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.

http://www.nhtsa.gov/DOT/NHTSA/NVS/Crash%20Avoidance/Technical%20Publications/2014/812040_CAMP_FLV_MitigationReport%20.pdf

CAMP

Crash Imminent Braking Consortium

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 – [illegible]
    - 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

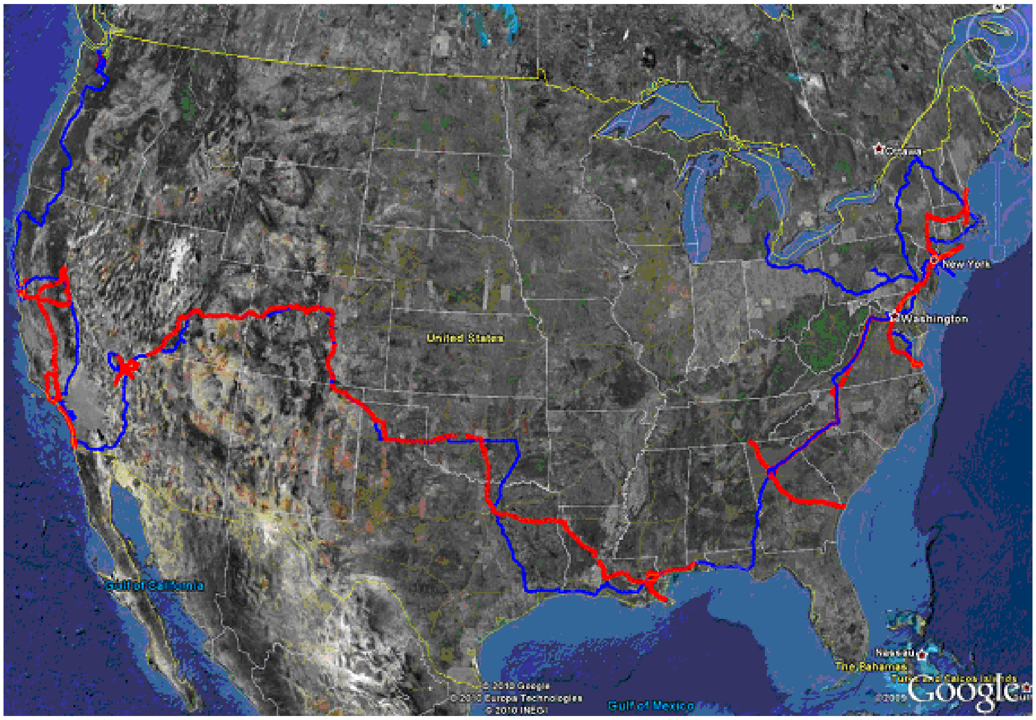
- Volpe analyzed 2005 – 2009 GES data and identified 67 pedestrian pre-[illegible]
- Similar analysis conducted of the Fatality Analysis Reporting System (FARS) data
  - FARS contained limited vehicle-pedestrian maneuver information, restricting its usefulness in determining critical crash parameters 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

CAMP CIB Real-World Operational Assessment Data (ROAD) Trip Pedestrian Observations

