Notice

This presentation contains a subset of the CAMP PCAM Final Briefing materials presented to NHTSA in June, 2013. The CAMP PCAM written Final Report should be referenced/consulted for information about the PCAM Project rather than the attached Presentation.

The Final Report provides important details surrounding the recommendations derived from this Project.

Pedestrian Crash Avoidance/Mitigation Project (PCAM Project)

Final Briefing

June 18, 2013
PCAM Project Overview

• Project Objectives
  – Develop and validate minimum performance requirements and objective test procedures for forward-looking PCAM systems involving in-traffic pedestrian crash scenarios, including:
    • Functional tests to evaluate the intended performance of PCAM systems where PCAM activation is warranted
    • Operational tests to assess the propensity of a PCAM system to produce false (unintentional) activations
  – Minimum performance requirements for both types of tests will be developed

• Project Organization
  – Existing CAMP- Crash Imminent Braking (CIB) Consortium Participants
  – Cooperative research with:
    • Volpe
    • VRTC – PCAM test method development and execution of tests
    • BASt – agreement between BASt and NHTSA to share research results on related projects
Pedestrian Crash Data Analysis Method

• Volpe analyzed 2005 – 2009 GES data and identified 67 pedestrian pre-

• Similar analysis conducted of the Fatality Analysis Reporting System (FARS) data
  – FARS contained limited vehicle-pedestrian maneuver information, restricting its usefulness in determining critical crash parameters needed for defining project test conditions
  – No further action taken with this data

• Crash data analysis was supplemented by a review of pedestrian observations recorded in the CAMP CIB ROAD Trip
  – Provided measureable details associated with pedestrian and driver actions that could not be obtained from GES crash data analysis
  – Helpful in defining representative test methods

June 18, 2013
CAMP CIB Real-World Operational Assessment Data (ROAD) Trip Pedestrian Observations

• Conducted 7/24/09 through 9/3/09
• 4324 total scenario observations
• Included Atlanta, Boston, Las Vegas, New Orleans, New York, Pittsburgh, San Diego, San Francisco, Seattle, and Washington DC
CIB ROAD Trip Routes


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All subject vehicle (SV) speeds include stopped - E

Potential Conflict Scenarios Detected - Vehicle “H”

- S1: Potential Crosspath Conflicts
- S2: Potential Right Turn into Conflicts
- S3: Potential Left Turn into Conflicts
- S4: Potential In-line Conflicts
- S5a: Bystander in median
- S5b: Bystander near roadside
- S5d: Traffic on Sidewalk
Speeds Observed for S1 Scenarios

95% of speeds observed from 1-25 mph

*Only 85 scenarios. New York, Las Vegas, New Orleans & San Francisco were filtered since it was not identified
'd d &

99.8% of speeds observed from 0-15 mph
Pedestrian detections are not disabled with speed, so the observed speed range appears to be due to the
kinematics of the S1 scenario

SV speeds > 1 km/h
Pedestrian Movement Observations (S1-S4)

Common Pedestrian Movement Observed

- Diagonal (L→R): 40%
- Diagonal (L←R): 11%
- With Traffic: 27%
- Against Traffic: 22%
- Right to Left (L←R): 8%
- Left to Right (L→R): 1%

Equal distributions in either direction for all scenarios
Diagonal pedestrian traffic was low

Common Pedestrian Movement Detected
Vehicle “H”

- Diagonal (L to R): 31%
- Diagonal (R to L): 27%
- With Traffic: 10%
- Against Traffic: 8%
- Right to Left: 1%
- Left to Right: 1%
- Not walking (standing, etc)

Equal distributions in either direction for all scenarios
Diagonal pedestrian traffic was low

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The observations from the CIB ROAD Trip were used to help understand potential reliability operational issues with PCAM systems.

The CIB algorithms used can be characterized as less refined than would be typically used in production systems. This presents positive scenarios that may need to be addressed by CIB systems.
What did the PCAM ROAD Trip Look Like?

