WMU/GM collaboration: Quiet cars in Yuma Arizona

Purposes

- Extend knowledge of impact of quiet vehicles on performance of basic Orientation and Mobility (O&M) tasks

- Assess impact of added sounds on detection of vehicles in typical O&M task performance

Location and Participants

- Yuma, Arizona; GM Proving Grounds
- 15 adults who are blind or severely low vision
  - 7 normal hearing, 5 with slight high frequency loss, 3 with systematic hearing loss
  - 8 experienced travelers, 7 less experienced
- Tasks performed with groups of 5 participants.
- Data analyzed as a whole as well as for hearing subgroups

Vehicles

- Saturn Vue hybrid
  - Electric Mode (EM)
  - Internal Combustion Engine (ICE)
  - EM with one of 5 added sounds
- 2010 Toyota Prius
- 2010 Chevrolet Cobalt (ICE)

Tasks

- Surge detection and discrimination of vehicle pathway
  - Related to perception of vehicles turning right on green or starting up at lighted intersection
- Gap detection
  - Related to optimal gap detection and use at roundabouts and other uncontrolled crossings
- Detection of approaching vehicles (forward and reverse)
  - Related to assessment of traffic phase, perception of slow moving vehicles in driveways and parking lots, recognition of slow moving traffic near intersections
- Detection of stopped vehicles
  - Related to perception of vehicles idling at an intersection or vehicles yielding at an uncontrolled crossing

