Expert Report of
Robert C. Lange

Jones v Harley-Davidson
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Qualifications and Report Organization

1 My name is Robert Carl Lange; I am a Principal and Corporate Vice President at Exponent Inc., a technical and scientific consulting firm. I received Bachelor of Science and Master of Science degrees from the University of Michigan. My Curriculum Vitae is included as Attachment 1 hereto, and my testimony log is included as Attachment 2. My hourly rate is $450 per hour.

2 I have been retained by Counsel representing defendant Harley-Davidson to provide observations and opinions regarding: the vehicle development process, vehicle level technical requirements and technology application patterns; vehicle systems technical requirements and interactions; motor vehicle safety and the science of collision injury reduction; collision injury data and public health; Antilock Brake Systems (ABS) and Combined Brake Systems (CBS); and to review and comment upon the assumptions and conclusions offered by Plaintiffs’ experts.

3 Prior to my employment with Exponent, I worked for the Ford Motor Company, Failure Analysis Associates (a technical consulting firm), and the General Motors Corporation (GM). During my career I have been involved in: statistical forecasting and reliability analyses; Design of Experiments (DOE) with emphasis on design and analysis of computer experiments; stochastic modeling and Monte Carlo simulations; motor vehicle safety and safety technology effectiveness; systems engineering (vehicle level performance criteria development and criteria distribution to systems and components including brake systems); motor vehicle safety; vehicle technology research, development, and application; motor vehicle related public policy and safety rulemaking; motor vehicle collisions, injuries, and public health; collision related data acquisition and analysis; problem identification and resolution; safety strategy development and tactical implementation; systems level design, development, validation, and certification; vehicle design, development, validation, and certification; potential vehicle defect investigations; vehicle defect, noncompliance, and customer satisfaction recalls.

4 At Ford Motor Company I had the following positions and responsibilities: Design Engineer, Supervisor of groups of Design Engineers, Technical Expert, and Supervisor of a vehicle design section responsible for vehicle level integration, program management, and vehicle imperatives including braking performance and brake system validation and certification.

5 At Failure Analysis Associates I had the following positions and responsibilities: Managing Engineer, Principal Engineer, and Vice President. I provided technical consulting services in automotive engineering, defect investigations, motor vehicle related public policy issues, and motor vehicle emissions. My research included vehicle braking systems and vehicle/brake system performance without antilock brake systems (ABS).

6 At GM I had the following positions: “Executive in Charge of Field Performance Analysis,” “Engineering Director Vehicle Development,” and “Executive Director Safety Integration.”
In those roles, my responsibilities varied somewhat over time and they included: motor vehicle safety integration; systems engineering; imperatives management, vehicle level criteria development, specification flow down, and component level criteria specifications including brake system performance for customer satisfaction; motor vehicle safety research; advanced program engineering; safety testing; market conditions, consumer preferences, and competitive analysis for new safety technology applications; safety strategy and technology development; establishment and execution of safety technology tactical implementation plans; defect investigations and recalls; public policy; safety certification requirements and execution of certification plans; and safety rulemaking for U.S. and international standards. I represented GM at various international safety fora including meetings of the United Nations Economic Commission for Europe (UNECE) World Forum for Harmonization of Vehicle Regulations, WP-29. I was the GM executive that worked with the Alliance of Automobile Manufacturers (the Alliance) and the Association of Import Automobile Manufacturers (AIAM) to cooperatively: test vehicle dynamic handling limits, characterize vehicle dynamics in parametric measures, analyze objective vehicle handling data, and propose metrics that could be embedded into a safety standard to require applications of Electronic Stability Control (ESC) systems in the light duty vehicle fleet. The collected vehicle dynamics data and analyses were given to the National Highway Traffic Safety Administration (NHTSA) and used by the NHTSA to develop Federal Motor Vehicle Safety Standard (FMVSS) 126.

I have served as a Director of: the National Safety Council, the American Coalition for Traffic Safety, the Crash Avoidance Metrics Partnership (CAMP), and the Vehicle Infrastructure Integration Consortium (VIIC).

I was a member of the Wayne State University Biomedical Department External Advisory Board and the Transportation Research Board Strategic Highway Research Plan 2 Implementation Report Committee. I am a past chair of the Vehicle Systems Standards Committee of the Society of Automotive Engineers.

Currently, I serve as a member of the University of Michigan Transportation Research Institute External Advisory Board and I participate in its case reviews. I am a recipient of the National Highway Traffic Safety Administration (NHTSA) U.S. Government Award for Safety Engineering Excellence.

My analyses and opinions are based on research I have conducted, case related information I have reviewed as of the date of this report, and my training and experience. My opinions are established to a reasonable level of engineering certainty. I will consider additional information as appropriate and I may supplement this report based upon any additional work that I may conduct or supervise in review of, analysis of, or response to additional information I receive or review.

This report is organized into ten sections:

A “Qualifications and Report Organization,” this section.
B “Case Background – The Complaint,” a brief description of the collision that gave rise to this lawsuit.

C “Deposition Summaries,” a review of the received depositions.


E “Antilock Brake System (ABS) Effectiveness,” a history of the research effort into determining if ABS is effective in motorcycles.

F “Antilock Brake System (ABS) Application to the U.S. Motorcycle Fleet,” an analysis of how manufacturers have introduced ABS into the motorcycle fleet.

G Combined Brake System (CBS) Effectiveness, “a history of the research effort into determining if CBS is effective in motorcycles.

H Combined Brake System (CBS) Application to the U.S. Motorcycle Fleet,” an analysis of how manufacturers have introduced CBS into the 2012 model year motorcycle fleet.

I ‘Motor Vehicle Injury Control and Safety Technology,’ a discussion of the public health model as applied to motor vehicle safety and the application of safety technologies.

J “Observations and Opinions,” a list of opinions that are based upon my professional experience and the analyses and data registered in this report.

11 References are registered in the report as endnote superscripts at the appropriate citation. The materials I relied upon for general background but did not reference are listed in Appendix A hereto. The case materials received and relied upon are listed in Appendix B hereto.

12 At trial, I anticipate using all of the figures and tables included herein, the references listed in the Reference section, the materials I relied upon for general background listed in Appendix A, and the case related materials listed in Appendix B.
Case Background - The Complaint

13 Plaintiffs Mark Jones and Pamela Jones have filed a complaint\(^3\), herein after “Plaintiffs’ Complaint.” Plaintiffs allege:

A “On or about June 15, 2012, Plaintiffs purchased a new 2012 Harley-Davidson Electra Glide Classic motorcycle (the "Motorcycle") from the Harley-Davidson dealership in Paris, Texas. The Motorcycle is a touring style motorcycle with an engine displacement of 103 cubic inches and weighing more than 850 pounds. The Motorcycle came equipped with unlinked thirty-two millimeter, four-piston fixed front and rear brakes, which Harley-Davidson bills as "state of the art and top of the line."\(^5\), par. 5

B “On July 6, 2013, Plaintiffs were driving the Motorcycle in the northbound lane of Texas Highway 271 in Mount Pleasant, Texas. Plaintiff Mark Jones was operating the Motorcycle, and his wife, Plaintiff Pamela Jones, was riding as a passenger on the back. At approximately 10:12 a.m., a southbound Chevrolet Avalanche (the "Avalanche") driven by Robert Viviano cut in front of Plaintiffs, forcing Plaintiff Mark Jones to attempt an emergency stop to avoid colliding with the Avalanche. In doing so, Mr. Jones engaged both the front and back brakes of the Motorcycle.\(^3\), par. 7

C “During the emergency stop, the Motorcycle's front and back wheels locked up and ceased rotating, causing the Motorcycle to skid, fishtail, and become unbalanced. At some point while the Motorcycle was skidding, it began to lean over. Suddenly, one or both of the wheels regained traction on the road surface, causing the Motorcycle to "high side," or pitch violently in the opposite direction of the initial lean. Both Plaintiffs were flung from the Motorcycle. Plaintiffs and the Motorcycle made impact with the pavement and slid some distance until coming to a stop in the northbound lanes of Texas Highway 271. These events occurring on July 6, 2013 are referred to herein as the "Wreck."\(^3\), par. 8

D “Had the Motorcycle been equipped with an anti-lock braking system ("ABS"), the likelihood of these serious injuries occurring would have been eliminated or substantially reduced. Indeed, the superior safety of ABS has been acknowledged and understood within the motorcycle manufacturing industry for some time. However, to this day, ABS does not come standard on most Harley-Davidson motorcycles, including the Electra Glide Classic model that Plaintiffs purchased. Rather, since 2008, Harley-Davidson has only offered ABS as an option on the Electra Glide Classic and other similar models. Harley-Davidson describes its optional ABS feature as follows:"

> “When it comes to Electra Glide Classic with optional ABS, "stopping power" has a double meaning. The components of our ABS are tastefully hidden within the wheel hub, so you'll still turn heads with a clean, streamlined design. More importantly, though, you get certainty in the saddle knowing your bike's going to behave when you need it.”

“Clearly, Plaintiffs' Motorcycle did not behave when they needed it to. And, as indicated by the above quote, Harley-Davidson did not expect that it would. Sadly, not only did
Harley-Davidson fail to install ABS as a standard feature on the Motorcycle, Harley-Davidson and its agents failed even to mention that ABS was an option available to Plaintiffs when they purchased the Motorcycle.” 3, par. 10, emphasis in original

E “Here, had the Motorcycle been equipped with ABS, Plaintiffs would have been able to stop the Motorcycle more safely and avoid or substantially reduce the likelihood of serious injury or other loss.” 3, par. 11

F “At the time the Motorcycle was placed into the stream of commerce, it was, or should have been, reasonably expected and foreseeable that the driver of the Motorcycle would be required to engage the Motorcycle's braking system in an emergency stopping situation. Further, it was, or should have been, reasonably expected and foreseeable that the Motorcycle's lack of ABS would cause the Motorcycle's wheels to lock up or cease rotating and, thus, cause the Motorcycle to skid, fishtail, and/or fall over during operation of the Motorcycle and its non-ABS, non-linked braking system.” 3, par. 20

G “With respect to the design of the Motorcycle, at the time it left the controls of Harley-Davidson, there were safer alternative designs available—i.e., ABS and linked braking systems. Specifically, the inclusion of ABS in reasonable probability would have prevented or significantly reduced the risk of loss caused to Plaintiffs. Further, such alternative designs were economically and technologically feasible at the time the Motorcycle left Harley-Davidson's control, as evidenced by the fact that Harley-Davidson offers ABS as an option on its motorcycles. To the extent ABS was not required by state or federal regulations at the time the Motorcycle was designed and manufactured, such regulations, if applicable, were inadequate to protect the public from unreasonable risks of injury or damage.” 3, par. 21

