Safety Program Research Questions: S05 Design of the In-Vehicle Driving Behavior and Crash Risk Study

Tom Dingus
Jon Hankey
Charlie Klauer
Dave LeBlanc

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Task 1: Specific Research Questions

- Questions should be representative of the major study goals.
- Must include, but not be limited to questions involving road departure and intersection crashes
- Questions should be stated precisely enough that they lead to specific data collection requirements and analysis techniques.
- Questions should include (but not be limited to) questions quite specifically related to countermeasures, again representative of the major study goals.
- To begin, use research questions developed by the SHRP II planning groups and those developed at the August 2006 SHRP II symposium.
- Consider questions that anticipate future issues, such as high speed congestion and an increase in the number of older drivers.
- For Road Departure and Intersections, also identify research questions that the data and subsequent analyses will probably not be able to answer.

Research Questions (Vision from SR 260)

SR 260

Employ new technologies to produce the necessary understanding of the relationship of multiple factors (human, vehicle, roadway and environmental) to the risk of collisions and casualties to support future countermeasure development and achieve substantial reductions in traffic crashes and casualties.

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Research Questions (shortest version)

Develop an understanding of the interaction of driver behavior with the roadway, vehicle and environment to improve safety

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Target of Opportunity

1. Objective exposure-based collision risk measures
2. Surrogate measures of collision risk
3. Address driver behavior, speeding, inattention, fatigue, age, gender, etc.
4. More detailed roadway data with greater coverage

Broad Areas

1. Evaluation of crash surrogates
2. Individual variability and systematic variation with age, gender and vehicle type
3. Relation of driver behavior and roadway characteristics
4. Lane-keeping/road departure
5. Intersection characteristics/control and collision risk

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Road Departure - Sample Research Questions

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

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Road Departure Risk Analysis

1. Risk Measures
   a) Road departure collisions
   b) Road departure surrogates
      - road departure (w/o collision)
      - time-to-road departure from lane-edge sensor

2. Independent Variables
   a) Road: grade, curve, shoulder, rumble strip
   b) Vehicle type: car, van, SUV
   c) Driver: age, gender, fatigue, inattention, speed
   d) Environment: light, weather

3. Product
   a) Relate road departure risk to driver, vehicle,
   b) roadway and environment factors

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Intersection Collisions
Sample Research Questions

1. What is the relative risk of different intersection maneuvers?
2. How much do left/right-turn lanes and/or signal phases reduce the collision risk of turns?
3. How do turn lanes change the pattern of conflicts?
4. What is the role of illegal maneuvers?
5. How does the relative risk of different intersection maneuvers vary with driver age and gender?
6. How does driver behavior (speeding, aggressive driving) affect the risk of intersection maneuvers?
7. What is the role of inattention, distraction?
8. How does the pattern of conflicts vary with traffic volume?

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Intersection Risk Analysis

1. Risk Measures
   a) Group data by traffic maneuver (conflict)
   b) Crash surrogates
      - Near-collisions/traffic conflicts
      - Crash margin measures

2. Independent Variables
   a) Intersection: design, signing, markings, signals, visibility
   b) Driver: age, gender, fatigue, inattention, distraction, speed, illegal actions
   c) Environment: light, weather

3. Product
   Relate collision and conflict risk to driver, vehicle, intersection and environment factors

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S05 Action Plan

1. Using detailed information from the following sources, identify specific research questions.

    a. SHRP II/Ken Campbell document, September 2003
    b. NHTSA expert panel “In Situ” document, 1998
    c. National Highway Research and Technology Partnership white papers, 2002
    d. Indiana Tri-level Study
    e. National data (NASS, NMVCCS, etc.)
    f. Volpe/NHTSA “37 crashes” (GM 44 crashes update)
    g. 100 Car past and future questions
    h. Teen/Older driver current/future questions
    i. August 2006 Symposium
    j. “Future” vehicle/roadway/driver questions generated by alliances/other experts

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Action Plan (Cont.)