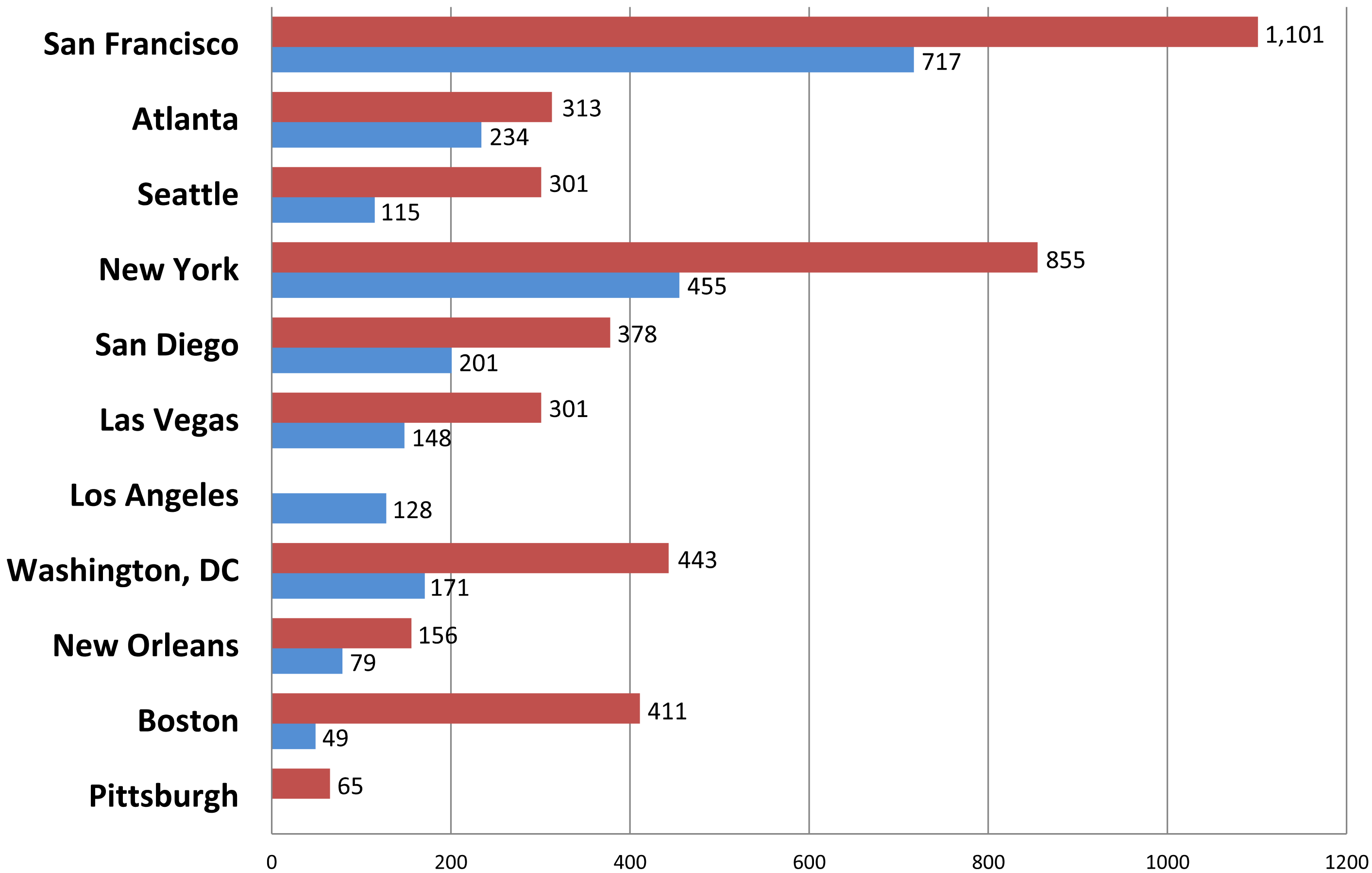
- Conducted 7/24/09 through 9/3/09
- 4324 total scenario observations
- Included Atlanta, Boston, Las Vegas, New Orleans, New York, Pittsburgh, San Diego, San Francisco, Seattle, and Washington DC

