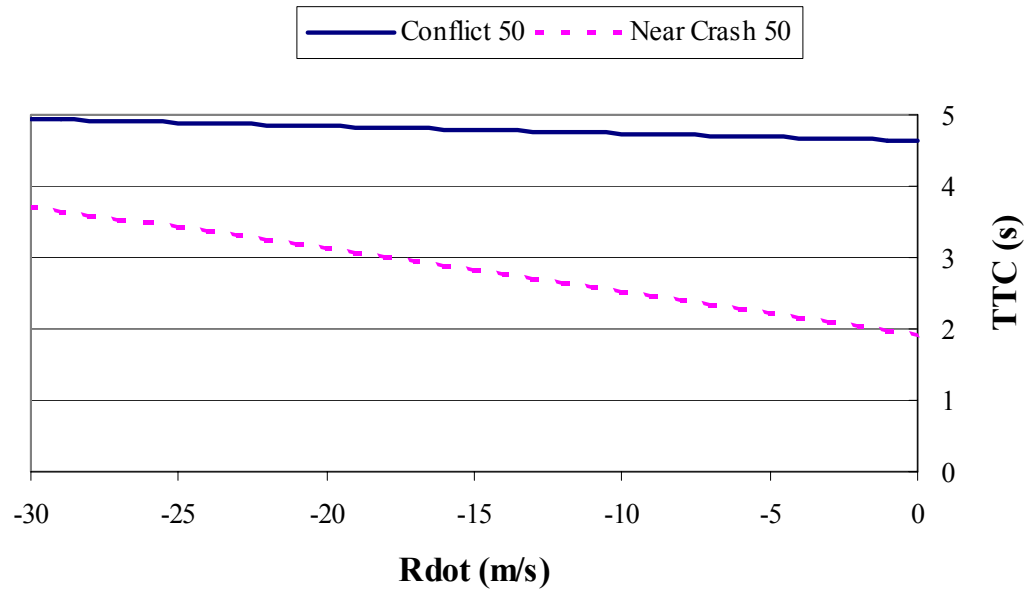
- *Low-intensity*: Quantified by TTC versus Range rate diagrams derived from CAMP's 50%-ile data.
- *High-intensity*: Quantified by TTC versus Range rate diagrams derived from CAMP's 95%-ile data.

