Preliminary Study of the Response of Forward Collision Warning Systems to Motorcycles

Vorläufige Studie über Kollisionswarnsysteme mit Blick auf Motorräder

John F. Lenkeit,
Terrance Smith PhD
Dynamic Research, Inc., USA

11th International Motorcycles Conference
October 3-4, 2016
Cologne

Background

- Demand for advanced driver-assistance systems (ADAS)—those that help with monitoring, warning, braking, and steering tasks—is expected to increase over the next decade, fueled largely by regulatory and consumer interest in safety applications that protect drivers and reduce accidents. For instance, both the European Union and the United States are mandating that all vehicles be equipped with autonomous emergency-braking systems and forward-collision warning systems by 2020*
- As drivers become comfortable with, and rely more on Advanced Driver Assistance Systems (ADAS), they may become less attentive to the driving task.
- If motorcycles are not detected by these systems, an unintended consequence of broad ADAS implementation may be an increase in the frequency of car-motorcycle accidents even as car-car accidents decrease.

* “Advanced driver-assistance systems: Challenges and opportunities ahead”, Mckinsey.com

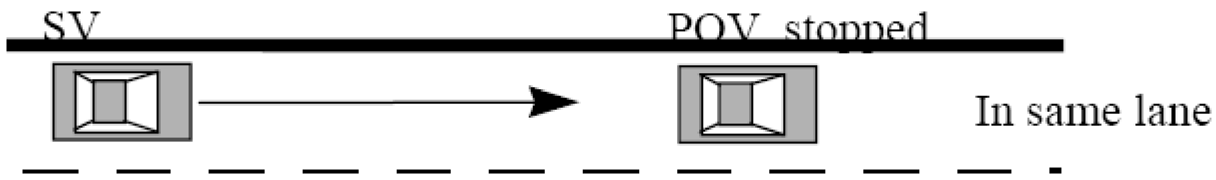
Background

- Existing and proposed near-future New Car Assessment Program (NCAP) activities are focused on evaluating the abilities ADAS technologies to avoid crashes:
    - car-car,
    - car- pedestrian
    - car-bicycle
- They do not explicitly address issues of car-motorcycle crashes.
- Some may assume that if a system works adequately for cars, bicycles and pedestrians, it will also work as well for motorcycles.
- The purpose of this study was to survey example current production vehicles equipped with Forward Collision Warning (FCW) systems to determine how well these systems function when the Principal Other Vehicle (POV) is an L3 mid-sized motorcycle.

Methodology – Test Scenarios

- Test procedures were based on NHTSA's *Forward Collision Warning System Confirmation Test*, February 2013 (NCAP)
- Test Scenarios
  - Test 1 - Subject Vehicle Encounters Stopped Principal Other Vehicle on a Straight Road (Stopped lead vehicle)
  - Test 3 – Subject Vehicle Encounters Slower Principal Other Vehicle on a Straight Road (Slower lead vehicle)
  - Test 2 - Braking lead vehicle was not done; (controlled motorcycle braking equipment not available at the time of testing)
- 7 runs for each scenario, of which 5 must pass for an overall pass
- Honda VFR800 used as the POV

Methodology – Test Scenarios



Test 1 - Stopped lead vehicle

- Initial SV speed: 45 mph (72.4 kph)
- Alert criteria: FCW alert must be issued when the time-to-collision (TTC) is at least 2.1 seconds
- Test ended when either of the following occurred:
  - The required FCW alert occurred.
  - The TTC to the POV fell to less than 90% of the minimum allowable range for the onset of the required FCW alert

Methodology – Test Scenarios

Test 3 - Slower lead vehicle

- Initial POV speed: 20 mph (32.2 kph)
- Initial SV speed: 45 mph (72.4 kph)
- Test began when headway from the SV to the POV was 329 ft (100 m)
- Test ended when either of the following occurred:
  - The required FCW alert occurred.
  - The TTC to the POV fell to less than 90% of the minimum allowable range for the onset of the required FCW alert.
- Alert criteria: FCW alert must be issued when the time-to-collision (TTC) is at least 2.0 seconds