CIB ROAD Trip Routes

□□□□□s “E” □B□□□□□d “H” □□□d□



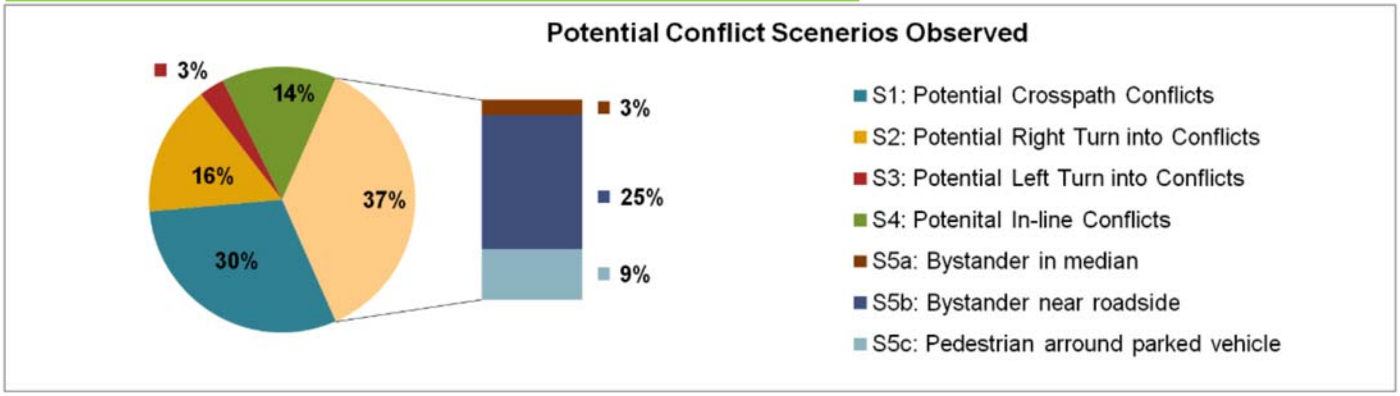
Total Observations/Detections per City

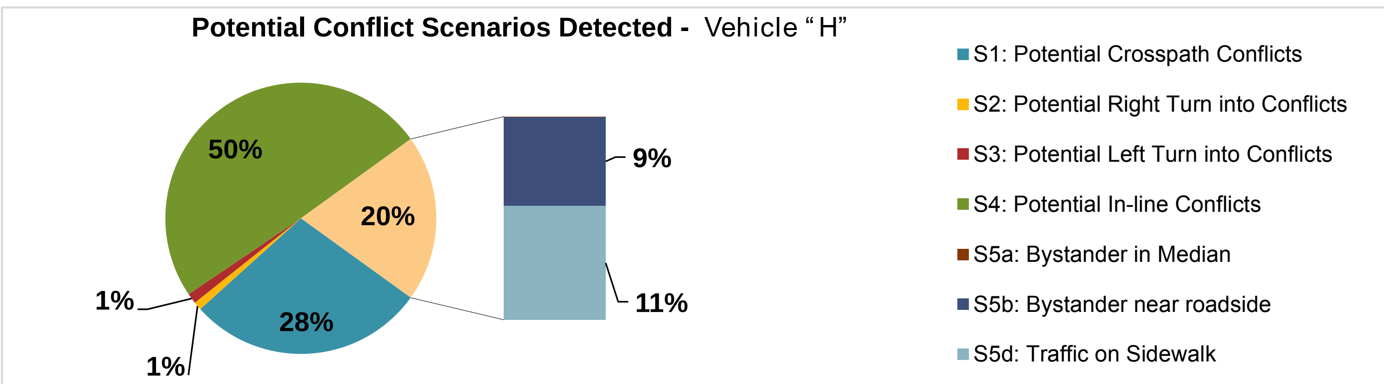


Potential Pedestrian Conflict Scenarios Observed

A "[illegible]" [illegible] analyst. For [illegible] H [illegible]

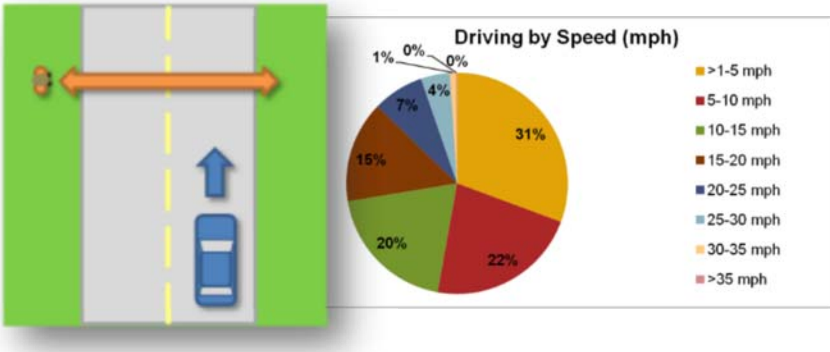
All subject vehicle (SV) speeds include stopped - [illegible] "E"





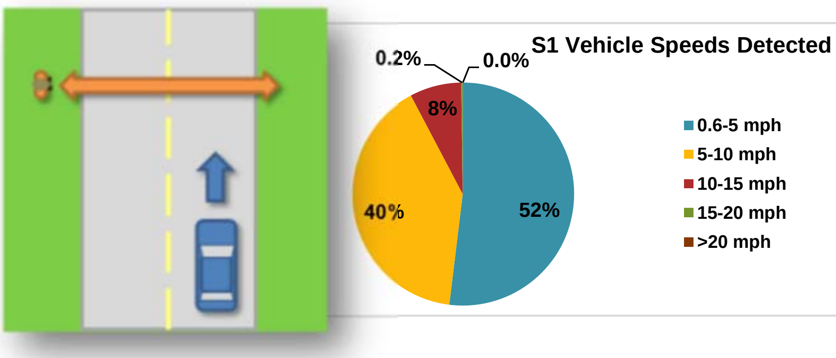
Speeds Observed for S1 Scenarios

“E”



- 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 ’ &

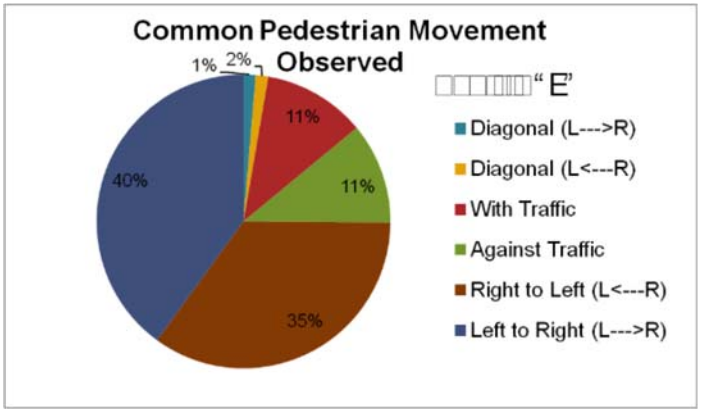
“H”



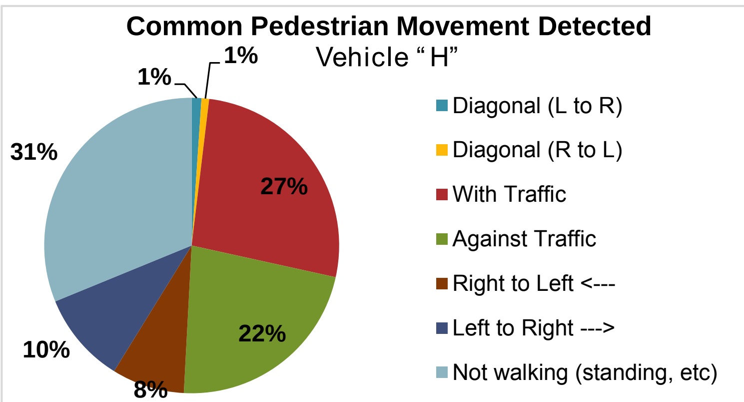
- 99.8% of speeds observed from 0-15 mph
- Pedestrian detections are not disabled with speed, so the observed speed range appears to be due to the kinematics of the S1 scenario