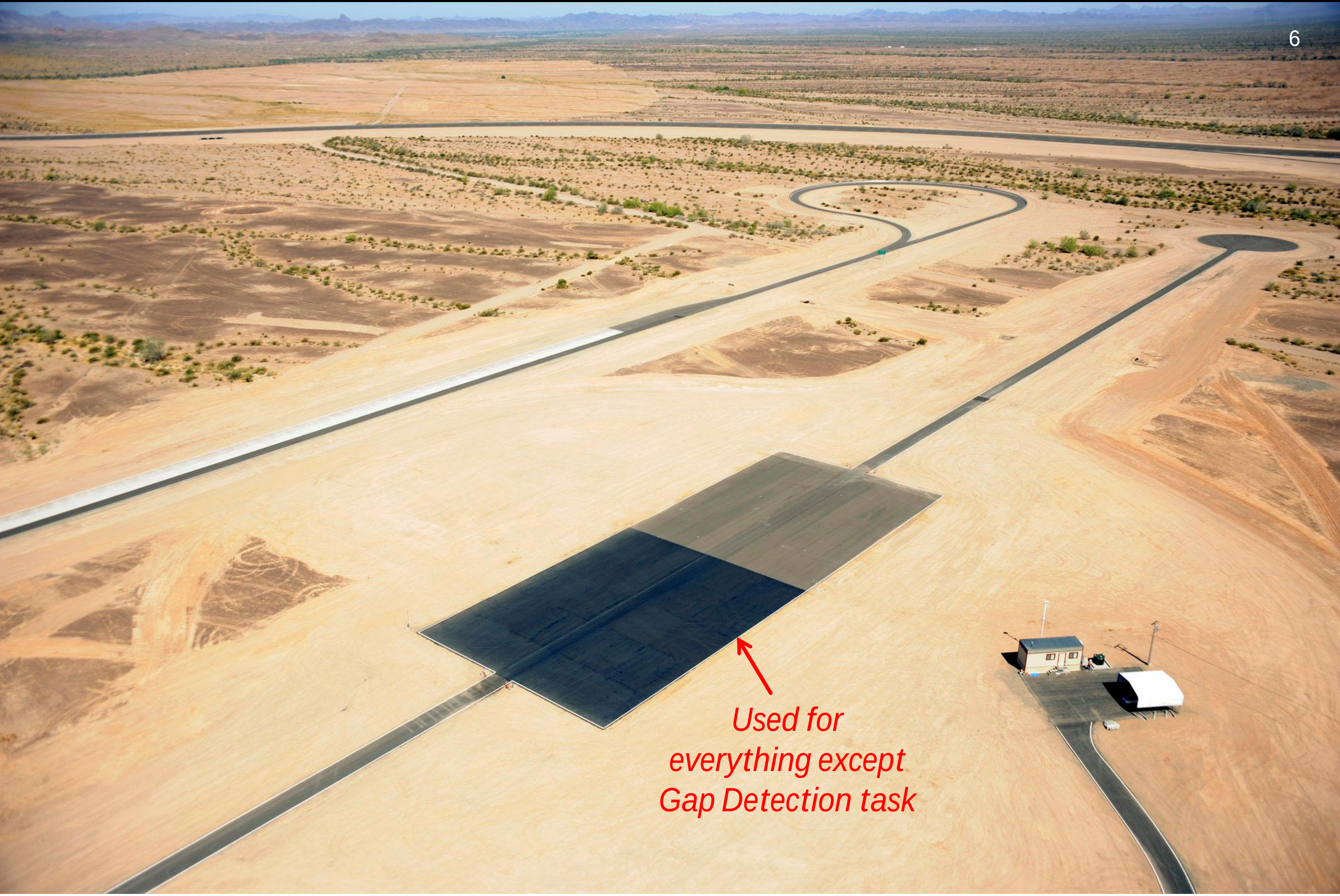


Photo from B. Reeder, Yuma Proving Grounds

Vehicle detection task

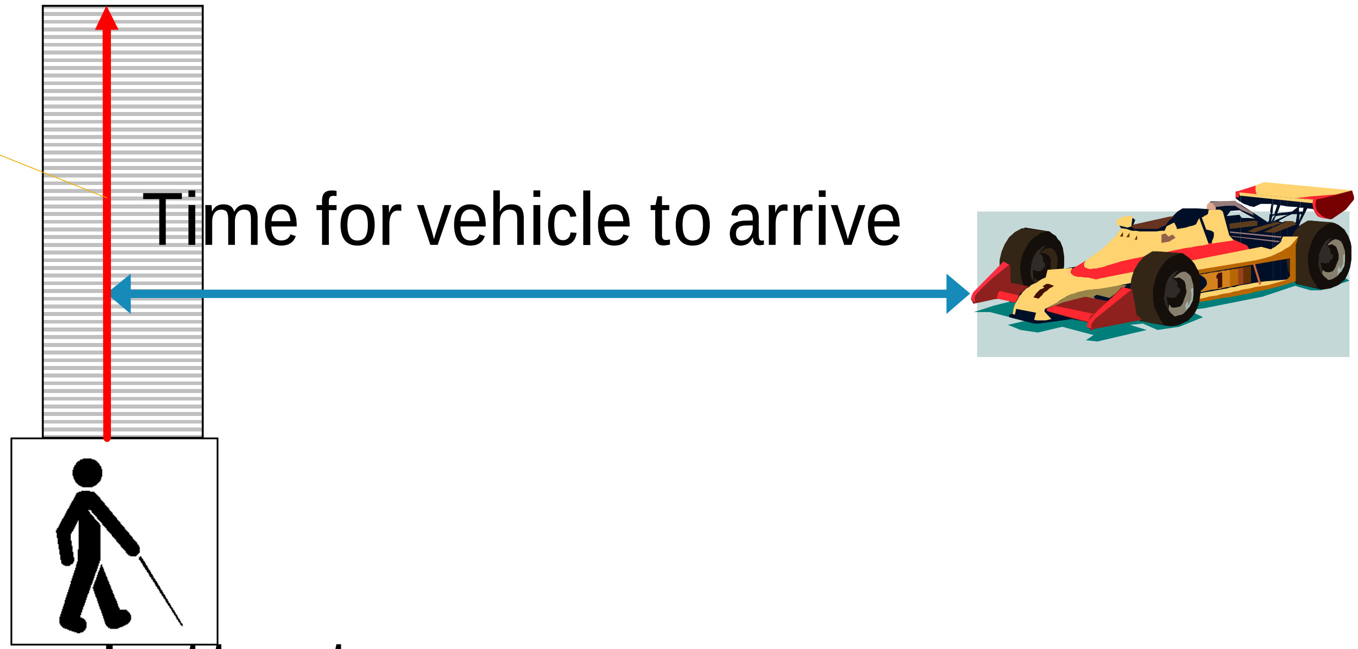
Procedures

- Conditions:
  - Constant slow speed passby (15 kph)
  - Backing toward pedestrian position (10 kph)
- Pedestrians 2 m from center of passing vehicles
- Pedestrians pressed button when they first heard vehicle approaching
- Vehicles included Toyota Prius (EM), Cobalt (IC), Saturn Vue (ICE, EM, and EM plus 5 added sounds)

Measures

- Vehicle position and speed as a function of time
- Sound level
- Distance of detection
  - Distance from pedestrian to vehicle when pedestrian indicated they heard the vehicle approaching
- Crossing margin
  - Time from pedestrian indication of detection to when vehicle passed by pedestrian position, minus crossing time
  - Crossing time calculated using standard 2 lane width and 3.5 ft/s