H “At the time the Motorcycle left the control of Harley-Davidson, it was defective and unreasonably dangerous within the meaning of §402A Restatement (Second) of Torts, in that it was not adequately designed, manufactured, assembled, tested, and/or marketed to minimize the risk of causing harm to the user or consumer's person and personal property. Specifically, the Motorcycle suffered from an unreasonably dangerous design and/or manufacturing defect that caused and resulted in the Wreck and Plaintiffs' injuries and the attendant damages.” 3, par. 22

I “The unreasonably dangerous and defective design and/or manufacture of the Motorcycle was a producing and proximate cause of Plaintiffs' damages sought herein.” 3, par. 23
Deposition Summaries

On April 6, 2015, Plaintiff Mark Jones was deposed and stated the following:

A. He knew his motorcycle did not have ABS prior to the crash. 4, 159:25-160:2

B. He doesn’t remember anything after hitting the brakes. 4, 225:20-21

C. He does not remember if he skidded and lost control. 4, 225:22-226:2

D. He does not remember the wheels locking up. 4, 226:6-7

E. He locked both brakes. 4, 250:8-16

F. Based on his understanding, he kept the bike upright and travelling in a straight line as much as he could. He stated, “I kept it upright ‘til we flew off of it.” He does not know why they flew off, and has never heard of a highside. 4, 249:6-14

G. He is guessing the speed limit is 35. He does not know how fast he was going right before the accident. 4, 306:5-12

H. Mr. Viviano turned between the car 3-4 car lengths in front and his bike. 4, 309:4-13

I. He isn’t sure if the Viviano vehicle was stopped prior to turning. 4, 312:20-24

J. He did not hit the Viviano vehicle. He does not remember if he tried to swerve left. He remembers hitting his brakes when he saw the Viviano vehicle. 4, 312:25-15

K. He began covering his brakes prior to the red light south of the Wal-mart. 4, 314:19-21

L. He had trembles in his hands prior to the time of the accident. He hit both brakes “pretty hard.” He said, “I clamped down.” 4, 316:13-25

M. He squeezed the front brake “Not as hard as I could. I--I--yes, I--I got on it.” He doesn’t know if he applied the front brake hard enough that it would have started sliding without the application of the rear brake. 4, 317:3-21

N. When asked, “basically if you were driving in a car, you were slamming the brakes on?” he answered, “Yes, sir.” He does not remember either wheel locking up, trying to swerve or steer, letting off the brakes, or anything after applying the brakes. He went straight, not making any effort to steer left to avoid the car that turned into his path. 4, 318:6-319:3

O. He does not remember what side the bike went down on. 4, 319:4-14

P. When asked, “Basically any motorcycle he has ever owned, this accident would have happen [sic] just like it did?” he answered, “Pretty much, yes.”
15 Avalanche driver Mr. Robert Vivano was deposed on July 2, 2015 and stated the following:

A  He was stopped in the turn lane for a minute and a half to two minutes prior to making his turn.5,14:13-16

B  He did not see the motorcycle prior to turning.5,16:12-14

C  The white car was traveling in the inside lane.5,16:15-18

D  He turned in front of the white car.5,17:19-21

E  His wife told him there was a motorcycle coming fast and that it might hit them.5,18:6-13

F  He believed the motorcycle had been traveling 55 mph when his wife pointed it out to him.5,29:13-16

G  He was traveling 5 to 10 mph as he was turning, but sped up to 20 mph to try and avoid the motorcycle.5,19:22-20:3

H  He believed he began his turn, and was into the Wal-Mart parking lot in 7 seconds.5,37:6-9

I  He looked in his rearview mirror and observed the bike swerve.5,20:17-24

J  He heard the braking tires on the road, and then heard scraping on the roadway after the motorcycle had passed behind his truck.5,21:2-22:3

K  His truck was fully out of the left lane, in the parking lot when the motorcycle passed behind his truck.5,22:8-13

L  After the accident, the motorcycle was on its side.5,24:22-25

M  After the accident, the occupants of the motorcycle were lying face down on the pavement and were not close to the motorcycle.5,25:6-17

16 Avalanche passenger Witness Noemi Martinez was deposed on July 2, 2015 and stated the following:

A  She was the right rear passenger in the Avalanche.6,9:5-12

B  When her husband, Robert Vivano, turned left, she looked back and saw the motorcycle going down.6,13:2-15

C  When she looked back and saw the motorcycle behind her, they were already out of the intersection.6,19:22-20:6

17 Officer Steve Rosalas was deposed and stated the following:
A The motorcycle was laid down on the roadway and he could see apparent skid marks and
gouge marks in the roadway. 7,32:21-33:1

B There were no signs of contact between the motorcycle and the Avalanche. 7,43:20-21

C He calculated the motorcycle’s speed at 46 mph based on skid marks. 7,54:24-55:14

D There were two separate skid marks left by the motorcycle. The operator of the
motorcycle applied the brakes, leaving the first skid mark, then let off the brake, and then
applied the brakes again. 7,57:5-22

E After the second skid the motorcycle came into contact with the ground on its left side and
either skidded or bounced across the surface to its final resting place. 7,65:17-23

F The wheels of the motorcycle had locked up, based on the actual curvature and the
directions of the skid mark. 7,71:8-14
Police Report and Witness Statements

18 Police report.

A The Texas Peace Officer’s Crash Report (Case ID #: 1300009855) associated with the incident that gave rise to this lawsuit recorded:

1 Crash date and time: July 6, 2013, 10:12am.

2 Number of units: 2.

3 Number of persons: 5.


5 Accident description (the subject vehicle is Unit # 1 in the Police narrative): “Unit 2 advised he was facing south in the 2300 block of S. Jefferson. Unit 2 stated he was in the turning lane preparing to make a left turn. Unit 2 advised the roadway appeared to be clear so he made the turn. Unit 2 advised his wife stated Unit 1 was traveling north in the 2300 block of S. Jefferson towards them. Unit 2 advised he accelerated his vehicle to get it out of the roadway. Unit 2 stated he did not make contact with Unit 1 but he did her [sic] them hitting there [sic] brakes. Unit 1 appeared to have lost control of the motorcycle and wrecked. All occupants of Unit 2 had no injuries. All occupants of Unit 1 suffered from major injuries and were transported to Titus Regional Medical Center then later flown to East Texas Medical Center Tyler for further [sic] treatment.”

6 The crash diagram is shown in Figure 1.
Figure 1. Crash diagram from police report.

7 Vehicles involved

a Unit 1: 2012 Harley Davidson, VIN 1HD1FFM16CB687341

b Unit 2: 2004 Chevrolet Avalanche, VIN 3GNEC12T64G102101
8 Traffic control: code = “11. Center Stripe/Divider.”
9 Light conditions: code = “1. Daylight.”
11 Roadway surface condition: code = “1. Dry”
12 Weather condition: code = “1. Clear”
13 Roadway alignment: code = “1. Straight, Level”
14 Street Description: “Flat Level Surface”
15 Posted Speed Limit: 45 mph
16 Persons:
   a Unit 1: 2 riders
   b Unit 2: 3 occupants
17 Airbag status:
   a Unit 1: code = “97. Not Applicable”
   b Unit 2: code = “1. Not Deployed”
18 Restraint use:
   a Unit 1: code = “97. Not Applicable”
   b Unit 2:
      1 Driver: code = “1. Shoulder and Lap Belt”
      2 Passenger 1 (2nd row right seat): code = “1. Shoulder and Lap Belt”
19 Helmet use:
   a Unit 1: code = “1. Not Worn.”
   b Unit 2: code = “97. Not Applicable”
20 Ejection:
a  Unit 1:  code = “2. Yes.”

b  Unit 2:

1  Driver:  code = “1. No.”

2  Passenger 1 (2\textsuperscript{nd} row right seat):  code = “1. No.”

3  Passenger 2 (2\textsuperscript{nd} row middle seat):  code = “1. No.”

21 Injury Severity

a  Unit 1:

1  Driver:  code = “99. Unknown.”


b  Unit 2:

1  Driver of Unit 2:  code = “N. Not Injured.”

2  Other 2 passengers of Unit 2:  code = “N. Not Injured.”

22 Apparent contributing factors

a  Unit 1 (may have contributed):  code = “61. Speeding – (Over Limit).”

b  Unit 2 (contributing):  code = “37. Failed to Yield ROW – Turning Left.”

23 Direction of vehicle travel:

a  Unit 1:  North

b  Unit 2:  South, turning East

24 Alcohol Specimen Type:

a  Unit 1:  code = “96. None”

b  Unit 2:  code = “2. Blood.”

19 Vehicle information.

A  2012 Harley Davidson Electra Glide Classic 103 Touring Motorcycle

1  VIN: 1HDIFFM16CB687341
20 Multiple witnesses described the incident in Affidavits they prepared (ref. Bates 1-6). Their names and Affidavit observations are included below:

A Noemi Martinez: “On this day of July 6, 2013 Robert Viviano being the driver, and my son & myself being the passenger were on the back seat. As the events happened Robert Viviano was going to turn into the Walmart with, we were [illegible] clear pass & oncoming traffic was by the sign on that says “Commerce Square” with enough footage to turn. Their [sic] was an incoming motorcycle & several other cars so he turned & the motorcycle was coming pretty fast Robert turned & I looked back & saw the motorcycle trying to stop but they could not. Then I told Robert that the individuals had fallen. He was already on parking lot by gas pump & he pulled & went over to the scene of the accident. The motorcycle was on the inside line & when we turn we were already on the other lane. So they were going pretty fast.”

B Robert Viviano: “I was headed to the Wal-Mart and was in the turning lane. I was driving a black avalanche barring license plate HHM472, as I got ready to turn there was a white car coming at a safe distance so I turned. As I turned my wife Noemi Martinez told me there was a motorcycle coming at us at a fast speed so I sped up and made the turn. My wife then said I think they fell so I parked my car and went to the scene of the accident. I then saw officer Fox pull into Walmart parking lot and I approached him and told him I was the guy he was looking for.”

C Jacquelyn O’Brien: “I had gotten gas and pulled into turn lane to get on 271. While I was waiting to cross a large Chevy truck pulled in front of motorcycle to turn causing motorcycle to wreck. The truck continued into Walmart parking lot. I did not see driver of truck.”

D Wendy Leonard: “a black avalanche turned left in front of the motorcycle. The motorcycle fish-tailed and crashed but didn’t hit the truck.”

E Shane Rejcek: “I was pulling out of Murphys gas station. I heard and saw bike fallover I saw black Avalanche pull in. I pulled in next to him. I started walking to the scene. He followed next to me. He is a Hispanic male maybe 5’10”, 5’11” 180-200lbs he stood there until people started mentioning a black truck. He had then started to walk in the direction of WalMart. Leaving his engine running.”