Methodology – Subject Vehicles

Subject Vehicles	Sensor Type(s)	Motorcycle Considered in Owner's Manual	AEB Function Provided
1	Camera, Radar	Yes	Yes
2	Camera, Radar	Yes	Yes
3	Camera	No	Yes
4	Camera, Radar	No	Yes
5	Camera, Radar	Yes	Yes
6	Camera, Radar	Yes	Yes
7	Camera, Radar	Yes	Yes
8	Camera, Radar	Yes	Yes

Methodology - Principal Other Vehicles (POV)

Methodology – Test Equipment

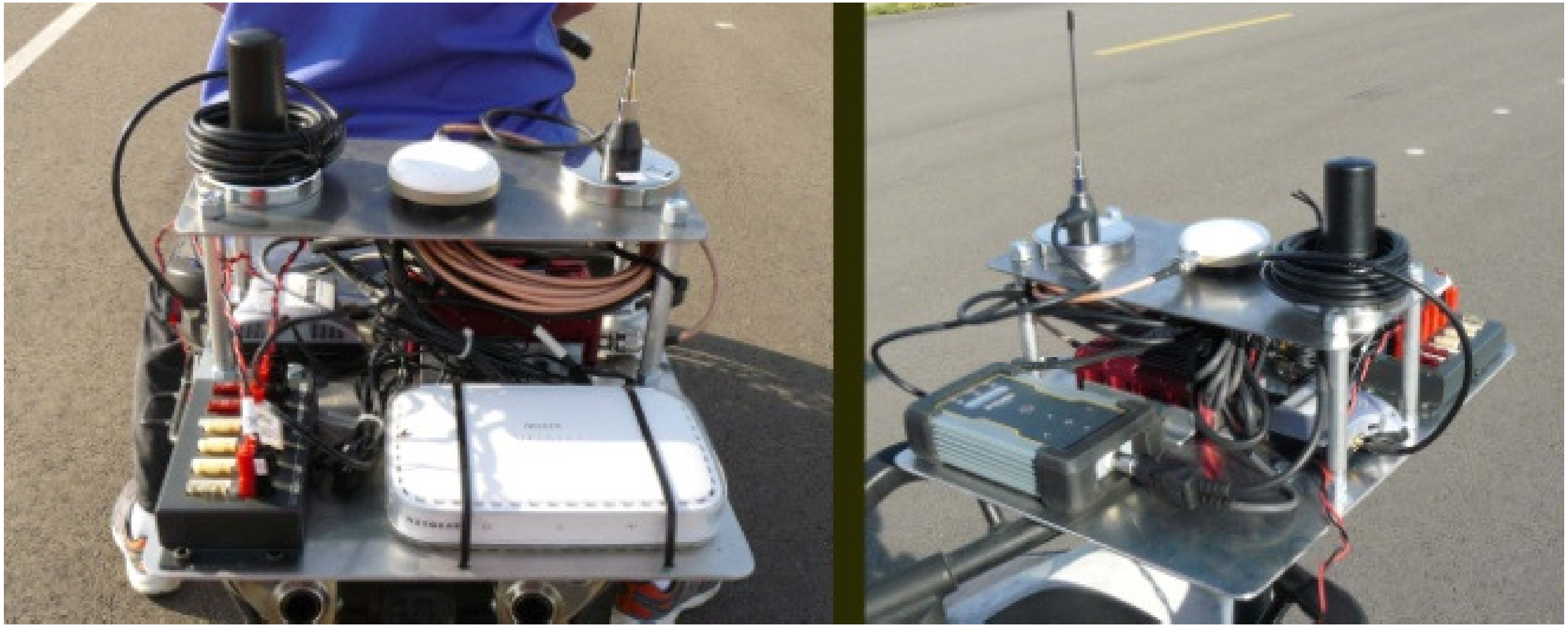
Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model
Differential Global Positioning System	Position, Velocity	Latitude: ±90 deg Longitude: ±180 deg Altitude: 0-18 km Velocity: 0-1000 knots	Horizontal Position: ±1 cm Vertical Position: ±2 cm Velocity: 0.05 km/h	Trimble GPS Receiver, 5700 (base station and in SV)
Multi-Axis Inertial Sensing System	Position; Longitudinal, Lateral, and Vertical Accels; Lateral, Longitudinal and Vertical Velocities; Roll, Pitch, Yaw Rates; Roll, Pitch, Yaw Angles	Latitude: ±90 deg Longitude: ±180 deg Altitude: 0-18 km Velocity: 0-1000 knots Accel: ±100 m/s2 Angular Rate: ±100 deg/s Angular Disp: ±180 deg	Position: ±2 cm Velocity: 0.05 km/h Accel: ≤ 0.01% of full range Angular Rate: ≤ 0.01% of full range Roll/Pitch Angle: ±0.03 deg Heading Angle: ±0.1 deg	Oxford Technical Solutions (OXTS) xNAV 550 in motorcycle, Inertial+ in SV
Real-Time Calculation of Position and Velocity Relative to POV	Distance and Velocity to POV	Lateral Lane Dist: ±30 m Lateral Lane Velocity: ±20 m/sec Longitudinal Range to POV: ±200 m Longitudinal Range Rate: ±50 m/sec	Lateral Distance to Lane Marking: ±2 cm Lateral Velocity to Lane Marking: ±0.02m/sec Longitudinal Range: ±3 cm Longitudinal Range Rate: ±0.02 m/sec	Oxford Technical Solutions (OXTS), RT-Range
Data Acquisition System [Includes amplification, anti-aliasing, and analog to digital conversion.]	Record Time; Position; Velocity; Distance to lane markings; Headway distance; Closing Velocity; Lateral, Longitudinal, and Vertical Accels; Roll, Yaw, and Pitch Rates; Roll, Yaw and Pitch Angles.	Sufficient to meet or exceed individual sensors	Sound digitized at 10 kHz, all other channels digitized at 100 Hz. Accuracy is sufficient to meet or exceed individual sensors	SoMat, eDaq ECPU processor SoMat, High level Board EHLS
Microphone	Sound (to measure time at alert)	Frequency Response: 80 Hz – 20 kHz	Signal-to-noise: 64 dB, 1 kHz at 1 Pa	Audio-Technica AT899
Light Sensor	Light intensity (to measure time at alert)	Spectral Bandwidth: 440-800 nm	Rise time < 10 msec	DRI designed and developed Light Sensor