2. Synthesize those research questions based on guidelines identified in the SHRP II S05 contract remembering to include issues related to road departures and intersections as well as future issues and driving behavior issues.

3. Create additional research questions of similar scope for the remaining crash types.

Action Plan (Cont.)

4. Categorize questions into five categories
    a. those that can be addressed directly from a current state of the art, lower-cost, mass-produced, data acquisition system (i.e., large fleet system)
    b. Those that can be addressed with a large fleet system, but only with significant post-hoc data reduction
    c. Those that can be addressed with a large fleet system, but only with the addition of a roadway information database
    d. those that may be feasible from a large fleet system with the inclusion of additional, or more capable, sensors
    e. those that will be addressable only from a highly sophisticated, higher cost, limited production system

Action Plan (Cont.)

5. Focus on category c as part of the interface with the Roadway Measurement Van and other GIS-enabled features.
6. Focus on category d as primary input for the initial system spec for the majority of the fleet.
7. Focus on e for the potential development of a higher capability, small fleet system and cohort.

Action Plan (Cont.)

Assumptions regarding large fleet capability:

- Installation on almost any car/van/light truck
- Installation in less than 2 hours
- Basic vehicle network information available
- Start with VTTI next generation research system:
  - Two cameras
  - Forward radar
  - Lane tracker machine vision
  - Head forward machine vision
  - Illumination
  - GPS
  - X,Y acceleration plus yaw
  - Speed plus as available: wipers, brake, headlight, turn signal, steering data

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Action Plan (Cont.)

Example Questions from Category a:

Those that can be addressed directly from a current state of the art, lower-cost, mass-produced, data acquisition system (i.e., large fleet system).

1) What are exposure differences, in terms of road type, speed selection and miles traveled, across driver age and gender sub-groups?
2) What are the individual differences in lane-keeping performance?
3) How does the within and between subject variation in lane keeping compare (i.e., to what extent does one driver consistently perform better than another driver)?
4) Do drivers travel at lower speeds and longer headways, and to what degree, in rain, snow, fog?
5) What is the driver response, in terms of immediate control input and subsequent speed selection, to in-vehicle CWS warnings?
6) What are the kinematic conditions, in terms of range, range rate, vehicle speed and deceleration, at the onset of a hard braking maneuver?

Action Plan (Cont.)

Example Questions from Category b:

Those that can be addressed with a large fleet system, but only with significant post-hoc data reduction.

1) What driver actions occur in the seconds preceding and during intersection crashes? Intersection near crashes?
2) How does aggressive driving behavior impact crash/near crash risk? Why do aggressive driving behaviors occur and how do they relate to ROR crashes/near crashes?
3) Human, multi-factor descriptors: How is driving behavior X and crash risk affected by both “permanent descriptors” (age, gender, driving experience, crash record) and “transitory descriptors” (fatigue, other impairment, distractions)?
4) Do drivers travel at lower speeds, and within what range, when pedestrians (especially children) are present?
5) What is the relative risk of various sources of present and near future devices (i.e., nomadic or in-vehicle devices such as IPhone or mobile office)?
6) What is the driver reaction time and control input selection for safety-critical events?

Action Plan (Cont.)

Example Questions from Category c:

Those that can be addressed with a large fleet system, but only with the addition of a roadway information database.

1) How are ROR crashes and near crashes impacted by different roadway features including shoulder width, speed, signage, delineators, etc.?
2) Are centerline rumble strips beneficial in improving lane keeping performance? Edgeline rumble strips?
3) Roadway/environment, multi-factor descriptors: How is driving behavior X and crash risk affected by both “permanent descriptors” (curvature, road surface, lane width sight distance) and “transitory descriptors” (weather, light condition, traffic flow, adjacent vehicles)?
4) How do turn lanes change the pattern of conflict at intersections?
5) How does lane-keeping and road departure on curves and grades compare with, and differ from, straight-flat road segments?
6) What is the role of speed relative to the posted speed limit in lane-keeping performance?