F Michael Molina: “Bike was ridden from Pittsburg going north in left lane of traffic came infornt [sic] of Walmart when a black Surbuan [sic] pull in front of the bike. Drive [sic] of bike lock the bike did his best to slow it down back end swerved 3 time and drive [sic] layed the bike over in middle of rd other car took off in to Walmart parken [sic] lot.”
Antilock Brake System (ABS) Effectiveness

Testing of passenger car ABS shows that the technology can reduce stopping distances, allow the driver to steer during panic braking, reduce yawing, and reduce the adverse effects of skidding. These improved abilities suggested the introduction of ABS into the passenger car fleet would have improved safety, but studies of ABS effectiveness have shown little benefit for equipping passenger cars with ABS. 1994\textsuperscript{9}, abstract and 1995\textsuperscript{10}, abstract NHTSA analyses showed that ABS helped reduce vehicle-to-vehicle collisions, but increased run-off-road crashes, resulting in little to no net accident benefits for vehicles equipped with ABS. A 1997 IIHS study\textsuperscript{11}, abstract found fatal crash rates were similar between vehicles with and without ABS. A 2004 Australian study\textsuperscript{12}, abstract found ABS has no statistically significant effects on secondary safety outcomes. The most recent study of passenger car ABS was published by the National Highway Traffic Safety Administration (NHTSA) in January of 2015 as part of its assessment of the safety effects of various motor vehicle technologies applied to passenger cars and light duty trucks.\textsuperscript{44} Concerning Four-wheel AntiLock Braking Systems, NHTSA wrote\textsuperscript{44}, p. 25-28:

A “As described above, during the 1990s NHTSA considered, but then deferred any requirement for ABS on passenger vehicles with GVWR less than 10,000 pounds. But eventually FMVSS No. 126 required ESC in cars and LTVs by MY 2012. Because, to date, every ESC system can perform ABS functions, all new cars and LTVs now have 4-wheel ABS.”\textsuperscript{11}

B “Modern 4-wheel ABS was first offered as standard equipment in 1985 on some lines of BMW, Lincoln and Mercedes and in 1986 on Chevrolet Corvette. Availability of ABS increased gradually from 1987 to 1990 and dramatically in 1991 and 1992, when it became standard on the majority of GM cars. From 1994 to 2001, about 60 to 65 percent of new passenger cars were equipped with ABS. At that time, ABS was usually standard on the larger and more expensive cars, optional and not too frequently sold on small economy cars. Four-wheel ABS installations for LTVs began in 1989 on some GM Astro/Safari minivans, Jeep Cherokee and Jeep Wagoneer. The market share for 4-wheel ABS in new LTVs steadily increased during the 1990s, as RWAL was phased out, and had reached about 90 percent by 2004.”

C “How ABS works: Few drivers are able to modulate pressure on the brake pedal optimally, given a sudden emergency situation or unexpectedly slippery surface. If excess pedal pressure locks only the front wheels, the vehicle will continue in a straight path, but the driver will be unable to steer it and avoid obstacles. If it locks the rear wheels, the vehicle can lose control. ABS senses if any of the four wheels have locked, and if so,
quickly releases the brakes on that wheel and lets it start rolling again. Cycles of releasing, holding and reapplying brakes are repeated many times per second.”

D “Expected benefits: The experience on the test track suggested that ABS could have safety benefits in many crash situations. Maintaining steering control and cutting stopping distances, especially on wet roads, could reduce frontal impacts into other vehicles and collisions with pedestrians. By preventing yaw and preserving steering control, ABS can help drivers keep their vehicle on a straight or curving road, and could prevent run-off-road crashes such as rollovers or fixed object impacts. However, there could be some adverse impact due to longer stopping distances on gravel and other loose surfaces away from the road.”

E “Crash avoidance – passenger cars: NHTSA’s initial evaluation, published in 1994 and based on 1990-to-1992 crash data from Florida, Missouri and Pennsylvania did not lead to a conclusion on the overall crash avoidance for ABS. Crash involvements as a frontally impacting car in a multivehicle collision were significantly reduced, especially on wet roads. But some types of run-off-road crashes significantly increased with ABS. A clearer picture emerged from NHTSA’s follow-up evaluation in 2009, based on GES data from 1995 to 2007 for a larger list of make-models. ABS reduced culpable involvements in multivehicle crashes by a statistically significant 17 percent, whereas the effect in run-off-road crashes had become negligible (1% increase). Table 1 shows how these involvements decreased, relative to the control group, for a list of make-models that switched from no ABS or from a low percentage optional installations to standard ABS or to a high percentage of optional installations.”

Table 1. ABS effectiveness.

<table>
<thead>
<tr>
<th>GES 1995 to 2007</th>
<th>Culpable Multi-Veh Involvements</th>
<th>Control Group</th>
<th>Risk Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unweighted Cases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 MY with 7% ABS</td>
<td>8,896</td>
<td>14,478</td>
<td></td>
</tr>
<tr>
<td>Next 2 MY, with 88% ABS</td>
<td>8,961</td>
<td>16,489</td>
<td></td>
</tr>
<tr>
<td>Weighted Counts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 MY with 7% ABS</td>
<td>1,062,451</td>
<td>1,802,565</td>
<td>.589</td>
</tr>
<tr>
<td>Next 2 MY, with 88% ABS</td>
<td>1,069,673</td>
<td>2,114,616</td>
<td>.506</td>
</tr>
</tbody>
</table>

F “This is a 14-percent reduction in culpable involvements for the group with 88 percent ABS relative to the group with 7 percent ABS. It amounts to a 17-percent reduction for standard ABS relative to no ABS (confidence bounds: 13 to 22%). Overall, a statistically significant 6-percent reduction in police-reported crash involvements can be attributed to ABS (confidence bounds: 4 to 8%).”

G “Fatality reduction – LTVs: NHTSA’s initial analysis of 4-wheel ABS in LTVs in 1995 showed increases of rollovers and side impacts with fixed objects not unlike the early results for passenger cars (although not statistically significant).”
“NHTSA’s follow-up evaluation in 2009 does not show a statistically significant overall effect for ABS. Fatal crash involvements increase by 1 percent (confidence bounds range from a 6% increase to a 4% reduction). Fatal run-off-road crashes increase by a non-significant 6 percent and culpable involvements in multivehicle crashes increase by a non-significant 1 percent. However, there is a statistically significant 14-percent reduction of collisions with pedestrians and bicyclists.”

“ABS is clearly beneficial in preventing nonfatal crash involvements of cars and LTVs, but has little or no net effect on fatal crashes. Whatever unfavorable effects ABS may have had on some types of run-off-road crashes (and the record is unclear because many of those findings are not statistically significant) will in the future be offset by the much larger benefits of ESC in these types of crashes.”

As noted in NHTSA’s introductory paragraph (paragraph 20A supra) NHTSA had not promulgated a rule mandating four wheel ABS in 4 wheeled light duty passenger cars.

While motorcycle ABS also shows potential safety improvements in reduced stopping distances and potentially improving stability by avoiding wheel lock in some events, it cannot be assumed that these measurable dynamic performance benefits will translate into real world safety improvements. Unbiased analysis of collision data is necessary to determine technology effectiveness. ABS improves stability and steering ability in limit braking in turns for light duty cars and trucks, but motorcycle ABS cannot improve stability in turns. This suggests ABS may be less effective for motorcycles than it has been for light duty passenger vehicles.

Review of some research concerning the measured effectiveness of motorcycle ABS follows.

In April 2008, the Highway Loss Data Institute (HLDI) published a bulletin describing a study of the 12 2003-2007 model year motorcycle models with optional ABS from which ABS presence can be determined from the Vehicle Identification Number (VIN) or model name. Utilizing insurance company data, HLDI found a statistically significant 19% reduction in collision claim frequencies for motorcycles with ABS. No statistically significant reduction was found for collision claim severities.

In October 2008, Kebschull and Zellner of Dynamic Research, Inc reported there were insufficient data to determine the effectiveness of motorcycle ABS from real world data. Instead, they studied the two large databases of motorcycle crashes (900 crashes from Hurt and 921 crashes from MAIDS), applied computer simulations to each accident reconstruction, and determined the injury effectiveness.

The Hurt study was conducted by the Traffic Safety Center at the University of Southern California with funding from the NHTSA and involved detailed on-scene accident investigations of motorcycle accidents in the Los Angeles area.
B The MAIDS study was done by the European Commission and the Association of European Motorcycle Manufacturers (ACEM) and involved detailed on-scene accident investigations of motorcycle accidents in France, Germany, Italy, Netherlands, and Spain from 1999-2000. Motorcycle use in Europe differs from that in the United States in that more scooters are used in Europe and more motorcycles and scooters are used for daily commuting. While about 34%,\textsuperscript{16} Tables 1 & 3 EU of motorcycles registered in Europe in 2013 were scooters, about 5%\textsuperscript{36} of motorcycles registered in the U.S. in 2013 were scooters. Plaintiff’s expert Mr. Timothy C. Lovett agreed that Europe has more scooters and more commuting motorcycles than the U.S.\textsuperscript{33, 268:22-269:10}

C The injury effectiveness for front and rear ABS was determined to be 3% from the Hurt study and 1% from the MAIDS study.

26 In March 2009, the Insurance Institute for Highway Safety (IIHS) published an article on the effectiveness of ABS in reducing fatal motorcycle crashes. The article was republished in 2011 with unknown changes and only the 2011 article\textsuperscript{17} is now available.

A A selection of 13 2003-2008 motorcycles that met the HLDI requirement was analyzed. For years 2003-2008, fatal motorcycle crashes were obtained from NHTSA’s Fatality Analysis Reporting System and exposure data were obtained from R.L. Polk and Company.

1 Fatal crash rates were determined for both ABS and non-ABS motorcycles by dividing the number of fatal crash involvements by the number of registered vehicle years.

2 The rate of fatal crash involvements per 10,000 registered vehicle years was 4.1 for ABS motorcycles and 6.4 for non-ABS motorcycles, corresponding to a statistically significant 37 percent reduction in the rate of fatal crash involvements per 10,000 registered vehicle years for the ABS models versus the non-ABS models.

B The article noted that the effectiveness estimate could have been influenced by differences in the two groups: those who chose not to purchase ABS and those who chose to purchase ABS.

1 Motorcyclists who chose ABS may be more safety conscious than those who decline, thus leading to lower fatal crash rates due to safer riding practices. The IIHS looked for selection bias in known risk factors. While non-ABS crashes involved more speeding (22% vs 17%), more intoxication (16% vs 12%), and more helmet use (74% vs 70%), the differences were not statistically significant.

2 However, the level of these factors for riders not involved in fatal crashes was unknown, so it was not possible to accurately quantify how such factors influenced the observed reduction in fatal crash rate for ABS motorcycles.
3 Another possible difference between riders with ABS and those without ABS that could influence the effectiveness estimate is the amount of miles driven. If riders with ABS travel less miles than those without, the effectiveness would go down (and vice versa).

27 In June 2009, Roll et al.\textsuperscript{18} analyzed detailed cases from the DEKRA PTW database, a German database of Powered Two Wheel motorcycle crashes with detailed expert analyses. They selected 51 cases from the database of 350 real-world crashes by imposing a reaction demand and a following braking of the motorcycle rider. They found up to 50% of the selected crashes could have been avoided by a simple 2 channel ABS. 50% of 51/350 is 7%, suggesting a maximum effectiveness of 7% is possible.