SV speeds > 1 km/h

Pedestrian Movement Observations (S1-S4)

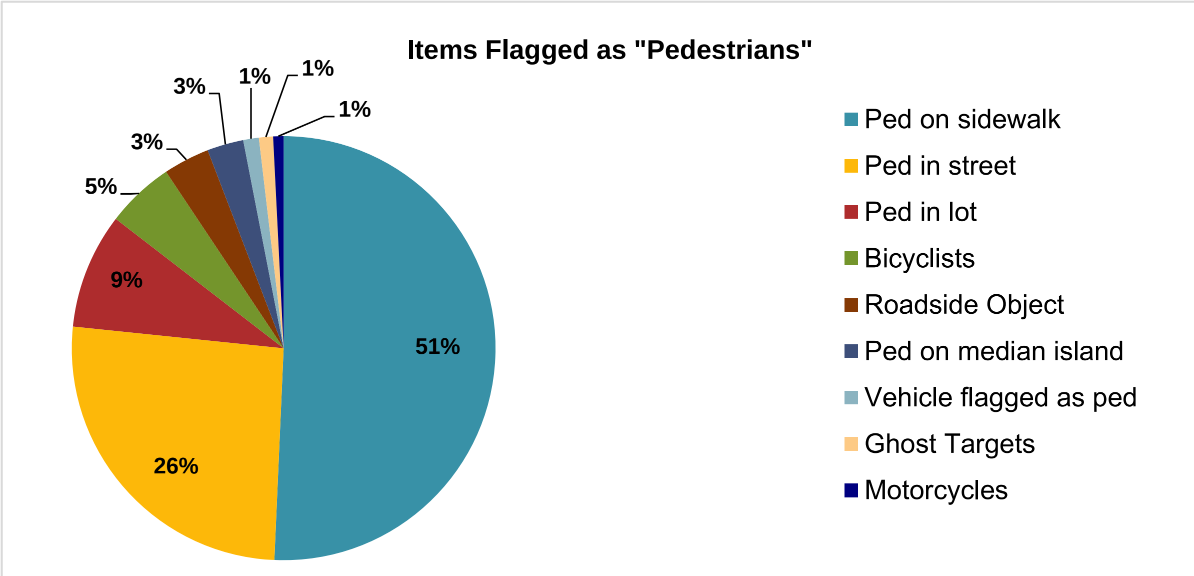


- Equal distributions in either direction for all scenarios
- Diagonal pedestrian traffic was low



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

Objects Flagged as “Pedestrians”



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. Consequently, these [illegible] 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:

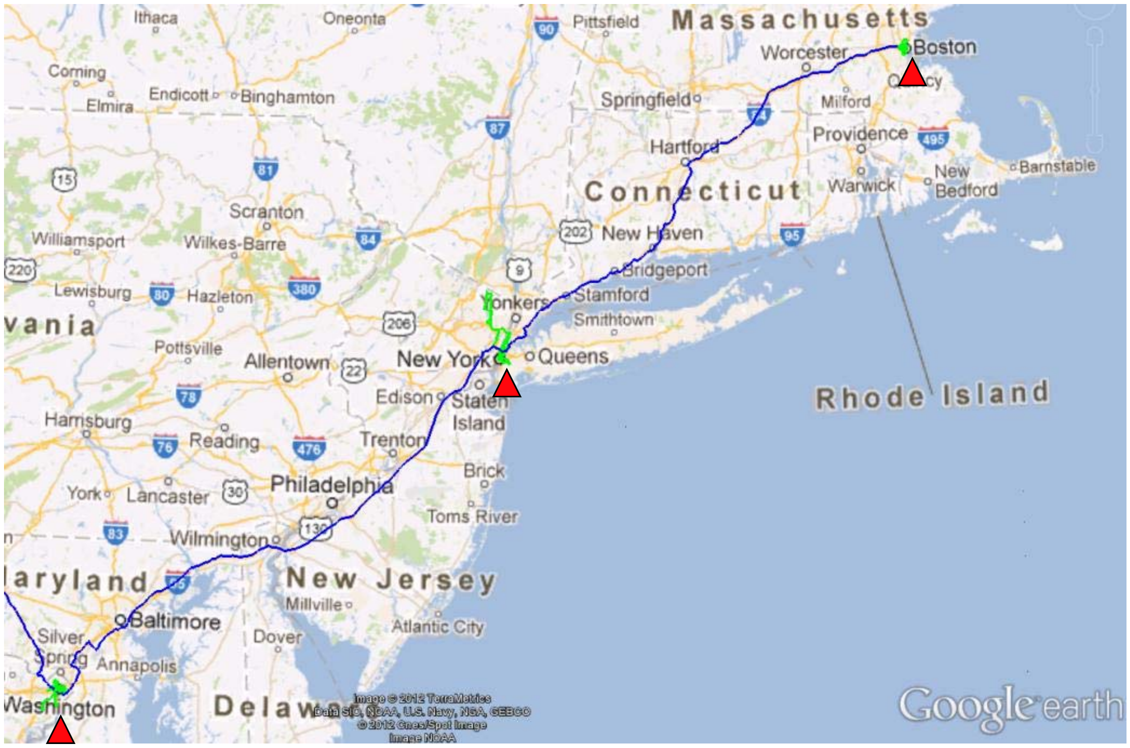
- Cities with widely varied pedestrian environments
- Pedestrian-friendly cities
- Pedestrian un-friendly cities