Three trips, concentrating on urban areas likely to result in pedestrian encounters:

• Cities with widely varied pedestrian environments
• Pedestrian-friendly cities
• Pedestrian un-friendly cities
The PCAM ROAD Trip Was Used to Assess Possible False Event Scenarios

- Positive performance tests only show one aspect of a PCAM’s
- Understanding the potential unintended consequences in real world operation of PCAM systems is important to assess
- In order to have a balanced assessment of PCAM system performance, test methods are required that can assess system performance with regard to false events
East Coast

• Three major East Coast cities were chosen based on high pedestrian traffic

• Executed on June 17-28, 2012

Florida

- Four major Florida cities (for America) as top four most dangerous metro areas for pedestrians

- Executed on July 15-27, 2012

June 18, 2013
West Coast

- Four major West Coast cities chosen based on high pedestrian traffic
- Executed on August 5-18, 2012
Objectives of the Analysis

- Analysis of the Data obtained during the ROAD Trip was performed to better understand several aspects of potential false activations pedestrian interventions including:
  - Scenarios likely to generate false interventions involving real pedestrians
  - Kinematics of these scenarios
  - How different algorithm thresholds can affect the rate at which such scenarios may occur
  - Conditions that may result in false pedestrian detections activations
Non-Critical Scenarios – Other Vulnerable Road Users

Two-wheelers: Bicycles and motorcycles

Print on bus looks like a pedestrian:

These subjects/objects were classified as pedestrians by the camera.
Non-Critical Scenarios – Non-Pedestrians

Public telephone:
Turning into parking lot

Mailbox/garbage can:
Steering towards garbage can

Undetermined objects, dark

Steering towards stop sign, dark
Operational Test Scenarios Tested During Validation Phase

- Due to project timing, complete analysis of the ROAD Trip data was not possible before validation testing was to begin.
- A set of prototype Operational Tests were selected, based on initial analysis of the ROAD Trip data.
- Engineering estimates of reasonable test parameters were chosen to evaluate the feasibility of the prototype Operational test methods.

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O1: Pedestrian Clears Vehicle
O4: Static Pedestrian

ROAD-Trip: O1 Pedestrian clears vehicle
O2: Right Turn With Pedestrian Outside Vehicle Path

ROAD-Trip: Right turn with standing pedestrians

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Operational Tests: Evaluation Criteria

• Autonomous braking unacceptable:
  – O1 walking mannequin stops 1m short before test lane
  – O2, O3 turning scenarios
    • Actively engaged driver: In areas with high pedestrian traffic, the driver sometimes needs to turn close to walking pedestrians. An autonomous braking may be objectionable to the driver.
    • Due to the sensor field of view and possible steering maneuvers of the active driver, a reliable prediction of the vehicle’s path is hard to achieve.
  – Mannequin static (1m from vehicle path)

• Limited autonomous braking potentially acceptable:
  – O1 mannequin clears vehicle
  – Vehicle changing lane, mannequin outside of the vehicle path
  – Mannequin very close to vehicle path (<1 m)
# Operational Tests With Braking Commanded

Note: This table shows the number of commanded autonomous braking observed out of a test series with x tests. It does not contain any information about the intensity or duration of the braking.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Description</th>
<th>Vehicle 1</th>
<th>Vehicle 2</th>
<th>Vehicle 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>O1</td>
<td>Mannequin clears vehicle</td>
<td>11 out of 12 (91%)</td>
<td>3 out of 10 (30%)</td>
<td>13 out of 20 (65%)</td>
</tr>
<tr>
<td>O1</td>
<td>Walking mannequin stops short before test lane</td>
<td>0 out of 11 (0%)</td>
<td>0 out of 10 (0%)</td>
<td>n/a</td>
</tr>
<tr>
<td>O2</td>
<td>Right turn, static mannequin outside vehicle path</td>
<td>0 out of 10 (0%)</td>
<td>6 out of 10 (60%)</td>
<td>n/a</td>
</tr>
<tr>
<td>O3</td>
<td>Left turn, static mannequin outside vehicle path</td>
<td>0 out of 12 (0%)</td>
<td>3 out of 10 (30%)</td>
<td>n/a</td>
</tr>
<tr>
<td>Lane Change</td>
<td>Vehicle lane change, static mannequin outside the vehicle path</td>
<td>0 out of 12 (0%)</td>
<td>9 out of 15 (60%)</td>
<td>0 out of 6 (0%)</td>
</tr>
<tr>
<td>O4 static</td>
<td>Static mannequin outside the vehicle path (1 m outside of vehicle path)</td>
<td>0 out of 12 (0%)</td>
<td>0 out of 10 (0%)</td>
<td>0 out of 12 (0%)</td>
</tr>
<tr>
<td>O4 moving</td>
<td>Static mannequin walking away very close (&lt; 1 m) to the right of the vehicle path</td>
<td>0 out of 9 (0%)</td>
<td>0 out of 16 (0%)</td>
<td>3 out of 7 (42%)</td>
</tr>
</tbody>
</table>