28 In October 2009, a document titled Review of the Studies on Motorcycle ABS by the Highway Loss Data Institute and Insurance Institute for Highway Safety was written by an unknown author\textsuperscript{19}. It states the HLDI and IIHS results should not be interpreted as estimates of effectiveness of motorcycle ABS due to the selective recruitment (a form of selection bias) which likely results from safer riders choosing to purchase motorcycles equipped with ABS. It states a similar selective recruitment with safety belt users resulted in an overestimation of safety belt effectiveness by 50%\textsuperscript{20}. This occurred even though all passenger vehicles had safety belts; selective recruitment effects with motorcycle ABS are likely even larger since the systems cost is substantial relative to motorcycle transactions prices. Additional findings included:

A Both the HLDI and IIHS studies are based on private and confidential data and thus cannot be verified by independent researchers.

B The HLDI and IIHS studies are based on only 12-13 models, in small minority of the available models and brands. About half of the exposures came from a single model, the Honda Gold Wing Touring. This is an additional form of selection bias with an unknown consequence.

C The 2008 Dynamic Research Inc. study found motorcycle ABS to not be cost effective (using the NHTSA’s method for calculating cost effectiveness) in comparison to several dozen safety regulations enacted for light passenger vehicles in the last 30 years.

D The 2008 Dynamic Research Inc. study states that ABS could be effective in no more than 1-12% of the crashes in the Hurt database and no more then 1-7% of the crashes in the MAIDS database. These are the percent of crashes in the “braking, capsize” and “braking, slide out” categories.

29 In December 2009\textsuperscript{21}, the HLDI updated its April 2008 study by adding the 2008 model year and increasing the models from 12 to 18, which doubled the collision exposure, and by looking at medical payment (which typically pays for operator injuries) and bodily injury liability (which typically pays for passenger injuries). The results were very similar. Collision claim frequencies decreased 22% (vs 19% in the 2008 study) for ABS motorcycles. For the newly studied medical payment coverage, claim frequencies decreased a significant
30% for ABS motorcycles. For the newly studied bodily injury liability coverage, the claim frequency decreased a significant 33%. If ABS were effective, one would expect claim severity to also decrease with ABS, but the results for collision, medical payment, and bodily injury liability claim severities were all not statistically significant.

30 In July 2010, the NHTSA released a report titled Motorcycle Antilock Braking Systems and Crash Risk, written by the Mathematical Analysis Division of the National Center for Statistics and Analysis. The report discussed the IIHS study and stated that confounding factors need to be considered when interpreting the results of the study. The report observed that riders who selected motorcycles with ABS may ride their motorcycles differently and for different numbers of miles than those who did not. Since there was no data to determine the significance of these confounding factors, the NHTSA addressed the question of motorcycle ABS effectiveness with an approach less subject to selection bias and not dependent on registrations as a valid measure of exposure to crash risk. The NHTSA approach, based on case-control comparisons, was previously used by the NHTSA to show passenger vehicle ABS was not effective in reducing fatal passenger vehicle crashes but was 6-8% effective in reducing nonfatal passenger vehicle crashes. The approach was also used to show passenger vehicle Electronic Stability Control (ESC), which is not possible on 2-wheeled motorcycles, was highly effective in passenger vehicles.

A In the case-control analysis of motorcycle ABS, “case” crashes are those that might be prevented or otherwise affected by ABS. “Control” crashes are those that are unlikely to be affected by ABS. The control crashes are a measure of crash exposure and the ratio of case crashes to control crashes is a measure of relative crash risk.

B The analysis identified fatal motorcycle crashes from 2001-2008 FARS and available 2001 and later police-reported state crash data corresponding to the same 13 models the IIHS study used for which ABS application can be definitively determined from the VIN.

C Two control groups were defined. The “strict” control group included stationary motorcycles and those moving less than 10 mph. The “relaxed” control group added multi-vehicle crashes in which the motorcyclist was not a fault and another driver in the crash was at fault.

D Under the hypothesis that ABS prevents crashes, the case to control ratio for the ABS motorcycles should be lower than the ratio for non-ABS motorcycles. For both control groups and for both the FARS and state data, difference in the ratios was not statistically significant. This led to the NHTSA’s conclusion, “Using this methodology, we did not find statistically-significant results to suggest that ABS affects motorcycle crash risk.”

31 In April 2012, the HLDI updated their study by adding 2009-2012 model years, which more than doubled the collision exposure from the 2009 study and brought the number of models to 32 (only 22 models had at least one claim, so only 22 models were analyzed). The results were similar. Collision claim frequencies decreased 23% (vs 22% in the 2009 study and 19% in the 2008 study) for ABS motorcycles. Medical payment claim frequency decreased 34% (vs 30% in the 2009 study) for ABS motorcycles. Bodily injury liability
claim frequency decreased 31% (vs 33% in the 2009 study). As far as claim severity, the results for collision claim severity and bodily injury liability claim severity were not statistically significant (as was found in the 2009 study). The medical payment claim severity increased 35% (vs statistically insignificant in 2009 study) for ABS motorcycles. The HLDI explained this increase in medical payment claim severity in ABS motorcycles by noting that low-severity claims were more highly reduced by ABS than high-severity claims.

32 In April 2013, the HLDI again updated their study, analyzing 25 models. The results were similar. Collision claim frequencies decreased 20% (vs 23% in 2012, 22% in 2009, and 19% in 2008) for ABS motorcycles. Medical payment claim frequency decreased 28% (vs 34% in 2012 and 30% in 2009) for ABS motorcycles. Bodily injury liability claim frequency decreased 22% (vs 31% in 2012 and 33% in 2009). As far as claim severity, the results for collision claim severity and bodily injury liability claim severity were not statistically significant (as was found in the 2112 and 2009 studies). The medical payment claim severity increased 22% (vs an increase of 35% in 2012 and statistical insignificance in the 2009 study) for ABS motorcycles. The study also found that ABS in combination with Combined Control Braking Systems (CCBS) had a higher decrease in collision claim frequency than ABS alone (31 % vs 20%).

33 In May 2013, the IIHS updated their 2011 study by adding collision years 2009-2011. The results were similar. The rate of fatal crash involvements per 10,000 registered vehicle years was 3.8 (vs 4.1 in 2011) for ABS motorcycles and 5.2 (vs 6.4 in 2011) for non-ABS motorcycles, corresponding to a statistically significant 31 (vs 37 in 2011) percent reduction in the rate of fatal crash involvements per 10,000 registered vehicle years for the ABS models versus the non-ABS models.

A The IIHS again noted that motorcyclists who chose ABS may be more safety conscious than those who decline, thus leading to lower fatal crash rates due to safer riding practices.

B The IIHS again looked for selection bias in known risk factors. While non-ABS crashes involved more speeding (25% vs 17%) and more intoxication (17% vs 13%), and more helmet use (76% vs 75%), the differences were not statistically significant (helmet use was very similar this time with 76% of non-ABS and 75% of ABS crashes having helmet use).

C As before, the level of these factors for riders not involved in fatal crashes was unknown, so it was not possible to accurately quantify how such factors influenced the observed reduction in fatal crash rate for ABS motorcycles.

D The number of miles driven differing between the two groups remained as a possible explanation for the reduction in fatalities. The IIHS commented on the 2010 NHTSA analysis, saying that it relied on defining a sample of crash types unrelated to ABS and that police crash report data lack sufficient data to do this. The IIHS concluded that the NHTSA study thus does not refute other research.
In 2013, Rizzi et. al\(^{28}\) used an induced exposure method to analyze motorcycle effectiveness utilizing police-reported crash data from Spain (2006-2009), Italy (2009), and Sweden (2003-2012) of a wide range of motorcycle types including scooters. ABS effectiveness on injury crashes was 24% in Italy, 29% in Spain, and 34% in Sweden, with corresponding minimum effectiveness of 12%, 20%, and 16%, respectively in those same jurisdictions. ABS effectiveness for severe and fatal crashes was 34% in Spain and 43% in Sweden, with corresponding minimum effectiveness of 23% and 24%, respectively.

In September 2014, the HLDI published a study\(^{29}\) in which they addressed the criticism of self-selection. The study utilized automotive (not motorcycle) claim frequency as an indicator of a rider’s crash risk on a motorcycle (it is not noted why motorcycle claim frequency was not used). The auto claims were mapped to the motorcycle claims utilizing demographic data. The study then showed that high auto claim frequency was associated with high motorcycle claim frequency.

A The same 25 models from the 2013 study were analyzed. Before controlling for a rider’s auto claim frequency, motorcycles with optional ABS were associated with a statistically significant 20% reduction in motorcycle collision claim frequency. After controlling for auto claim frequency, the reduction increased to 21%. Controlling for auto claim frequency did not substantively inform the observed ABS effect. The study was then confirmed by adding in motorcycles for which ABS was not available and motorcycles for which ABS was standard.

B The HLDI noted the following limitations of the study. Auto and motorcycle claims were matched using the demographic data of birth date, zip code, gender, and marital status and may have produced erroneous matches. Riders with no auto policy and riders with motorcycle and auto policies through different insurance companies were excluded.

C The effects of ABS and auto claim frequency on motorcycle collision severity were once again not statistically significant for these studies.

In November 2014, Fowler et. al (Exponent)\(^{30}\) utilized a case-control approach (similar to the NHTSA’s research method) to study the effectiveness of ABS in motorcycles. The results indicated that ABS is effective in reducing the risk of both fatal and police-reported motorcycle crashes in the U.S. and Florida, respectively. Crashes with the greatest risk reductions included those where the motorcycle was traveling straight pre-impact and there was a multi-vehicle intersection collision, the front or top of the motorcycle struck the side or rear of another vehicle, or the first harmful event was an overturn. The study observed, “Given the potential importance of motorcycle class on ABS effectiveness and the fact that only one touring model was included the use of the reported results for a national prediction of lives saved or crashes prevented is not possible.” That is, ABS effectiveness at the type level as of the time that study was performed was indeterminate; based upon that analysis, we cannot definitively predict ABS effectiveness as applied to touring type motorcycles such as is the subject motorcycle.
In February 2012, Ezana Wondimneh of the NHTSA presented “Motorcycle Antilock Braking Systems and Crash Risk Estimated from Case-Control Comparisons” to WP.29/GRRF. The Working Party on Braking and Running Gear (GRRF) is the subsidiary body of the World Forum for Harmonization of Vehicle Regulations (WP.29) that prepares regulatory proposals on active safety, braking and running matters to WP.29. This group of experts conducts research and analysis to develop and propose active safety requirements of vehicles. This presentation appears to have been a summary of the NHTSA study described in paragraph 30 supra. NHTSA reported to the WP-29 GRRF:

A “Under the hypothesis that ABS prevents crashes, we would expect a lower ratio of case to control crashes for the ABS group than for the non-ABS group.”