Methodology – Test Equipment

Instrumentation installed in SV

Methodology – Test Equipment

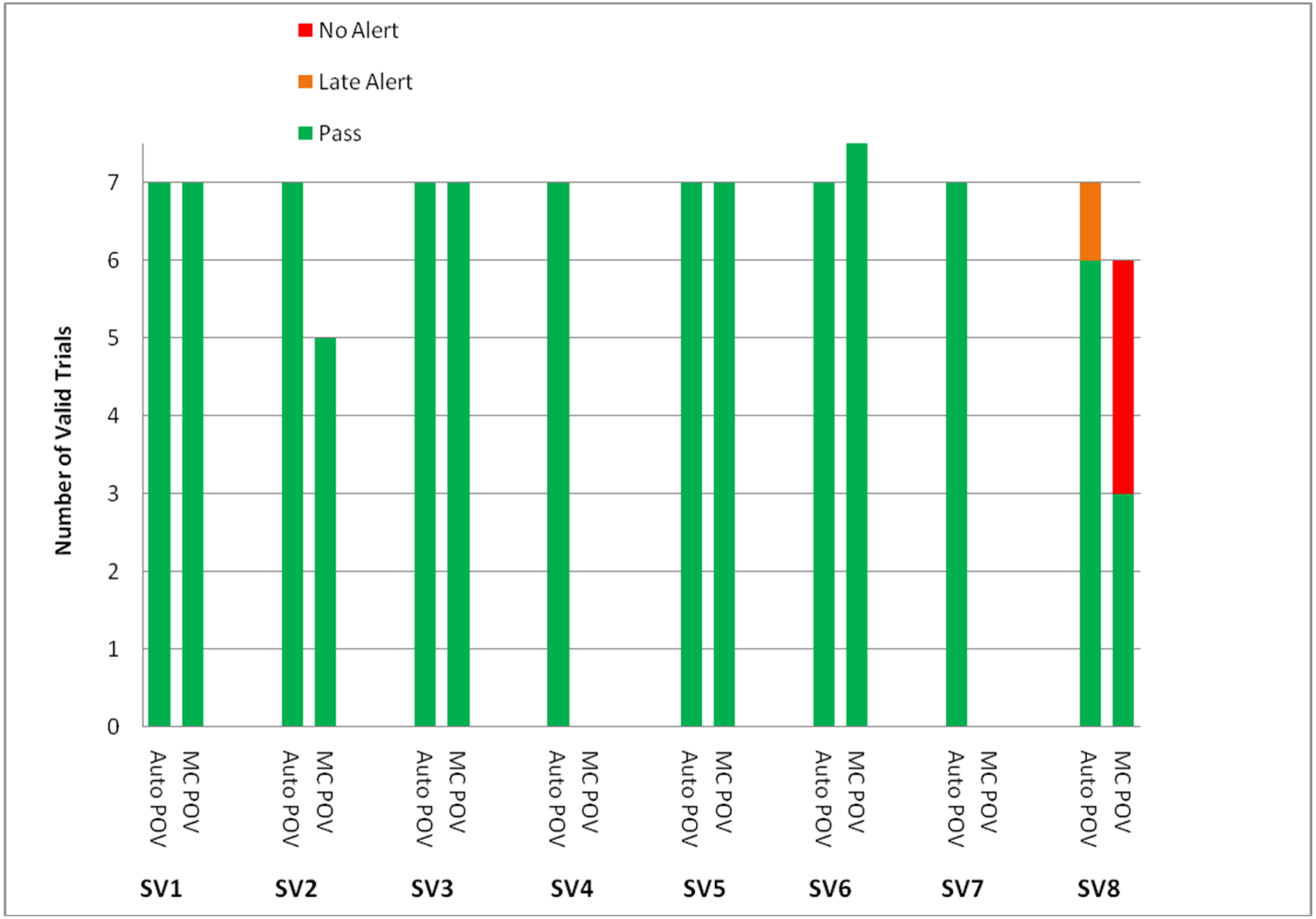
Instrumentation mounted on motorcycle



Results

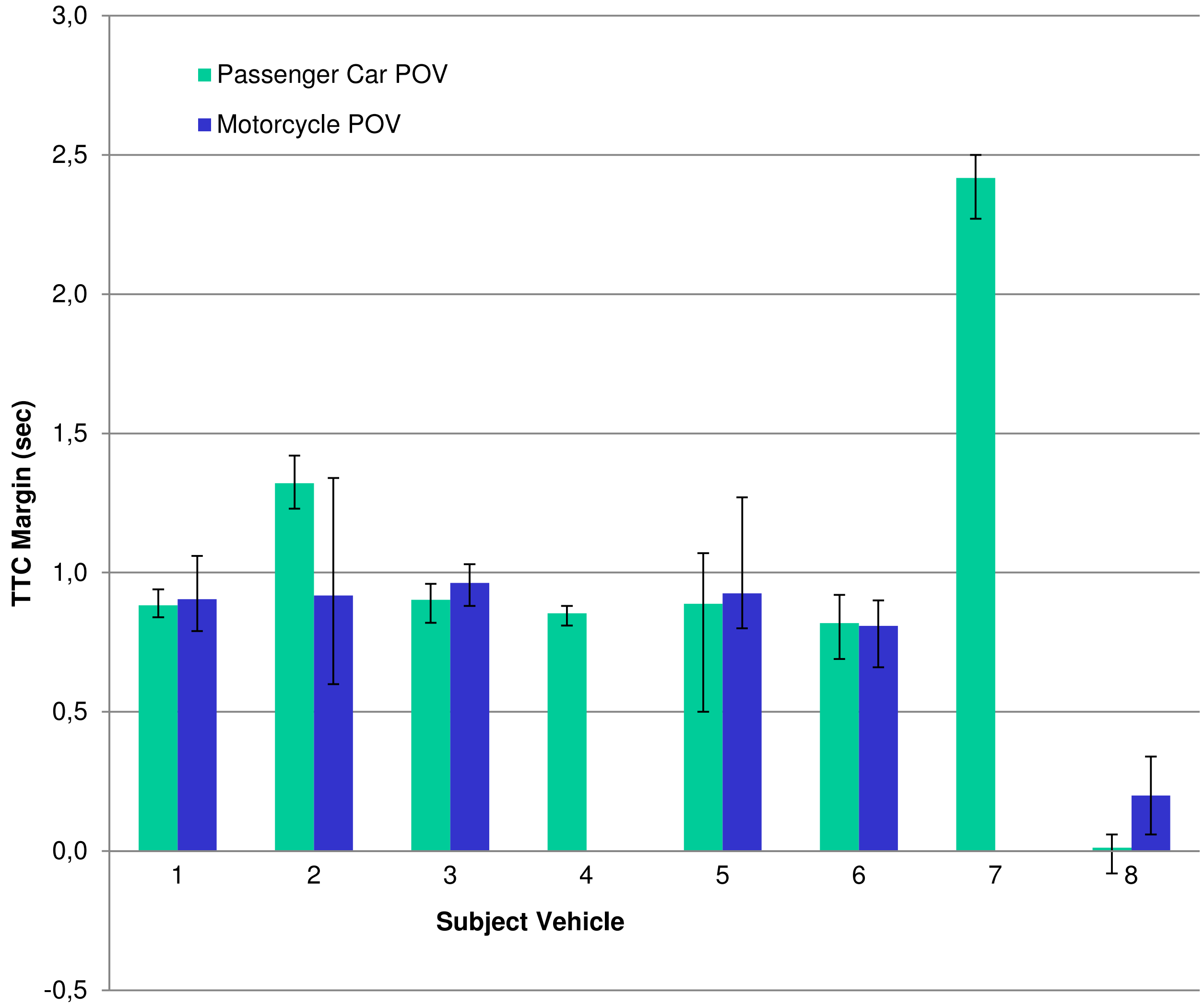
- Pass/Fail criteria are those of the NHTSA test procedure
- These were developed assuming a passenger car POV
- May not be what would have been chosen for a motorcycle
- Timing data are reported in terms of TTC margin:
  - TTC = 0: alert occurred exactly at the minimum TTC (pass)
  - TTC < 0: alert occurred after the minimum TTC (fail)
  - TTC >0: alert occurred before the minimum TTC (pass)