Crossing margin measure



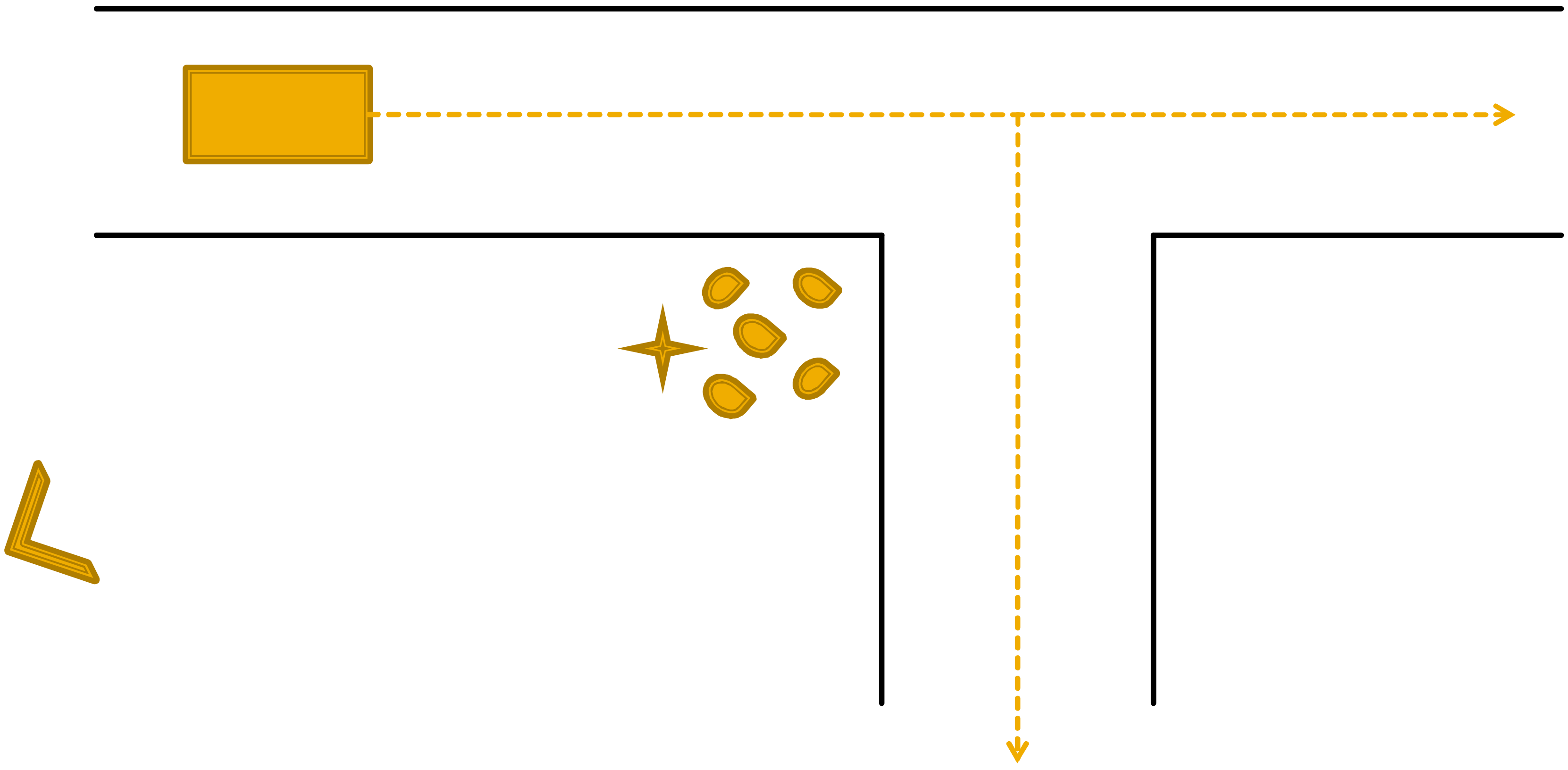
Crossing margin = vehicle passing time – 6.9 seconds

Regression Analysis for Forward Detection

- Predictors for Forward Detection Crossing Margin (seconds) (N = 185). $R^2 = .643$