The PCAM ROAD Trip Was Used to Assess Possible False Event Scenarios

- Positive performance tests only show one aspect of a PCAM s[illegible]s[illegible]’s [illegible] [illegible]
- 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

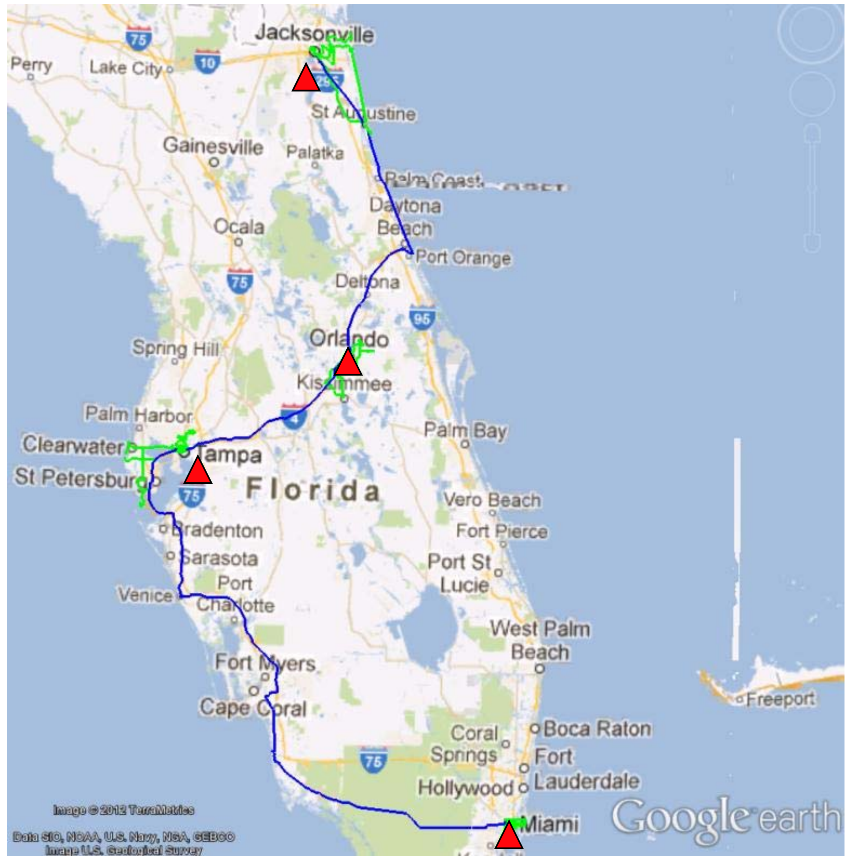
East Coast

- Three major East Coast cities were chosen based on high pedestrian traffic
- Executed on June 17-28, 2012



Florida

- Four major Florida cities d[illegible]d [illegible] "D[illegible]s [illegible] D[illegible]s[illegible] [illegible]" [illegible]s[illegible] for America) as top four most dangerous metro areas for pedestrians
- Executed on July 15-27, 2012