☐ = potentially unacceptable braking activation

*June 18, 2013*
O3: Vehicle Making Left Turn Towards Pedestrian

<table>
<thead>
<tr>
<th>Host Vehicle Parameters</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed</td>
<td>10 - 15 mph</td>
</tr>
<tr>
<td>Longitudinal Acceleration</td>
<td>±1.0 m/s²</td>
</tr>
<tr>
<td>Radius of Curvature</td>
<td>20 m</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pedestrian Parameters</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed</td>
<td>0 mph</td>
</tr>
<tr>
<td>Distance from Vehicle Path (outside)</td>
<td>1 m</td>
</tr>
</tbody>
</table>
Operational Test Specifications with the Input of the PCAM ROAD Trip

• Physical requirements of the tests replicate the range of values observed in the field
• In real world situations, false activations are rare and not always repeatable
• It is recommended that these tests be run as a series of repeated tests, run with randomly distributed physical characteristics that are within the purposely wide ranges
## Operational Test Conclusions

*(Tests Similar to Functional Scenarios)*

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Description</th>
<th>Vehicle Speed (mph)</th>
<th>Mannequin Speed (mph)</th>
<th>Vehicle Path</th>
<th>Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>O1</td>
<td>Similar to S1 but mannequin either stops short or clears the vehicle path 1 to 2 seconds before collision can occur</td>
<td>5 – 20</td>
<td>3.1</td>
<td>straight</td>
<td>High priority Significant number of potential unintended Precharge and FCW events</td>
</tr>
<tr>
<td>O2</td>
<td>Similar to S2 but a static mannequin is positioned outside the vehicle path</td>
<td>10 – 15</td>
<td>Stationary mannequin positioned 1.0 m outside of <em>d</em>e`s</td>
<td>15 m radius curve</td>
<td>High priority Significant number of potential unintended Precharge and FCW events and some potential Autobraking events</td>
</tr>
<tr>
<td>O3</td>
<td>Similar to S3 but a static mannequin is positioned outside the vehicle path</td>
<td>10 – 20</td>
<td>Stationary mannequin positioned 1.0 m outside of <em>d</em>e`s</td>
<td>20 m radius curve</td>
<td>High priority Significant number of potential unintended Precharge and FCW events and some potential Autobraking events</td>
</tr>
<tr>
<td>O4</td>
<td>Similar to S4 but mannequin stays outside of the vehicle path</td>
<td>10 – 20</td>
<td>6.2 along path 1.0 m outside of vehicle path</td>
<td>straight</td>
<td>Low priority Small number of potential unintended Precharge and FCW events</td>
</tr>
</tbody>
</table>
## Operational Test Conclusions
(Additional Unique Scenarios)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Description</th>
<th>Vehicle Speed (mph)</th>
<th>Mannequin Speed (mph)</th>
<th>Vehicle Path</th>
<th>Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lane Change (Low Speed)</td>
<td>Vehicle encounters a pedestrian moving in a path parallel to the vehicle and just outside its path while changing lanes</td>
<td>10 – 15</td>
<td>Stationary mannequin positioned 1.0 m outside of vehicle path</td>
<td>1st turn of lane change @ 20 m range 2nd turn of lane change @ 10 m range</td>
<td>Medium priority Small number of potential unintended Precharge, FCW and Autobraking events</td>
</tr>
<tr>
<td>Lane Change (High Speed)</td>
<td>Vehicle encounters a pedestrian moving in a path parallel to the vehicle and just outside its path while changing lanes</td>
<td>15 – 25</td>
<td>Stationary mannequin positioned 1.0 m outside of vehicle path</td>
<td>1st turn of lane change @ 30 m range 2nd turn of lane change @ 15 m range</td>
<td>Medium priority Small number of potential intended Precharge, FCW and Autobraking events</td>
</tr>
<tr>
<td>Curve Entrance</td>
<td>Vehicle encounters a pedestrian who is just past the beginning of a curved section of roadway such that the pedestrian appears to be in the path of the vehicle</td>
<td>10 – 20</td>
<td>Stationary mannequin positioned 1.0 m outside of vehicle path</td>
<td>20 m radius curve</td>
<td>Low priority Small number of potential unintended Precharge and FCW events</td>
</tr>
</tbody>
</table>
Backup
PCAM Project Organization

NHTSA Project Order Manager

Scott Geister
General Motors & CAMP Program Manager

Ford

Mercedes-Benz

Continental

Delphi

General Motors

PCAM Consortium Management Committee

Michael Shulman
Raymond Kiefer
Frank Baumann
Continental

Ford

General Motors

Jeffrey Skvarce
Todd Moury
Timothy Zwicky
Michael Carpenter
Matthias Struck
Continental

Delphi

Ford

General Motors

Principal Investigator

Mercedes-Benz

PCAM Technical Management Team Leads

Testing & Test Track Services

Engineering Services

Project Administrative Services

Contracted Support Services (Representative Examples Shown)