Results - Slower POV, Pass/Fail



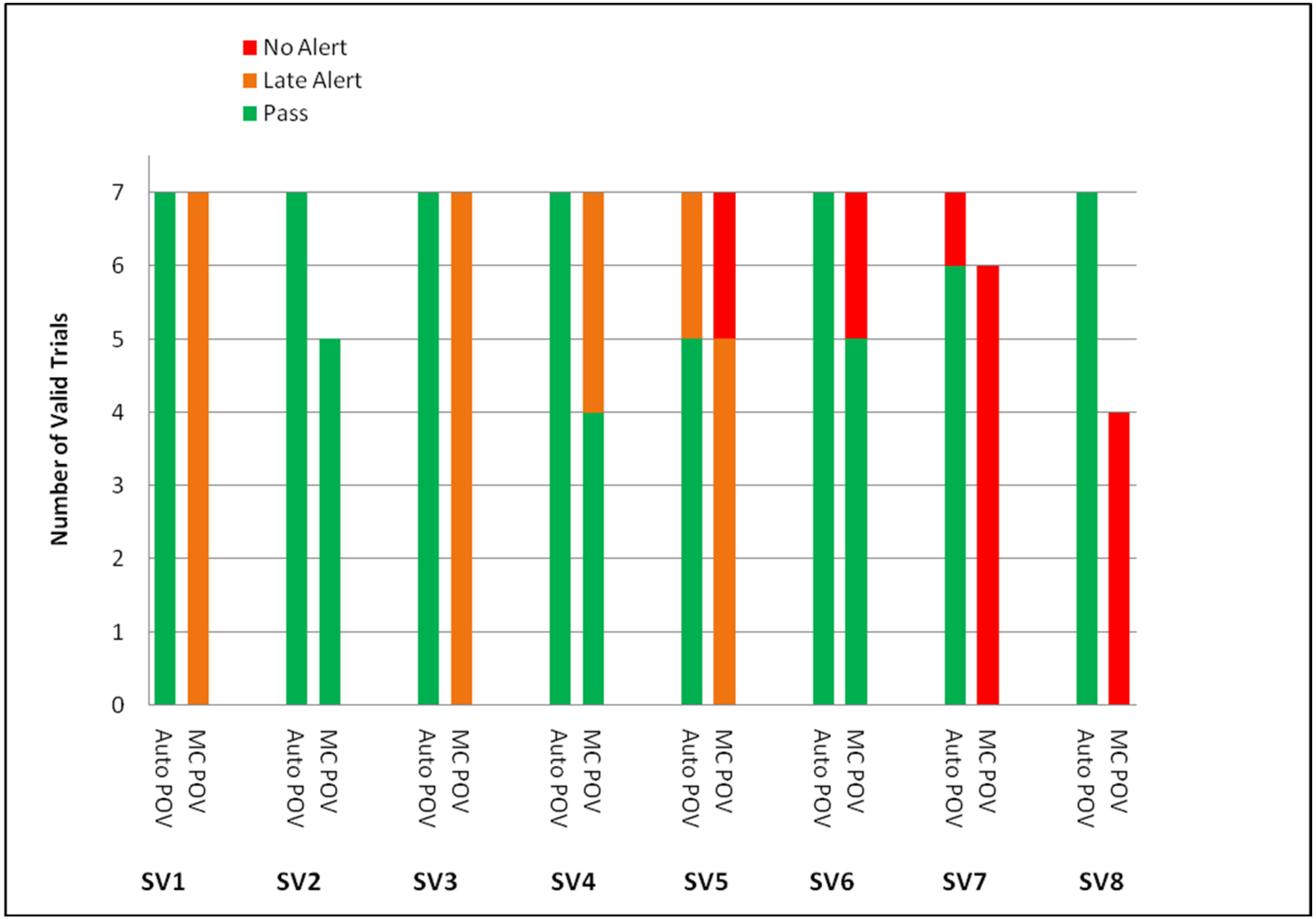
Note that Slower POV tests were not conducted with the motorcycle for SVs 4 and 7