West Coast

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

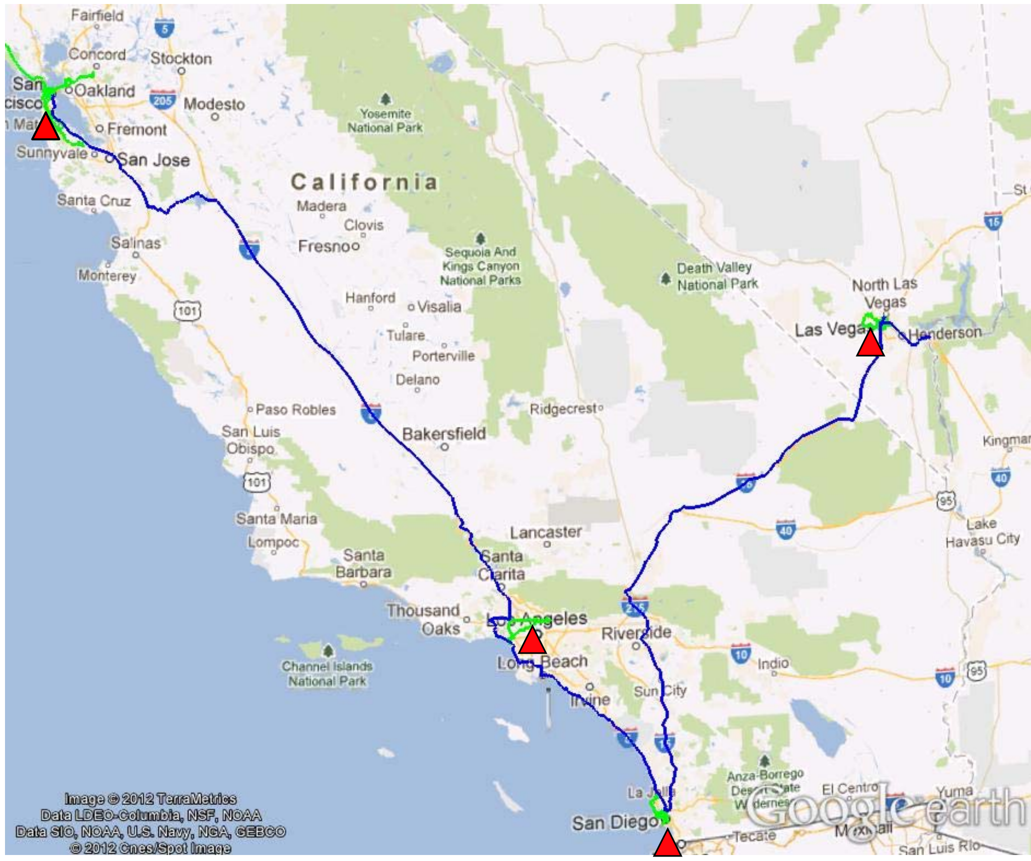


Image © 2012 TerraMetrics. Data LEDO Columbia, NSF, NOAA. Data SIO, NOAA, U.S. Navy, NGA, GEBCO. © 2012 Cnes/Spot Image. ©2012 Google. Used with permission.