Variables	*B*	*SE B*	*β*	*CI (95%)*	
				Lower	Upper
Constant	74.66	13.58		47.87	101.45
Average wind speed (mph)[a]	-2.37	.33	-.47	-3.02	-1.71
Amplitude modulation depth difference (11 dB vs. 5.5 dB)	-9.82	1.76	-.30	-13.28	-6.35
Hearing loss at 500 Hz (dB)	-.35	.07	-.29	-.48	-.22
Amplitude modulation depth difference (11 dB vs. 28 dB)	-8.83	2.00	-.28	-12.77	-4.89
Vehicle velocity at detection (km/h)	-1.97	.50	-.19	-2.96	-.98
Minimum ambient sound level (dB)[b]	-.54	.15	-.21	-.83	-.25
Overall vehicle sound level (dBA)[c]	.531	.15	.18	.17	.90

Pathway discrimination task



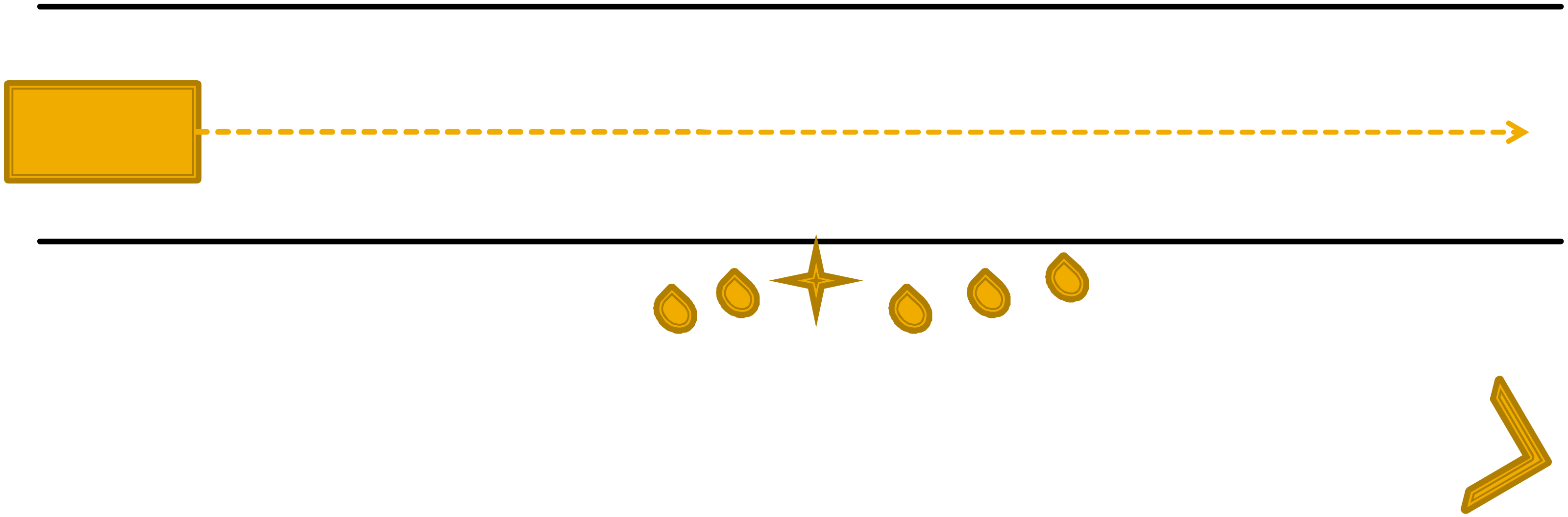
Procedures

- Starting beyond 50 feet, vehicles approached from behind participants, stopped, then without exceeding 10 kph either:
  - continued straight past pedestrians
  - turned right in front of them
- Order of path presentation randomized
- Pedestrians pressed button when they first heard vehicle start from a stop, then voted for whether vehicle went straight or turned as soon as they could determine the path

Measures

- Vehicle position and speed as a function of time
- Sound level
- Participant button press when surge was detected and when discrimination of path was made
- Surge detection lag (time from vehicle beginning to move to pedestrian indicating perception of vehicle moving)
- Path decision lag (time from vehicle beginning to move to when pedestrian voted on straight or turning path)
- Pathway accuracy rate (% of correct path choices made)