Action Plan (Cont.)

Example Questions from Category d:

Those that may be feasible from a large fleet system with the inclusion of additional, or more capable, sensors.

1) How do crash avoidance systems, including ESC, impact driver behavior in ROR or Rear End crash scenarios? (OBD II)
2) How often, for what length of time, and in what pattern, do drivers look away from the forward roadway? What are the individual differences among and between drivers? (Eyes forward)
3) What is the role of inattention in intersection errors/conflicts? (Eyes forward)
4) What is the influence of adjacent traffic or opposing traffic on lane keeping? (Cameras, low cost side sensor)
5) How do circumstances of low friction affect driver behavior and crash/near crash risk? (OBD II, traction control, wheel slip, other)
6) How does driving behavior and crash/near crash risk change when single/multiple passengers are present (Passenger/seat belt sensor/camera)

Action Plan (Cont.)

Example Questions from Category e:

Those that will be addressable only from a highly sophisticated, higher cost, limited-production system.

1) What is the prevalence of straight crossing path (SCP) traffic signal violations? (Machine vision sensor and high res camera to detect signal state)
2) For willful SCP signal violations, what is the position, speed, etc of the crossing traffic. (Side facing radar)
3) What percentage of time do drivers look at mirrors, in-vehicle devices, nomadic devices, signs, external distractions? (Eye tracker)
4) How often, and under what circumstances do drivers drive while under the influence of alcohol? What are the individual differences, both between and within drivers, related to alcohol use? (Passive alcohol sensor)
5) How often, and under what circumstances, do drivers drive while fatigued? What are the individual differences, both between and within drivers, related to fatigue? (Fatigue sensor(s))
6) How is lane-keeping performance related to adjacent lane traffic and roadside factors? (360 deg object tracking)