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

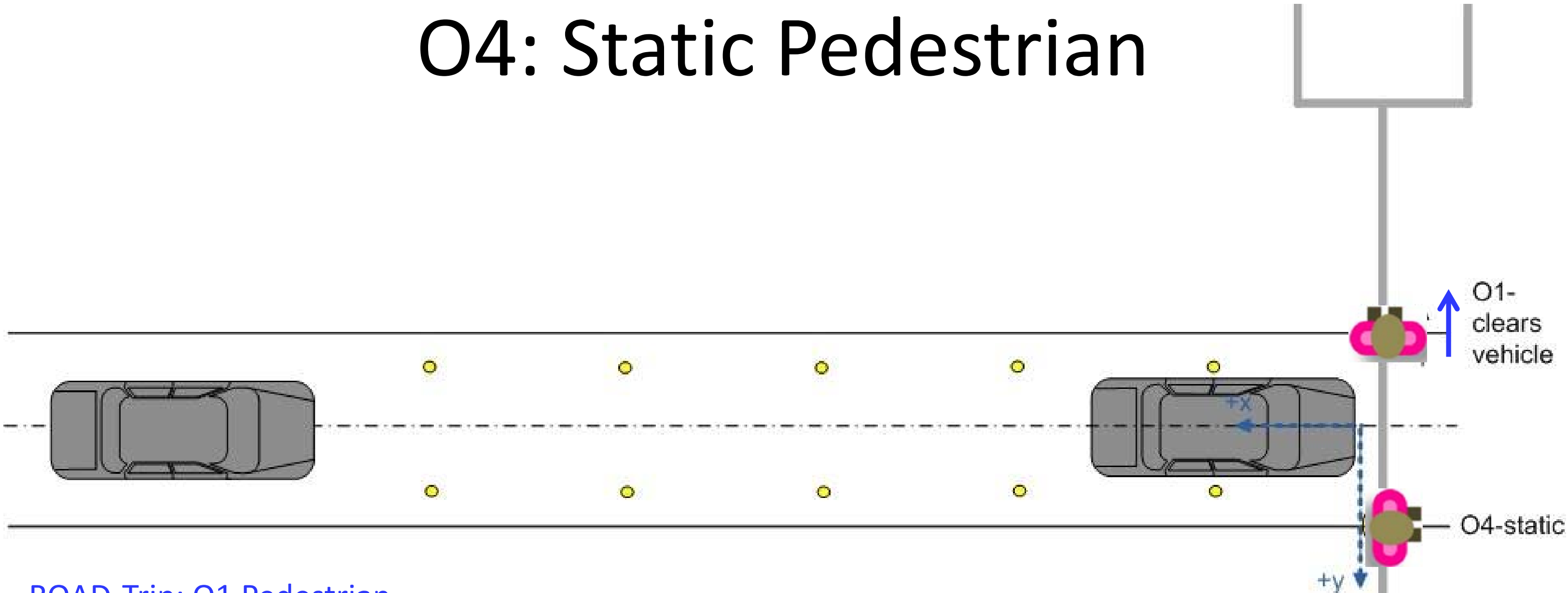
Undetermined objects, dark

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

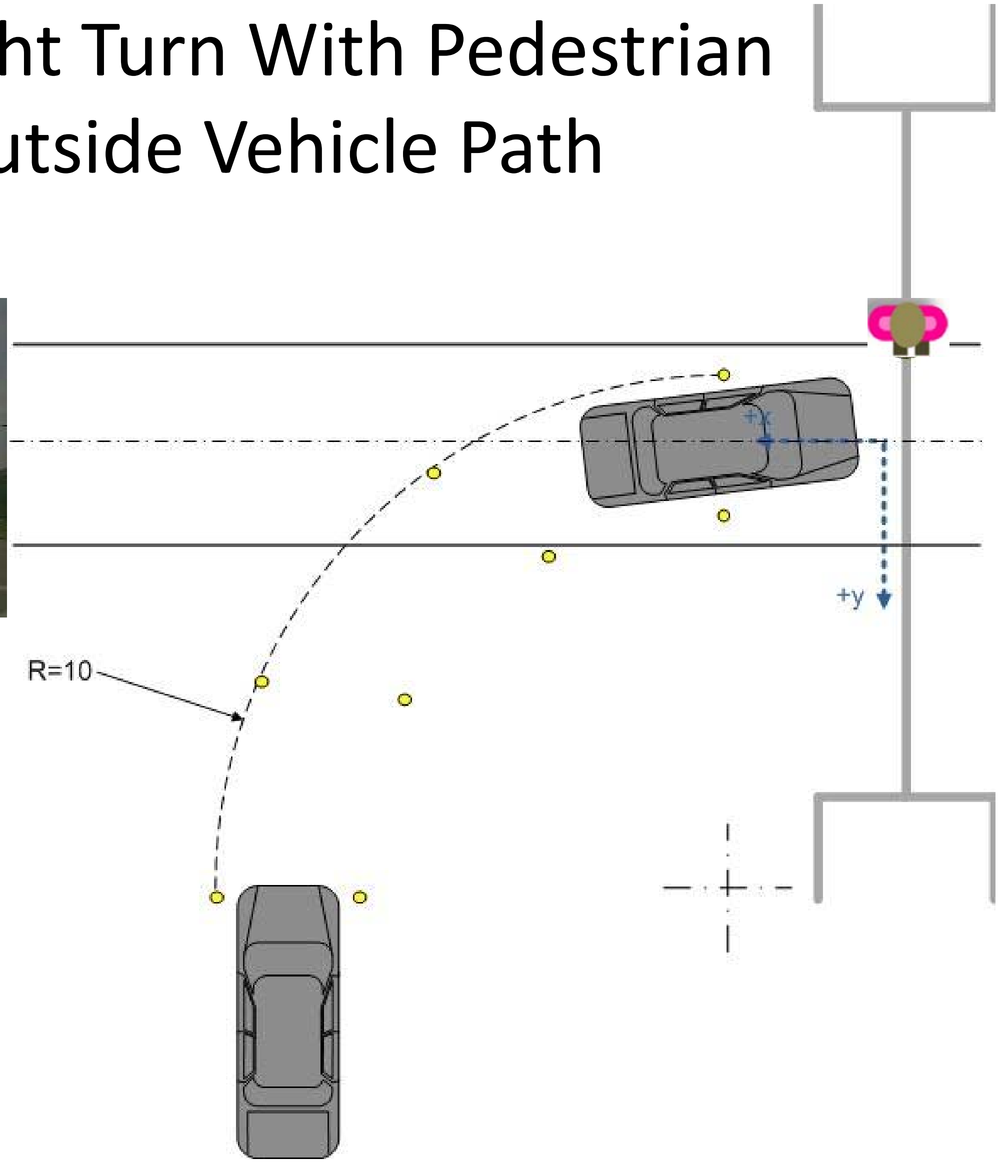
O1: Pedestrian Clears Vehicle
O4: Static Pedestrian



ROAD-Trip: O1 Pedestrian clears vehicle

O2: Right Turn With Pedestrian Outside Vehicle Path

ROAD-Trip: Right turn with standing pedestrians



June 18, 2013

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)

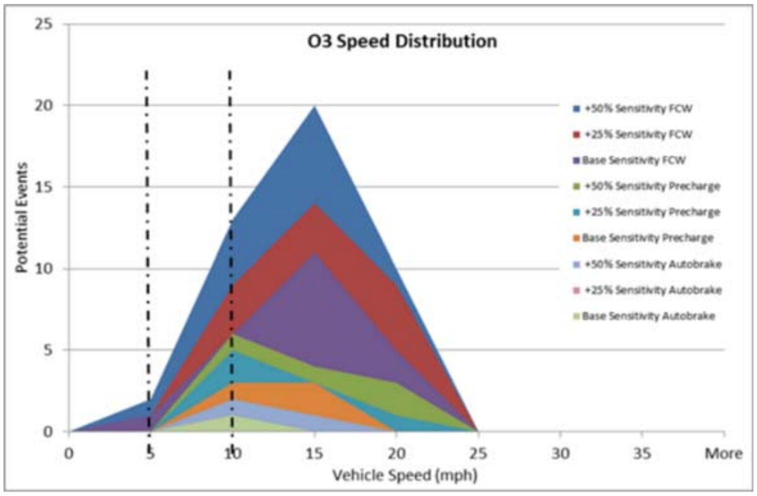
Operational Tests With Braking Commanded