Results - Slower POV, TTC Margin

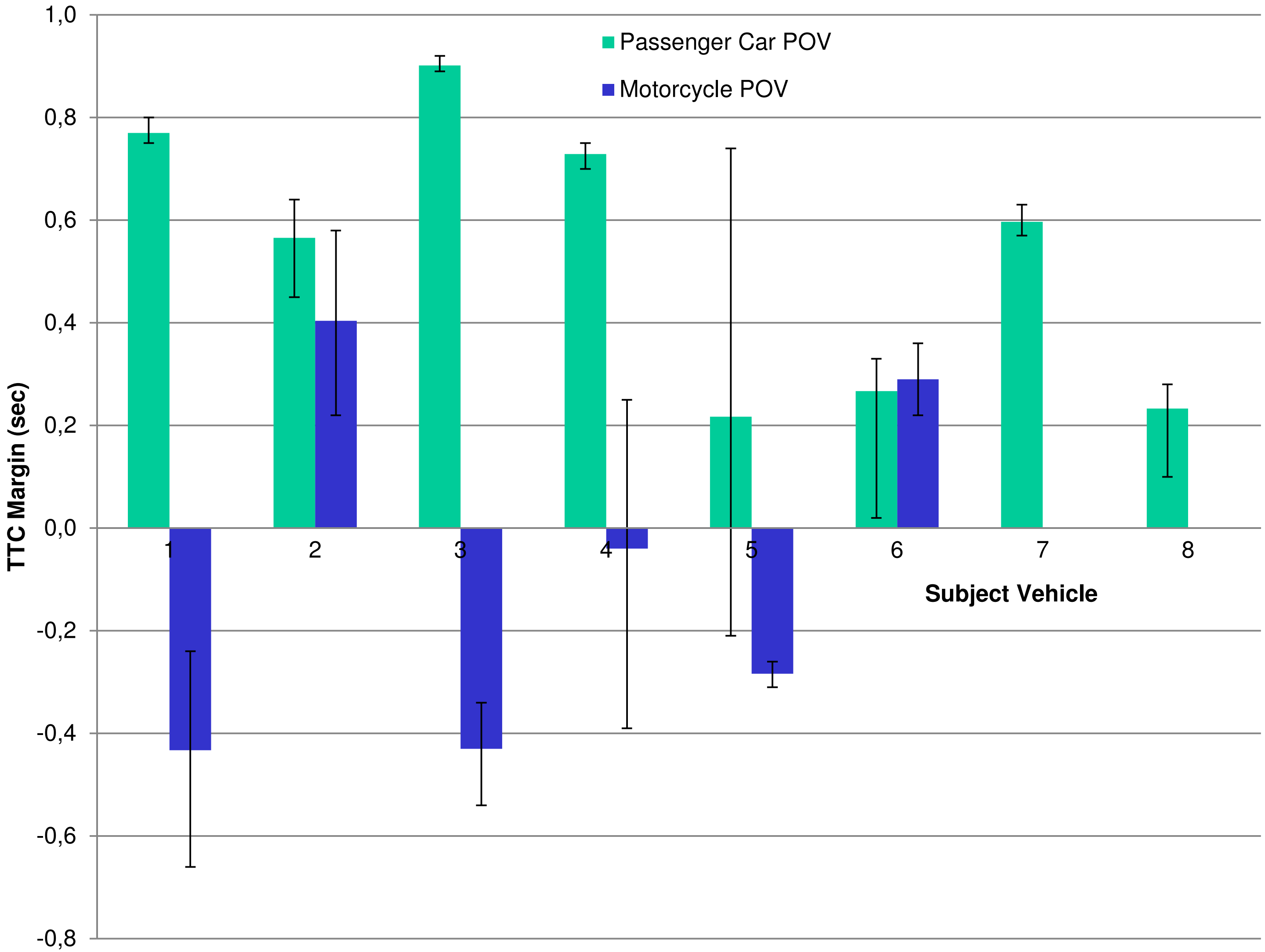


Note that Slower POV tests were not conducted with the motorcycle for SVs 4 and 7

Results - Stopped POV, Pass/Fail



Results - Stopped POV, TTC Margin



Results - Summary for Valid Runs

		Pass (%)	Fail, Late Alert (%)	Fail, No Alert (%)
Stopped Lead Vehicle	Car	95	4	2
	MC	32	44	24
Slower Lead Vehicle	Car	98	2	0
	MC	93	0	8
Overall	Car	96	3	1
	MC	59	24	17

Discussion-Context

- Motorcycle POV was inadequately detected in 40% of trials
- Data from the Motorcycle In-Depth Accident Study (MAIDS) indicates that 60% of all OV to motorcycle occur in a 120 degree arc in front of the OV driver
- The US Hurt Study reported a similar finding ; 77% of all OV to motorcycle accidents occurred within a 60 degree arc directly in front of the OV driver.
- MAIDS also concluded that 37% of all OV to motorcycle accidents involved an OV driver perception failure; OV driver may have failed to see the motorcycle
- Conspicuity efforts have focussed on visibility to the human eye of of the motorcycle and rider, e.g. lighting treatments, clothing etc.
- Adaptation of existing technologies and sensors on the automobile could be adapted to provide enhanced conspicuity to the vehicle
- V-V including motorcycles is in development

Conclusions

- As drivers become comfortable with, and rely more on Advanced Driver Assistance Systems (ADAS), they may become less attentive to the driving task.