B “A simple comparison using the relaxed definition of the control group shows that the ratio of crashes of interest to control-group crashes was:

1 44 / 10 = 4.40 with ABS

2 243 / 59 = 4.12 without ABS.”

C “The calculated ratio of case to control crashes for ABS motorcycles was slightly higher than the rate for non-ABS motorcycles – However, this result was found not statistically significant.”

D The NHTSA concluded:

1 “Without ABS, and using two sets of data (fatal crashes and, separately, all police-reported crashes), we did not find statistically-significant results to suggest that ABS affects motorcycle crash risk.”

2 “Conclusions from these comparisons would depend on three assumptions”

a “That crashes involving non-culpable motorcycles are an adequate control group”

b “That the ABS itself was the only difference, notwithstanding possible biases associated with the owner's decision to purchase optional ABS affecting how the vehicle is used.”

c “That the experience on the motorcycles that were available with optional ABS was typical of the experience expected on a wider range of models.”

3 “Finally, the null results should be treated with caution because of the small numbers of control-group motorcycle crashes available for many of the comparisons.”

The Plaintiffs’ produced eight documents regarding ABS effectiveness. Several of the documents were duplicates of the IIHS and HLDI materials reviewed and summarized above. The new documents that were not previously reviewed do not materially affect the state of
understanding regarding ABS effectiveness in motorcycles or change the opinions expressed herein.

39 Studies of ABS effectiveness as a crash avoidance technology on touring type motorcycles are equivocal and not as yet settled. However, if we had a scientific basis for determining the effectiveness of ABS in crash avoidance, we cannot then conclude that the application of the technology would have necessarily prevented any specific accident or injury. Safety technologies are not 100% effective and some crashes and injuries persist with the application of safety technology. Plaintiffs’ expert Mr. Timothy C. Lovett only reviewed materials from IIHS and HLDI regarding motorcycle ABS. When asked if he has read any study that questions the validity of the studies done by the IIHS and the HLDI, Mr. Lovett states, “I have not. Are there?”

40 Many groups, organizations, institutions, and individual parties have a shared interest in motor vehicle safety. Safe transport is an essential element for personal mobility and trade in goods and services. Motor vehicle collisions and the associated injuries extract a human and economic toll; it is in society’s interest to minimize that toll and reduce those costs by improving roadway safety. Some parties with this shared interest in motor vehicle safety improvement are: roadway users, vehicle manufacturers, safety researchers and practitioners, governmental institutions (legislative, administrative, judicial, law enforcement, transport and health officials), first responders, the medical community, roadway designers and builders, and taxpayers.

41 In the United States, some elements of roadway safety are directed by the U.S. Congress through the Motor Vehicle Safety Act of 1966 as amended and now codified as 49 USC Chapter 301.

A The United States Code for Motor Vehicle Safety (Title 49, Chapter 301) defines motor vehicle safety as “the performance of a motor vehicle or motor vehicle equipment in a way that protects the public against unreasonable risk of accidents occurring because of the design, construction, or performance of a motor vehicle, and against unreasonable risk of death or injury in an accident, and includes nonoperational safety of a motor vehicle.”

B The Safety Act authorizes the NHTSA to issue vehicle safety standards and to require manufacturers to recall vehicles that have safety-related defects or that do not meet Federal Safety Standards.

42 NHTSA has not promulgated rulemaking that required ABS applied to motorcycles.
Antilock Brake Systems (ABS) Applications to the U.S. Motorcycle Fleet

I have researched the way motorcycle manufacturers developed and applied ABS technology to motorcycles in the U.S. and how consumers responded to the introduction of ABS. Data was collected from the IIHS/HLDI database that tabulated ABS availability by make, model, and model year for model years 2002-2014. The collected data was updated based on the 2012 Harley-Davidson sales brochure. Based on photographs of each model, the models were classified into one of 7 categories:

A On-road

B Adventure: mix between on-road and off-road

C Dual-sport: Off-road motorcycle with legal requirements for on-road operation added

D Off-road

E Scooter

F 3-wheeled

G Sidecar

Considering only on-road, adventure, and dual-sport models, the percent of models with ABS as not available, optional, or as standard equipment was plotted for model years 2002-2014 (Figure 2). Gray indicates ABS was not available on the specific model, yellow indicates ABS was available as optional equipment on the model, and green indicates ABS was provided as standard equipment on the model. One can observe:

A The percent of motorcycle models with ABS as optional or standard equipment has increased monotonically for the U.S. new motorcycle fleet.

B Up to and including the subject model year of 2012, the majority of new motorcycle models have not offered ABS as optional equipment nor provided ABS as standard equipment.

C Up to and including model year 2013, of those new motorcycle models that had ABS available, a greater proportion of the fleet offered ABS as optional equipment as compared to those models that provided ABS as standard equipment. 2014 is the first model year in which more models were offered with ABS as standard equipment as compared to those models that offered ABS as optional equipment.

D In the 2012 model year, 54.6% of models did not offer ABS, 26.4% of models offered it as optional, and 19.0% offered it as standard; in 2012, ABS was an emerging technology not widely applied or accepted by consumers.
Figure 2. ABS availability by model year.

Figure 3 to Figure 15 present the data in tabular form by model year. Each manufacturer is listed at the bottom of the table and each model made by the manufacturer is listed above. No fill color indicates ABS was not available, yellow indicates ABS was optional, and green indicates ABS was standard. The following observations are made:

A  For each model year from 2008, the first year Harley-Davidson introduced ABS on consumer motorcycles, to 2014, Harley-Davidson has marketed more motorcycle models with ABS offered as optional equipment or provided as standard equipment than any other motorcycle manufacturer.

1   Figure 16 shows that in the subject 2012 model year, Harley-Davidson had more motorcycles with optional or standard ABS than any other motorcycle manufacturer. In 2012, Harley-Davidson offered 26 such models, BMW offered 13 and Honda offered 11. Ten manufacturers offered ABS on 2 or fewer models.

B  In model year 2012, only one motorcycle manufacturer, BMW, offered ABS as standard on all of its models.
C By 2014, Harley-Davidson offered ABS as optional or standard on all of its models. The only other manufacturers to do this were BMW, Indian, and MV Agusta. Plaintiffs’ expert Mr. Timothy C. Lovett acknowledged that Harley-Davidson has adopted ABS as standard faster than most motorcycle manufacturers.33, f00.22-25

D The subject 2012 Harley-Davidson Electra Glide Classic offered ABS as optional.

E The entire Touring Family of Harley-Davidson motorcycles offered ABS as standard or optional equipment in model year 2012. Any Harley-Davidson motorcycle purchaser could have found a touring motorcycle with ABS had they wanted to purchase a bike with that particular feature.

1 Five of the Touring models were available with ABS as optional equipment: Road King, Street Glide, Electra Glide Classic (subject), Road Glide Custom, and Ultra Classic Electra Glide.

2 Six of the Touring models were available with ABS as standard equipment: Road King Classic, Road Glide Ultra, Electra Glide Ultra Limited, CVO Street Glide, CVO Road Glide Custom, CVO Ultra Classic Electra Glide.

![ABS Availability Chart](chart.png)

**Figure 3.** 2002 ABS availability by manufacturer.
### Figure 4. 2003 ABS availability by manufacturer.

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>2003 ABS Availability</th>
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<td>American Ironhorse</td>
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<td>Aprilia</td>
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### Figure 5. 2004 ABS availability by manufacturer.

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### Figure 6. 2005 ABS availability by manufacturer.

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Figure 7. 2006 ABS availability by manufacturer.

Figure 8. 2007 ABS availability by manufacturer.
## Figure 9. 2008 ABS availability by manufacturer.

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<th>Model Year 2009 ABS Availability</th>
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<td>Ducati</td>
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<td>Harley-Davidson</td>
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<td>Husqvarna</td>
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<td>Hyosung</td>
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<td>KTM</td>
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<td>Moto Guzzi</td>
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<tr>
<td>MV Agusta</td>
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<tr>
<td>Redneck</td>
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<tr>
<td>Suzuki</td>
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<tr>
<td>Thunder Mountain</td>
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<td>Triumph</td>
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<td>Victory</td>
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<tr>
<td>Yamaha</td>
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</tbody>
</table>

## Figure 10. 2009 ABS availability by manufacturer.

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Model Year 2008 ABS Availability</th>
<th>Model Year 2009 ABS Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Ironhorse</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aprilia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Big Dog</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMW</td>
<td></td>
<td></td>
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<tr>
<td>Brammo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buell</td>
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<tr>
<td>Ducati</td>
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<tr>
<td>Harley-Davidson</td>
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<tr>
<td>Honda</td>
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<tr>
<td>Husqvarna</td>
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<tr>
<td>Hyosung</td>
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<tr>
<td>Indian</td>
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<tr>
<td>Kawasaki</td>
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<td>KTM</td>
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<tr>
<td>Moto Guzzi</td>
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<td>Suzuki</td>
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<tr>
<td>Thunder Mountain</td>
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<td>Triumph</td>
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<td>Victory</td>
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<tr>
<td>Yamaha</td>
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</tbody>
</table>

[Continued on the next page...]
### Figure 11. 2010 ABS availability by manufacturer.

#### Model Year 2010 ABS Availability

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Model Year 2010 ABS Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aprilia</td>
<td></td>
</tr>
<tr>
<td>BMW</td>
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</tr>
<tr>
<td>Buell</td>
<td></td>
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<tr>
<td>Ducati</td>
<td></td>
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<tr>
<td>Harley-Davidson</td>
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<td>Honda</td>
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<td>Husqvarna</td>
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<td>Hyosung</td>
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<td>Indian</td>
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<td>Kawasaki</td>
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<td>KTM</td>
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<td>Moto Guzzi</td>
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<td>MV Agusta</td>
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<td>Suzuki</td>
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<td>Triumph</td>
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<td>Ural</td>
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<tr>
<td>Victory</td>
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</tr>
<tr>
<td>Yamaha</td>
<td></td>
</tr>
<tr>
<td>Zero</td>
<td></td>
</tr>
<tr>
<td>Not Available</td>
<td></td>
</tr>
<tr>
<td>Optional</td>
<td></td>
</tr>
<tr>
<td>Standard</td>
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</tbody>
</table>

### Figure 12. 2011 ABS availability by manufacturer.

#### Model Year 2011 ABS Availability

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Model Year 2011 ABS Availability</th>
</tr>
</thead>
<tbody>
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<td>Aprilia</td>
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<tr>
<td>BMW</td>
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<tr>
<td>Buell</td>
<td></td>
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<tr>
<td>Ducati</td>
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<tr>
<td>Harley-Davidson</td>
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<td>Honda</td>
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<td>Husqvarna</td>
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<td>Hyosung</td>
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<td>Indian</td>
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<td>Kawasaki</td>
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<td>KTM</td>
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<td>Moto Guzzi</td>
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<td>MV Agusta</td>
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<td>Yamaha</td>
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<td>Zero</td>
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<tr>
<td>Not Available</td>
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<tr>
<td>Optional</td>
<td></td>
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<tr>
<td>Standard</td>
<td></td>
</tr>
</tbody>
</table>
**Figure 13. 2012 ABS availability by manufacturer.**

**Figure 14. 2013 ABS availability by manufacturer.**
Figure 15. 2014 ABS availability by manufacturer.

Figure 16. Number of 2012 Motorcycles with ABS as optional or standard by manufacturer.
47 Further, application of ABS technology compromises the ability of some consumers to individually customize their motorcycle. The complexity of an ABS system makes some modifications, such as changing wheels, more complicated.