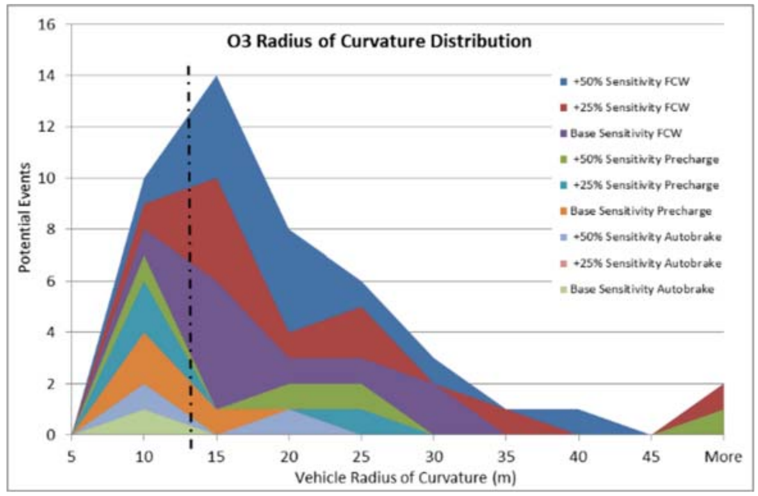
Note: This table shows the number of commanded autonomous braking observed out of a test series with x tests. It does not contain any information about the intensity or duration of the braking.

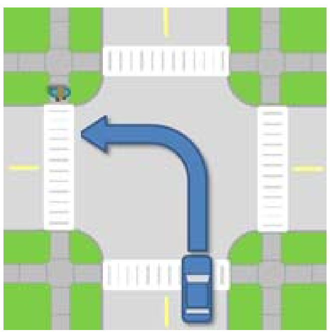
Scenario	Description	Vehicle 1	Vehicle 2	Vehicle 3
O1	Mannequin clears vehicle	11 out of 12 (91%)	3 out of 10 (30%)	13 out of 20 (65%)
O1	Walking mannequin stops short before test lane	0 out of 11 (0%)	0 out of 10 (0%)	n/a
O2	Right turn, static mannequin outside vehicle path	0 out of 10 (0%)	6 out of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

□ = potentially unacceptable braking activation

O3: Vehicle Making Left Turn Towards Pedestrian







Host Vehicle Parameters	
Speed	10 - 15 mph
Longitudinal Acceleration	±1.0 m/s^2
Radius of Curvature	20 m
Pedestrian Parameters	
Speed	0 mph
Distance from Vehicle Path (outside)	1 m

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)

Scenario	Description	Vehicle Speed (mph)	Mannequin Speed (mph)	Vehicle Path	Notes:
O1	Similar to S1 but mannequin either stops short or clears the vehicle path 1 to 2 seconds before collision can occur	5 – 20	3.1	straight	High priority Significant number of potential unintended Precharge and FCW events
O2	Similar to S2 but a static mannequin is positioned outside the vehicle path	10 – 15	Stationary mannequin positioned 1.0 m outside of [illegible]	15 m radius curve	High priority Significant number of potential unintended Precharge and FCW events and some potential Autobraking events
O3	Similar to S3 but a static mannequin is positioned outside the vehicle path	10 – 20	Stationary mannequin positioned 1.0 m outside of [illegible]	20 m radius curve	High priority Significant number of potential unintended Precharge and FCW events and some potential Autobraking events
O4	Similar to S4 but mannequin stays outside of the vehicle path	10 – 20	6.2 along path 1.0 m outside of vehicle path	straight	Low priority Small number of potential unintended Precharge and FCW events

Operational Test Conclusions

(Additional Unique Scenarios)

Scenario	Description	Vehicle Speed (mph)	Mannequin Speed (mph)	Vehicle Path	Notes:
Lane Change (Low Speed)	Vehicle encounters a pedestrian moving in a path parallel to the vehicle and just outside its path while changing lanes	10 – 15	Stationary mannequin positioned 1.0 m outside of vehicle path	1st turn of lane change @ 20 m range 2nd turn of lane change @ 10 m range	Medium priority Small number of potential unintended Precharge, FCW and Autobraking events
Lane Change (High Speed)	Vehicle encounters a pedestrian moving in a path parallel to the vehicle and just outside its path while changing lanes	15 – 25	Stationary mannequin positioned 1.0 m outside of vehicle path	1st turn of lane change @ 30 m range 2nd turn of lane change @ 15 m range	Medium priority Small number of potential intended Precharge, FCW and Autobraking events
Curve Entrance	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	10 – 20	Stationary mannequin positioned 1.0 m outside of vehicle path	20 m radius curve	Low priority Small number of potential unintended Precharge and FCW events

Backup

PCAM Project Organization