- If motorcycles are not correctly identified by these systems, an unintended consequence of broad ADAS implementation may be an increase in the frequency of car-motorcycle accidents even as car-car accidents decrease.
- In order for the safety benefits of ADAS systems to extend to motorcycles, such systems need to reliably detect motorcycles in potential crash scenarios.
- One way to encourage and verify this would be to include motorcycles or their representations in ADAS test procedures.

Recommendations

- Further investigation of ADAS-equipped car to motorcycle scenarios e.g.:
  - Braking lead vehicle
  - Blindspot detection
- Examine ways to make motorcycles more detectable to ADAS sensors
- Include motorcycles or their representations in ADAS test procedures.

Recommendations

- Identify the response properties of a range of actual motorcycles (including riders) to sensing technologies, including radar, camera, lidar, etc.;
- Develop crashable motorcycle targets and delivery systems
- Identify and rank the most commonly occurring motorcycle-car accident scenarios and develop specific test scenarios to address those.
- Include these targets and motorcycle specific scenarios in future test procedures; and
- Retroactively introduce these into existing test procedures.

Acknowledgements

- The authors would like to thank the following for their contributions to this effort:
  - Brian Kebschull,
  - Michael Van Auken
  - Stephen Rhim
  - Theresa Cornwell
  - Nadine Wong and
  - David Weir PhD

of Dynamic Research

Dedication

Peter Gareth Dean
1958 - 2015