48 To supplement the model-based analysis in paragraphs 43 through 45 supra, Exponent performed a registration-based analysis of ABS technology application. R.L. Polk/IHS data for motorcycle registrations in calendar years 2002-2015 was acquired and analyzed. The raw registration data for model years 1988 (first appearance of motorcycle ABS) through 2014 was examined to remove the motorcycle categories established by Polk as: “SCOOTER,” “OFF-HWY,” and “ATV,” and body styles “STRAIGHT TRUCK” and “WAGON.” Motorcycle models for which ABS as standard, optional, or not available could not be determined were also excluded. ABS availability during model years 1988-2001 was determined by examining sales brochures, price sheets, and the Kelly Blue Book website. The 1988-2014 models with ABS standard or optional were mapped to Polk registration data, utilizing the National Insurance Crime Bureau VIN decoder books where necessary or where they enabled optional ABS to be assigned as ABS or Non-ABS. Some models with optional ABS could not be definitively categorized by VIN, and for such models, the ABS status is reported as “indeterminate.” The compiled results are shown in Table 2.
Table 2. Registration counts and percentages of motorcycles with ABS, without ABS and “indeterminate” ABS status for registration years 2002-2015 and model years 1988-2014.

<table>
<thead>
<tr>
<th>Registration Year</th>
<th>ABS</th>
<th>Indeterminate</th>
<th>Non-ABS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>40,720 (1.3%)</td>
<td>37,594 (1.2%)</td>
<td>2,942,945 (97.4%)</td>
</tr>
<tr>
<td>2003</td>
<td>45,474 (1.3%)</td>
<td>47,722 (1.4%)</td>
<td>3,432,444 (97.4%)</td>
</tr>
<tr>
<td>2004</td>
<td>50,835 (1.3%)</td>
<td>61,378 (1.5%)</td>
<td>3,936,221 (97.2%)</td>
</tr>
<tr>
<td>2005</td>
<td>56,105 (1.2%)</td>
<td>73,322 (1.6%)</td>
<td>4,478,376 (97.2%)</td>
</tr>
<tr>
<td>2006</td>
<td>62,027 (1.2%)</td>
<td>84,401 (1.6%)</td>
<td>5,050,057 (97.2%)</td>
</tr>
<tr>
<td>2007</td>
<td>70,972 (1.2%)</td>
<td>91,258 (1.6%)</td>
<td>5,626,261 (97.2%)</td>
</tr>
<tr>
<td>2008</td>
<td>83,264 (1.3%)</td>
<td>121,448 (1.9%)</td>
<td>6,117,371 (96.8%)</td>
</tr>
<tr>
<td>2009</td>
<td>96,394 (1.4%)</td>
<td>212,287 (3.1%)</td>
<td>6,497,631 (95.5%)</td>
</tr>
<tr>
<td>2010</td>
<td>106,405 (1.5%)</td>
<td>287,287 (4.1%)</td>
<td>6,566,692 (94.3%)</td>
</tr>
<tr>
<td>2011</td>
<td>126,955 (1.8%)</td>
<td>349,452 (5.0%)</td>
<td>6,518,040 (93.2%)</td>
</tr>
<tr>
<td>2012</td>
<td>163,655 (2.3%)</td>
<td>426,826 (6.1%)</td>
<td>6,413,225 (91.6%)</td>
</tr>
<tr>
<td>2013</td>
<td>212,488 (3.0%)</td>
<td>529,980 (7.5%)</td>
<td>6,268,641 (89.5%)</td>
</tr>
<tr>
<td>2014</td>
<td>283,520 (4.0%)</td>
<td>645,307 (9.1%)</td>
<td>6,197,923 (87.0%)</td>
</tr>
<tr>
<td>2015</td>
<td>402,468 (5.6%)</td>
<td>708,383 (9.8%)</td>
<td>6,095,043 (84.6%)</td>
</tr>
</tbody>
</table>

Figure 17 shows the ABS availability for motorcycles in each registration year. Comparison of Figure 17 to Figure 2 shows that when based on motorcycles on the road, the application of ABS into the motorcycle fleet occurred much more slowly than the application of ABS on new models. In registration year 2012, 91.6% of the registered model year 1988-2014 motorcycles did not have ABS; that is about 6.4 million motorcycles on the road in 2012 that did not have ABS. According to the Plaintiffs’ experts’ theory, all of these motorcycles are defective.
Figure 17. ABS insertion by registration year.
Combined Brake System (CBS) Effectiveness

50 Some of the research papers described in paragraphs 24 through 37 supra, considered the effectiveness of Combined Brake Systems (CBS). On a motorcycle without CBS, the right handle bar brake lever applies the front brake and the right foot pedal applies the rear brake. The CBS technology applies both the front and rear brakes when either the right handle bar brake lever is pulled or the right foot pedal is depressed.

51 The 2009 HLDI study21, p. 2 stated, “Due to the small sample of non-CBS motorcycles in the study, the effect of CBS could not be evaluated.” This study involved only motorcycles with optional ABS that could be determined from the VIN. 20 motorcycles met this criterion and only 18 had claims data. Of these 18 models, the sample of non-CBS motorcycles was too small to determine the effect of CBS.

52 The 2010 NHTSA study22, p. 7 performed case-control comparisons separately for non-CBS and CBS motorcycles, addressing the concern that ABS may perform differently depending on whether it is used alone or with CBS. The NHTSA found “there were no statistically-significant differences between non-ABS and ABS motorcycles found for either non-CBS or CBS models, using either control group.”

53 The 2011 Teoh/IIHS study17, p. 173 stated, “However, due to the small sample of non-CBS motorcycles in this study, the effect of CBS could not be evaluated.” As noted in paragraph 51, the small sample of non-CBS motorcycles was only in the sample studied. Most motorcycles in the U.S. fleet did not have CBS.

54 The 2012 HLDI study25, p. 2 made the identical statement as the 2009 HLDI study, “Due to the small sample of non-CBS motorcycles in the study, the effect of CBS could not be evaluated.”

55 Rizzi in 201328, p. 9, referring to CBS and other potential safety systems, stated, “real-life crash data are still too limited for evaluation of these systems.”

56 The April 2013 IIHS study27, p. 11 found, “The combined control brake system (CCBS) along with ABS showed larger reductions in collision claim frequency, severity, and overall losses than ABS by itself. The benefits for CCBS are encouraging but the amount of available data is still small. Additional data will further refine this result.” As with the ABS studies, the effect on claim severity was not significant.

57 The studies above show that there is insufficient data to determine the effectiveness of CBS.
Combined Brake System (CBS) Application to the U.S. Motorcycle Fleet

58 Utilizing the same list of motorcycle models as the ABS availability study, CBS availability for the 2012 model year was determined by reviewing sales brochures, owner’s manuals, and motorcycle websites. The CBS availability is shown in Figure 18. No fill color indicates CBS was not available, yellow indicates CBS was optional, green indicates CBS was standard, and blue indicates that semi-combined brakes were standard. The following observations are made:

A In model year 2012, 20 out of 173 or 11.6% of motorcycle models offered CBS as standard. This includes the semi-combined brakes on the BMWs.

B In model year 2012, 13 out of 173 or 7.5% of motorcycle models offered CBS as optional.

C In model year 2012 140 out of 173 or 80.9% of motorcycle models did not offer CBS.

D In model year 2012, only one motorcycle manufacturer, BMW, offered CBS as standard on all of its models. But on most of the models it was a semi-combined system. While the handle bar lever operated both brakes, the foot pedal only operated the rear brake. In the subject collision, in which Mr. Jones heavily applied only the rear brake according to Plaintiffs’ expert Tim Lovett, BMW’s CBS system would not have taken that input and applied the front brake.

1 If the BMW semi-combined motorcycles are excluded, in model year 2012, 12 out of 173 or 6.9% of motorcycle models offered CBS as standard.

E For the other manufacturers that provided CBS as standard equipment on some models (Honda, Kawasaki, Triumph, Victory, and Yamaha), strong application of the foot pedal will generally only apply about 1/3 of the available front braking.
A 2011 Harley-Davidson survey (ref. Bates 2159-2191, specifically 2183) determined the preferences for CBS (linked) versus independent brake systems reported below in Table 3.

A 53% of panelists preferred independent brake systems

B 22% of panelists preferred combined or linked brake systems.

Table 3. Harley-Davidson survey of linked versus independent brake systems.

Based on these consumer preferences and the lack of public health research showing CBS to be effective, it is reasonable for Harley-Davidson to produce motorcycles with independent brake systems.
Motor Vehicle Injury Control and Safety Technology

61 The National Traffic and Motor Vehicle Safety Act was adopted in 1966. The law established the National Highway Traffic Safety Bureau, now the National Highway Traffic Safety Administration (NHTSA), to address the need for roadway safety. The act required the NHTSA to promulgate motor vehicle rules to protect the public against “unreasonable risk of death or injury” in traffic collisions.

A It is impossible to provide an absolute level of safety with no collisions and no injury due to impact insult in collisions; this fact was recognized and the NHTSA was expressly authorized to promulgate rules that ensure a reasonable level of safety performance in the design of motor vehicle products.

B The NHTSA meets this responsibility through research and promulgation of Federal Motor Vehicle Safety Standards (FMVSS) that are imposed as mandatory performance requirements on qualifying motor vehicles that are offered for sale in the U.S. Under NHTSA’s oversight, manufacturers are required to self-certificate to FMVSS requirements; annually, the NHTSA requests manufacturers’ documentation of manufacturers’ self-certification process and results.

C The NHTSA audits certification results and FMVSS compliance through its own enforcement test programs. Failure or near failure in NHTSA testing, can lead to recall by the manufacturer for non-compliance following resolution of an investigation process by the NHTSA and the affected manufacturer.

D FMVSS by definition are imposed to meet the need for motor vehicle safety and to assure a reasonable level of safety in vehicles that comply with FMVSS requirements.

62 The Safety Act, Title 49 – Transportation, chapter 301 – Motor Vehicle Safety states its purpose and policy is to “reduce traffic accidents and deaths and injuries resulting from traffic accidents. Therefore it is necessary:”

A “to prescribe motor vehicle safety standards for motor vehicles and motor vehicle equipment in interstate commerce; and”

B “to carry out needed safety research and development.”

63 The Safety Act provides the following definitions:

A “‘defect’ includes any defect in performance, construction, a component, or material of a motor vehicle or motor vehicle equipment.”