Gap detection task



Procedures

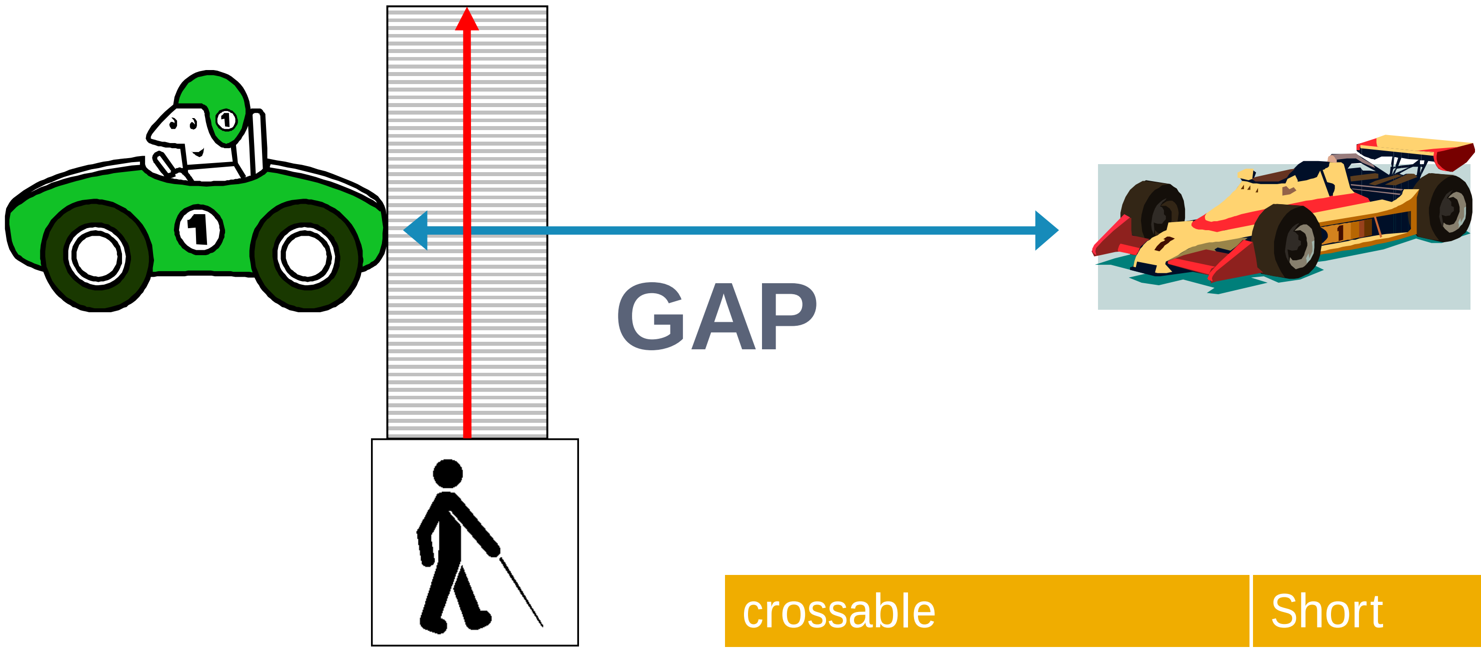
- A series of vehicles (Prius, ICE vehicles, Vue ICE, EM and EM with added sounds) circled on the dynamics testing pad
- Participants remained in one position and pressed a button whenever they would cross a 2 lane street in front of them
- Vehicles cycled through in several groupings, creating long and short gaps, each started and ended by each type of vehicle


150

Measures

- Participant button press when a crossing would be initiated
- Vehicle position and speed as a function of time
- Sound level
- Crossable gaps taken = percent of all gaps 6.9 sec or longer during which pedestrian crossed (efficiency)
- Short gaps taken = percent of all gaps shorter than 6.9 sec during which pedestrian crossed (risk)
- Time to Pass (TTP) margin

Time to pass measure



6.9 sec. to cross

crossable	Short
6.9+ seconds	< 6.9 seconds
Time to pass margin	
6.9+ = would have crossed when following vehicle arrives	< 6.9 = sharing roadway with passing vehicle

General observations

- Which sound performs best depends on whether detection or decision-making is required

  - DETECTION→ *When do I hear a vehicle coming?*
  - DECISION MAKING→ *When I am at an intersection, is the car I detect going straight or crossing right in front of me?*

    When I am at an uncontrolled intersection, do I have enough time to cross the street?

- Although important, detection is NOT a sufficient metric for judging sound appropriateness

General observations (cont.)

- Some sounds improved performance over both a vehicle in EV mode as well as internal combustion vehicles, at the same dB level as the IC vehicle.

- Testing done under well-controlled, low ambient sound conditions→ further testing needed under high ambient and “live” traffic conditions

End

- Thank You