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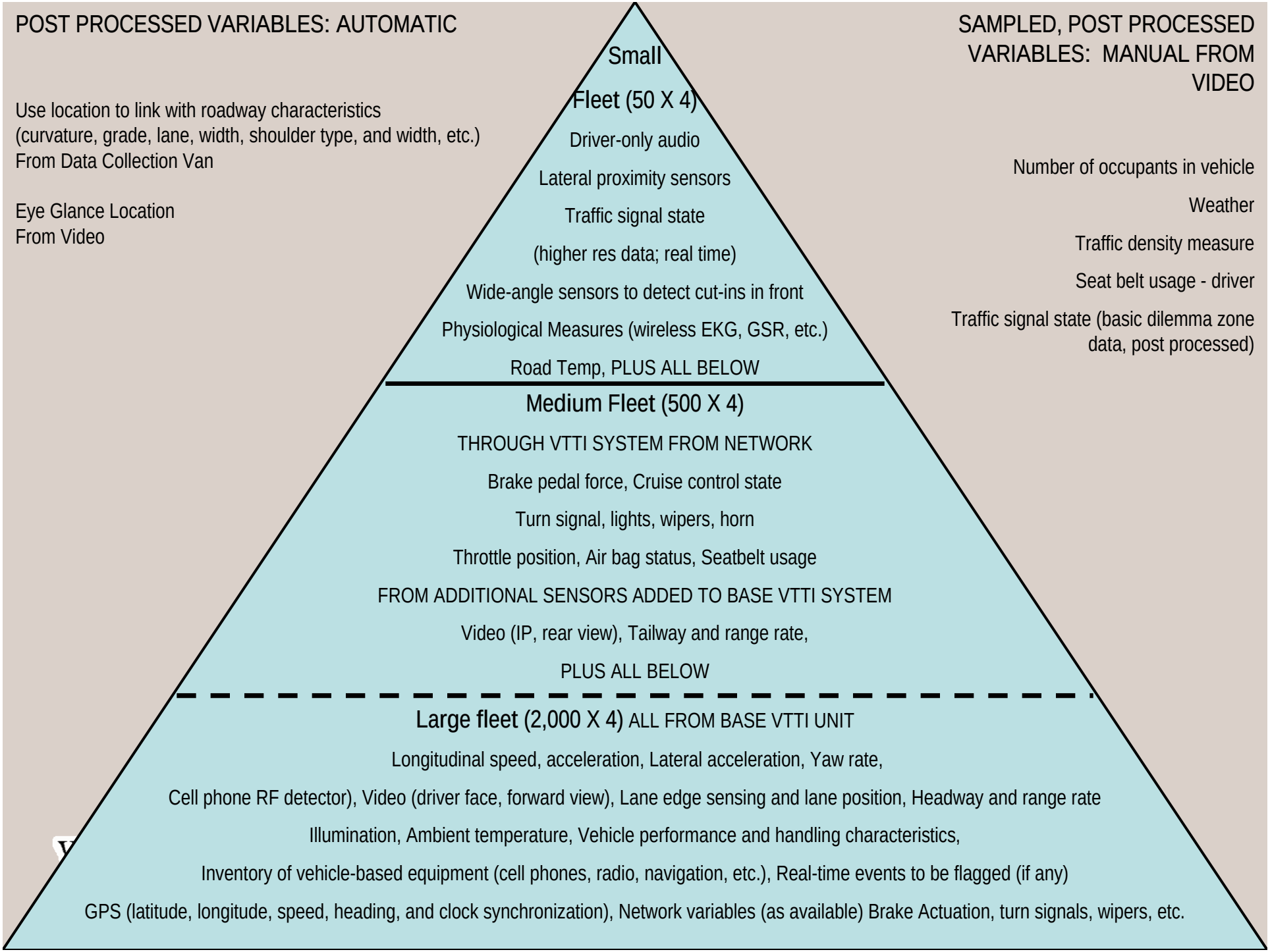
POST PROCESSED VARIABLES: AUTOMATIC
Use location to link with roadway characteristics
(curvature, grade, lane, width, shoulder type, and width, etc.)
From Data Collection Van
Eye Glance Location
From Video
SAMPLED, POST PROCESSED VARIABLES: MANUAL FROM VIDEO
Number of occupants in vehicle
Weather
Traffic density measure
Seat belt usage - driver
Traffic signal state (basic dilemma zone data, post processed)
Small Fleet (50 X 4)
Driver-only audio
Lateral proximity sensors
Traffic signal state
(higher res data; real time)
Wide-angle sensors to detect cut-ins in front
Physiological Measures (wireless EKG, GSR, etc.)
Road Temp, PLUS ALL BELOW
Medium Fleet (500 X 4)
THROUGH VTTI SYSTEM FROM NETWORK
Brake pedal force, Cruise control state
Turn signal, lights, wipers, horn
Throttle position, Air bag status, Seatbelt usage
FROM ADDITIONAL SENSORS ADDED TO BASE VTTI SYSTEM
Video (IP, rear view), Tailway and range rate,
PLUS ALL BELOW
Large fleet (2,000 X 4) ALL FROM BASE VTTI UNIT
Longitudinal speed, acceleration, Lateral acceleration, Yaw rate,
Cell phone RF detector), Video (driver face, forward view), Lane edge sensing and lane position, Headway and range rate
Illumination, Ambient temperature, Vehicle performance and handling characteristics,
Inventory of vehicle-based equipment (cell phones, radio, navigation, etc.), Real-time events to be flagged (if any)
GPS (latitude, longitude, speed, heading, and clock synchronization), Network variables (as available) Brake Actuation, turn signals, wipers, etc.

Discussion Items

1) Are there additional sources of research questions that we should be considering?
2) How can we best obtain information regarding “near future” vehicle questions?
3) To what degree should we focus on newer, or higher-end, vehicle types to obtain “near-future” data?
4) What are the relative merits of creating a highly instrumented sub-fleet to answer “all” of the research questions?

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