B “‘motor vehicle safety’ means the performance of a motor vehicle or motor vehicle equipment in a way that protects the public against unreasonable risk of accidents occurring because of the design, construction, or performance of a motor vehicle, and
against unreasonable risk of death or injury in an accident, and includes nonoperational safety of a motor vehicle.”

C “‘motor vehicle safety standard’ means a minimum standard for motor vehicle or motor vehicle equipment performance.”

64 The Safety Act establishes “GENERAL REQUIREMENTS.—The Secretary of Transportation shall prescribe motor vehicle safety standards. Each standard shall be practicable, meet the need for motor vehicle safety, and be stated in objective terms.” Safety technologies and requirements are usually developed through the application of a public health model for motor vehicle collision injury reduction; there are multiple steps to this model.

A Collection and analysis of collision injury data to identify opportunities for potential improvement and prioritize safety needs.

B Injury control opportunities identified in analyses of public health data relate to the “Injury Triangle” in which three elements interact: The vehicle, the (roadway) environment, and the human roadway user. Figure 19 is an illustration of the injury triangle and the public health improvement process that applies to collision related injury control.

![Injury Triangle Diagram]

Figure 19. Injury triangle.
In motor vehicle safety, there are opportunities for intervention in the injury triangle interactions in three distinct periods: prior to the collision, during the collision, and post-collision. These three time periods can be cross referenced to the injury triangle to create a three by three matrix. This nine cell matrix is called the “Haddon Matrix” named after Dr. William Haddon Jr., first Administrator of the NHTSA. The “Haddon Matrix” is shown in Figure 20. Safety researchers can and do, search for collision injury improvement opportunities in each of the nine cells.41

<table>
<thead>
<tr>
<th>Crash</th>
<th>Host (Driver)</th>
<th>Roadway (Environment)</th>
<th>Vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>During</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 20. Haddon Matrix.41

As collision injury data defines particular opportunities for potential improvement (injury reduction opportunities), research efforts can proceed to: invest, invent, and develop possible countermeasures for application.

Research and development identify possible approaches for countermeasure invention, size the potential safety opportunity associated with an emerging countermeasure, assess potential risks and adverse consequences of a new invention, and define operational parameters (test conditions, acceptance criteria, etc.) for evaluation of the emerging countermeasure.

This public health improvement process (collision data based research, opportunity identification, countermeasure development, countermeasure integration into new vehicle VDP, and deployment of the countermeasures into the marketplace) has been in application more than five decades.

We can measure and judge the success of this injury reduction model by review of fatal and severe injury rates over time. Figure 21 illustrates the results of this process, and we can see the motor vehicle collision fatal injury rate registered about an 80% reduction over the period 1966 to 2013.42, Table 2 This trend is mirrored in the decline of injury rate per million vehicle miles traveled of about 54% over the period 1988 to 2013.42, Table 2 This is
a very positive result and illustrates the success of the process: research, innovation, development, and deployment of injury reduction technologies.

**Figure 21.** Motor Vehicle Fatality and Injury Rates per 100 Million Vehicle Miles Traveled, 1966-2013. The data described above and Figure 21 reference all motor vehicle crashes. The NHTSA also tabulated data for motorcycle crashes in the same domains. The motorcycle fatal collision rate has declined from 56.7 fatalities per 100 million miles of travel in 1975 (the first year for data) to 22.9 in 2013, a 60% reduction. For motorcycle collision related injuries, the injury rate has declined from 1,049 in 1988 to 434 collision injuries per 100 million miles of travel in 2013, a 59% reduction. These data are illustrated in Figure 22 below.

**B** The data described above and Figure 21 reference all motor vehicle crashes. The NHTSA also tabulated data for motorcycle crashes in the same domains. The motorcycle fatal collision rate has declined from 56.7 fatalities per 100 million miles of travel in 1975 (the first year for data) to 22.9 in 2013, a 60% reduction. For motorcycle collision related injuries, the injury rate has declined from 1,049 in 1988 to 434 collision injuries per 100 million miles of travel in 2013, a 59% reduction. These data are illustrated in Figure 22 below.

**C** NHTSA has reported that motorcycle collisions have higher rates of fatal and occupant injury as compared to occupants of other vehicles. The NHTSA wrote: “Motorcycles made up 3 percent of all registered vehicles in the United States in 2013 and accounted for
only 0.7 percent of all vehicle miles traveled. Per registered vehicle, the fatality rate for motorcyclists in 2013 was 6 times the fatality rate for passenger car occupants, as shown in Table 2. The injury rate for motorcyclists (1,052) was slightly higher than the injury rate for passenger car occupants (1,005). Per vehicle mile traveled in 2013, motorcyclist fatalities occurred 26 times more frequently than passenger car occupant fatalities in motor vehicle traffic crashes, and motorcyclists were nearly 5 times more likely to be injured as shown in Table 2.  

Figure 7
Motorcyclist Fatality and Injury Rates per 100 Million Vehicle Miles Traveled, 1975-2013

Figure 22. Motorcyclist Fatality and Injury Rates per 100 Million Vehicle Miles Traveled, 1975-2013
66 Safety improvements measured in reductions to fatal and severe injury rates have been realized due in part to improvements in: driver and occupant behaviors, roadway designs, legislative and law enforcement initiatives, public education efforts, post collision treatment, and broad implementation of motor vehicle safety technologies. Most injury reduction technologies have been developed and deployed into the stream of commerce without a regulatory mandate.

67 Motor vehicle collision data can be analyzed to characterize collisions by type and outcome, to analyze collision patterns for improvement opportunities, to measure safety improvements, and to assess the effectiveness of safety technologies. The NHTSA has studied public health records to assess the effectiveness of various safety technologies and FMVSS requirements. No safety technology has proven to be 100% effective in eliminating collisions, collision related injuries or collision related fatalities. The most recent study of safety technologies applied to passenger cars and light trucks was published in January 2015. In this document, NHTSA reported upon the estimated effectiveness of multiple safety technologies for passenger cars and light trucks delivered to the public. Some of the NHTSA’s observations are summarized below:

A Dual Master Cylinder Brake Systems provide separate hydraulic connections to at least two braking wheels such that a hydraulic leak will not disable the entire braking capacity of a vehicle service brake. Mandated by FMVSS 105/135, Dual Master Cylinders are measured to be 0.7% effective in reducing relevant fatal crashes in passenger cars.

B FMVSS 105/135 stopping distance requirement (associated with front disc brakes) is measured to be 0.17% effective in reducing relevant fatal crashes in passenger cars.

C Four-wheel antilock brake systems (ABS) are measured to be 1% effective in reducing relevant fatal crashes in passenger cars and 6% effective in reducing police-reported collisions. Four-wheel ABS is beneficial in preventing collisions of cars and LTVs, but has little effect on fatal injuries in crashes.

D Center high-mounted stop lamps (CHMSL) are measured to be 4% effective in reducing relevant crashes and non-fatal injuries in passenger cars.
E Retro reflective tape on heavy trailers is measured to be 41% effective in reducing nighttime crashes on unlighted roadways.\textsuperscript{44, pg. 41}

F Electronic stability control (ESC) is measured to be 16% effective in reducing collision related collisions and is 74% effective in fatal first-event rollovers.\textsuperscript{44, pg. 50}

G FMVSS No. 201, occupant protection in interior (instrument panel in front of right front passenger) impact is measured to be 16% effective in reducing front collision related fatal injury to unrestrained right front occupants.\textsuperscript{44, pg. 60}

H FMVSS 201U occupant protection in the upper interior (greenhouse pillar structures, rail supports and roof) head impact is measured to be 32% effective in head injury\textsuperscript{44, pg. 63} and 6% effective in reducing fatal injuries.\textsuperscript{44, pg. 64}

I FMVSS No. 203 (steering column collapse load) and FMVSS No. 204 (steering column rearward displacement in a front crash) are jointly measured to be 12% effective in reducing driver fatalities in front crashes.\textsuperscript{44, pg. 74}

J High Penetration Resistant (HPR) windshields (FMVSS 205) are measured to be 74% effective in reducing face and head lacerations in frontal crashes\textsuperscript{44, pg. 78}

K Two point (lap) safety belts are measured to be 27% effective in reducing fatal collision injuries for front seated occupants.\textsuperscript{44, pg. 97}

L Three point safety belts (lap and shoulder belts) are measured to be 48% effective in reducing fatal crash related injuries for front seat outboard occupants\textsuperscript{44, pg. 107}, 10% effective in passenger car near side impacts and 39% effective in passenger car far side impacts.\textsuperscript{44, pg. 109}

M Three point safety belts (lap and shoulder belts) are measured to be 44% effective in reducing fatal crash related injuries for rear seat outboard occupants.\textsuperscript{44, pg. 112}

N Seat belt pretensioners and load limiters are measured to be 13% effective in reducing fatal crash related injuries for belted occupants.\textsuperscript{44, pg. 112}

O Driver air bags are measured to be 12% effective in reducing fatal injuries to belted drivers.\textsuperscript{44, pg. 125}

P Passenger front air bags are measured to be 14% effective in reducing fatal injuries to belted drivers.\textsuperscript{44, pg. 128}

Q Infant (less than 1 year of age) child seats are measured to be 71% effective in reducing collision fatalities.\textsuperscript{44, pg. 149-150}

R Child restraints for persons 1 to 4 years of age are measured to be 54% effective in reducing collision fatalities.\textsuperscript{44, pg. 150}
Side door beams were first invented and deployed by GM in the 1960s and are measured to be 14% effective in reducing near side collision fatalities and 15% effective in reducing far side fatalities in single vehicle crashes.\textsuperscript{44, pg. 163}

The FMVSS 214 side impact dynamic test is measured to be 17% effective in reducing side collision fatalities: near and far side, single and multi-vehicle collisions.\textsuperscript{44, pg. 170}

Head curtain and torso side impact air bags are measured to be 31% effective in reducing near side collision fatalities, 12% in far side impacts.\textsuperscript{44, pg. 174}

These effectiveness measures are displayed on the bar graph in Figure 23 below.

Figure 23. Safety technology effectiveness.\textsuperscript{44}

No motor vehicle safety technologies have yet been reported to be 100% effective in reducing collisions or collision-related injury. Even with application of motor vehicle safety technologies directed to specific safety needs, injury potential cannot be reduced to zero. That is why motor vehicle safety must be assessed based upon a reasonable basis, not an absolute basis.
A Motor vehicles are designed to provide a reasonable level of safety performance but are not, and cannot be designed to provide an absolute level of protective capacity to all occupants in all collision circumstances regardless of occupant tolerance to injury insult, collision type, or collision severity.

B Some occupants are frail to impact insult, do not take advantage of all available safety equipment (motorcycle riders not wearing helmets or other safety equipment), or are positioned such that a vulnerable body area may be exposed to impact insult.