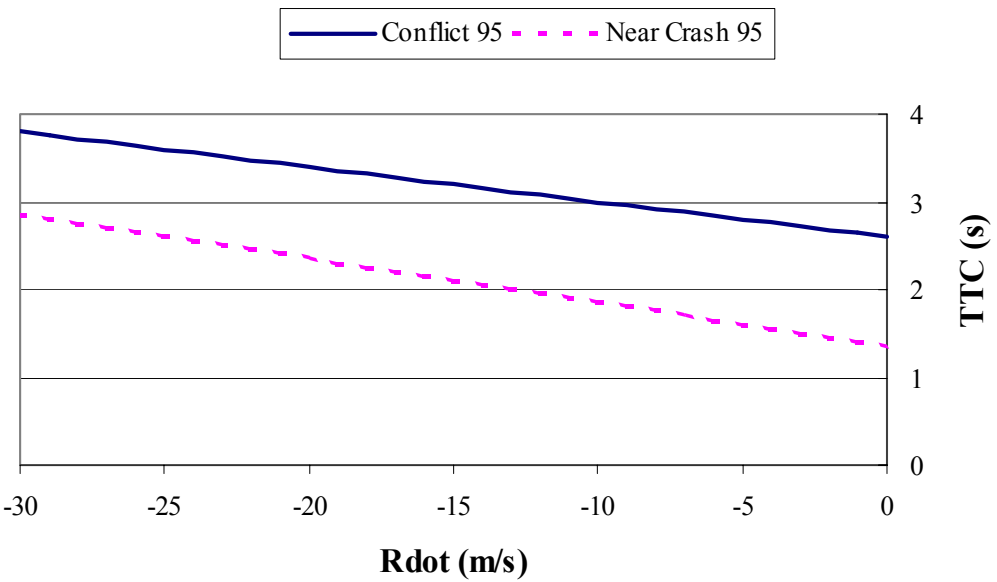
Driving Conflict Identification



Conflict Type and Intensity Classification

Lead Vehicle Stopped – Braking Response





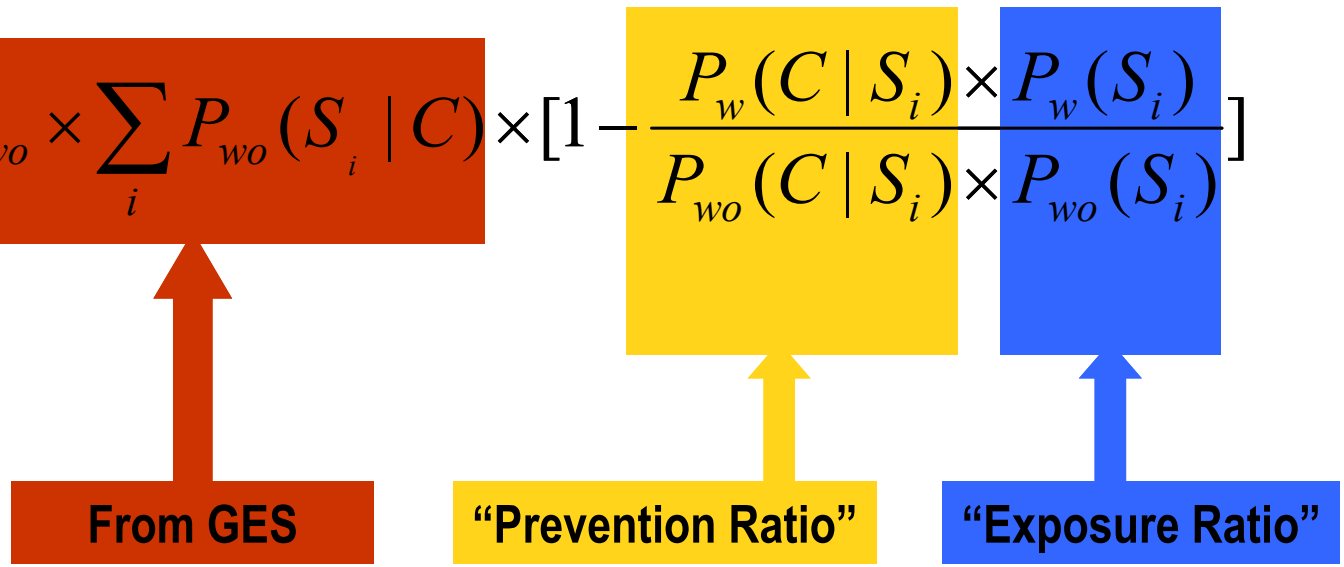
Safety Benefits Estimation

Simplest Form

$$B = [P_{wo}(C) - P_{w}(C)] \times \text{Miles Driven}$$

Useful form

$$B = N_{wo} \times \sum_{i} P_{wo}(S_i \mid C) \times \left[1 - \frac{P_w(C \mid S_i) \times P_w(S_i)}{P_{wo}(C \mid S_i) \times P_{wo}(S_i)}\right]$$



Exposure Ratio Analysis

Analysis:

- Comparison between ACAS disabled (1st week) and 2nd half distance traveled with ACAS enabled.

Dynamic Scenarios:

- Lead vehicle stopped
- Lead vehicle moving at slower constant speed
- Lead vehicle decelerating

Measures of Performance:

- MOP1= No. of conflicts per 100 Km traveled
- MOP2= No. of near crashes per 100 Km traveled

Prevention Ratio Analysis

Driver Response Analysis:

- Initiation Measures:
  - Time-to-collision
  - Time headway
- Intensity Measures:
  - Minimum time-to-collision
  - Peak acceleration
  - Average acceleration

Prevention Ratio Estimation:

Monte Carlo simulations based on data from bins with statistically significant difference in response initiation

Rare Events

- Analysis of *severe* near crashes based on response intensity using aggregate numerical data:
  - TTCmin ≤ 3 seconds and
  - Peak acceleration > 0.3g
- Analysis of video episodes triggered by crash imminent alerts that might have prevented a rear-end crash:
  - Driver distraction
  - High peak deceleration

Unintended Consequences

- Analysis of low risk (host vehicle @ constant speed) driving performance using numerical data:
  - Time headway
  - Position within travel lane
  - Speed ratio (vehicle speed/speed limit)
- Analysis of inattention (distraction or eyes-off-the-road) using alert-triggered video episodes.
- Anecdotal remarks based on few observations.

Observations

Questions?

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    - http://www-nrd.nhtsa.dot.gov/departments/nrd-12/pubs_rev.html