69 As regarding motorcycle safety, the NHTSA has reported: “Helmets are estimated to be 37 percent effective in preventing fatal injuries to motorcycle operators and 41 percent for motorcycle passengers. The NHTSA estimates that helmets saved the lives of 1,617 motorcyclists in 2011. (Traffic Safety Facts: 2011 Data, NHTSA, DOT HS 811 765) For more information on the campaign by NHTSA and the States to increase helmet use, see www.nhtsa.gov.” This is a higher safety effectiveness than most of the safety technologies the NHTSA analyzed in the 2015 report (see paragraph 67 supra) except for retroreflective tape on heavy trailers, high penetration resistant windshields, and manual restraints (three point belts and child restraints).

70 In application of motor vehicle injury control science, new technologies are phased in over time; installation of injury mitigating technologies are often initiated by individual manufacturers in advance of rule-making. Successful safety technologies then grow in application over time; I studied and reported the results of my research in this area. Emerging technologies are generally introduced on a limited basis to allow:

A Market assessment, consumer acceptance and desire for the technology, considerations regarding ease of use, adaptability to consumer use patterns, transparency or obviousness of the technology.

B Development of the supply base.

C Progression along cost reduction curve.

D Effective integration into future planned vehicle design generations.

E Possible assessments of technology functions and effectiveness.

F Assessments of systems effects and limitations on other vehicle systems (e.g. ABS on motorcycle wheel and tire assemblies available for custom application by individual consumers).

G Identification of potential unanticipated safety penalties in time to mitigate significant adverse consequences.

71 We studied introduction and application of 28 safety technologies introduced into the stream of commerce on light duty passenger vehicles over the period 1998 - 2010. A census of technology presence was tabulated by: technology, model year, manufacturer, make, model,
body style, and technology not available or technology presence as standard or optional equipment. We observed:

A Each new safety technology begins with small model penetration proportions.

B The proportion of new vehicle models offered with an emerging technology grows over time.

C Emerging safety technologies are offered both as optional and standard equipment during the introduction period.

D Emerging safety technologies are not universally applied into the entire new vehicle fleet at a single time.

Motorcycle vehicle development programs (VDP) must contain multiple basic underlying elements that serve as building blocks and define the overall process; these building blocks are:

A Definition of overall vehicle level performance requirements (many imperatives and requirements are competing and may be mutually exclusive at some level);

B Requirements for dynamic response characteristics to driver control inputs and roadway conditions.

C Satisfaction of regulatory and legal requirements.

D Technology contenting.

E Requirements for the design and subjective elements of consumer evaluations in purchase consideration, fit and finish, appearance, cost, flexibility for customization, etc.

Requirements can be both physical and functional (performance) in nature. Examples of a physical requirement might be: overall vehicle weight, overall vehicle external/internal dimensions, seating arrangements, powertrain packaging requirements, etc. Functional requirements are defined as vehicle level performance specifications under defined operating conditions for evaluation and or testing. Such functional requirements are often set by FMVSS or engineers’ own vehicle test procedures and acceptance criteria applied as extra regulatory specifications. Requirements are defined at the vehicle level.

A Motorcycles are built from multiple complex systems: frame structure, powertrain, electrical, etc.

B Vehicle systems interact and influence one another through: physical contact, data transfer, energy transfer, or materials transfer. A design change to one system can influence other systems, subsystems, or components.
C Vehicle level requirements must be deconstructed into technical specifications at a systems, sub-system, and component level. The VDP is used to analyze, assess, validate and certify each specification and requirement.

74 Plaintiffs’ experts’ Dr. John B. Lenox and Mr. Timothy C. Lovett are critical of Defendant Harley-Davidson for not providing the subject vehicle with ABS as standard rather than as an option for elected purchase by the consumer. Both Dr. Lenox and Mr. Lovett characterize the 2012 Harley-Davidson Electra Glide Classic as defective due to lack of ABS or CBS. They assert that ABS technology was available, would have been effective in preventing the loss of control event associated with Plaintiffs’ injuries, and that absence of the available safety technology (ABS) renders the subject vehicle defective.

A By Plaintiffs’ Experts’ theory of defect, 2012 Harley-Davidson Electra Glide Classic models with ABS and/or CBS are not unreasonably dangerous and identical motorcycles without ABS and/or CBS are unreasonably dangerous and defective.

B The fact that engineers have developed and delivered into the stream of commerce a technology solution to safety challenges cannot be taken as evidence of a condition that is unreasonably dangerous or defective simply because a product is not equipped with the safety technology in question, in this case ABS and/or CBS.

C If Plaintiffs’ experts assertions regarding absence of available safety technology (ABS and/or CBS) were true, then all vehicles manufactured subsequent to first application of every new safety technology that were not equipped with that same technology would by definition be unreasonably dangerous and defective.

75 Were the premise proffered by Dr. Lenox and Mr. Lovett valid, every new safety technology that has been applied to the 4 wheeled light duty passenger vehicle fleet (for example: Dual Master Cylinder Brake Systems, Front Disc Brakes, Forward Collision Warning, Adaptive Cruise Control, Lane Departure Warning, Side Blind Zone Alert, Backup Cameras, Automatic Collision Notification, etc.) would have rendered defective every contemporary product that was not built with the technology once it had become available.

A From a public policy perspective, such an outcome would present a perverse dis-incentive to any new safety research oriented to address new safety opportunities. No safety researcher or engineer has ever proposed that the invention and application of safety advances render vehicles without those safety advances as unreasonably dangerous or defective because they suddenly present an unreasonable risk to motor vehicle safety just because of a new invention or development and application of an emerging technology.

B For more than five decades safety engineers, safety researchers, and safety regulators have searched public health records for improvement opportunities, identified opportunities, invented and developed effective solutions and applied those solutions to the new car fleet; over time, fleets convert from not having technology to having technology.
C Absence of a new safety feature on a vehicle, or provision of that feature as optional rather than standard equipment on a vehicle model does not render the model on which the feature is not standard equipment to be unreasonably dangerous or defective.

D Motor vehicle safety has been a continuous progression of incremental improvement due to invention, development, and application of new safety technologies. The adoption of new technologies cannot be applied retrospectively as a standard of technology contenting or performance for subsequent models that had not been engineered to reflect new standards or technologies.

E Emerging safety technologies can improve safety, but do not make the vehicles that do not incorporate them less safe than those same models had been before the invention, development and application of the new technology and/or structure/restraints to other vehicles.

F Therefore the simple absence of a new feature or standard is not an indication of defect in vehicles that do not offer the feature, or that provide the feature on an optional basis.

G Not all motorcycles available for sale in the 2012 U.S. new vehicle fleet had ABS as standard equipment. See Figure 13 supra.

H In 2012, six motorcycle manufacturers did not offer ABS on any model in the U.S. new vehicle fleet (ref. Figure 16), 54.6% of new models did not offer ABS, and 26.4% of new models offered ABS as optional equipment; under Plaintiffs’ Experts’ theory, all of these models (without ABS) are unreasonably dangerous and defective.

I Mr. Lovett’s son owned motorcycles in the 2000s that did not have ABS and Mr. Lovett considers these motorcycles defective. 33, 102:18-106:5

J Mr. Lovett had ridden many motorcycles and only one has had ABS. He considers the rest defective. 33, 110:8-20

K Mr. Lovett has two friends with Harley-Davidson motorcycles without ABS and he has not told his friends they are defective. 33, 114:24-116:18

L In his deposition, Mr. Lovett identified 2010 as the year after which motorcycles without standard ABS become defective. 33, 277:10-14. He does not explain his selection of that year. But in that year about 74% of new motorcycle models did not offer ABS as standard or optional equipment and only about 4% offered ABS as standard.

M Mr. Lovett states that any safety feature that is available should be standard. 33, 279:25-280:2 He then went on to state only safety features that can prevent a crash should be standard. 33, 282:19-25 He then further refined the statement for automobiles by stating the only safety features that need to be standard are seatbelts, airbags, and ABS. 33, 298:8-13 When asked if his Navigator without lane departure warning is defective he stated, “I don’t remember that.” 33, 283:24-284:16
When asked if cars without backup cameras are defective, Mr. Lovett states, “I still have a head that I can pivot” and then answered no. When asked if he can apply brakes on a non-ABS vehicle to avoid a crash he stated yes. When asked if somebody fails to pivot their head and runs over a child and there is no backup camera is it that person’s fault, he stated yes.

In the context of the Safety Act, a safety defect is defined as a problem that exists in a motor vehicle or item of motor vehicle equipment that: poses an unreasonable risk to motor vehicle safety, and exists in a group of vehicles of the same design or manufacture, or items of equipment of the same type and manufacture.

Risk can be assessed as a standalone consideration or as an element to be weighed against the benefit provided by the element that presents the risk.

Often a risk-benefit balancing is done in consideration of safety defect issues. In such a context, if the benefits of a feature outweigh the risks, the risk is acceptable and the product is not defective.

In the U.S., most motor vehicle defect determinations for safety and non-compliance recall actions are initiated by manufacturers; a minority of recall actions is influenced by the NHTSA’s investigations. Motor vehicle manufacturers, the NHTSA, and, of course in the context of product liability disputes, a trier of fact, can make a defect determination.

Whether manufacturer-initiated or NHTSA-influenced, each defect determination and resultant recall action results from a process of identification, investigation, and resolution.

The defect investigation process involves the following steps: recognition that a potential safety problem or non-compliance condition may exist; collection of data related to the issue; analysis of relevant data including risk assessments; implementation of some decision making process; resolution; and notification to the involved parties as appropriate.

It is not enough to simply identify a theoretical technology that one can envision, determine that the technology in question is absent from a vehicle model of interest, and to therefore conclude that due to the absence of the theoretical technology, the subject vehicle model of interest is defective. Were these operational criteria valid, each and every injury could be addressed with some theoretical countermeasure technology; and regardless of potential safety tradeoffs, practicality, efficacy, or potential adverse effects, any vehicle that did not present the theoretical technology would by definition be defective. Such a prospect is unreasonable.

It is not enough to simply identify a specific safety technology that is available in the marketplace, to determine that the specific technology in question is absent from a particular vehicle model of interest, and to therefore conclude that due to the absence of the available technology, the subject vehicle model of interest is defective. Were that operational criteria
the case, each and every model that did not present a safety technology as standard equipment after that specific technology had been introduced into the stream of commerce would have been defective. Such a prospect is unreasonable.

A Were such a prospect the basis for defect determination, each vehicle distributed into the stream of commerce that was not equipped with a new emerging technology would by definition, be defective. Under such a standard, every make/model/model year vehicle that did not have:

1 Dual master cylinder brakes since the early 1960s would have been defective;
2 Daytime Running Lights (DRLs) after about 1994 would have been defective.
3 Center High Mounted Stop Lights (CHMSLs) after about 1968 would have been defective.
4 Night vision after 2000 would have been defective.
5 Forward collision warning after about 2010 would have been and will be defective.
6 Lane departure warning after about 2010 would have been and will be defective.
7 And so on for each safety innovation ever invented, applied in production and proven to have been effective in safety improvement.
8 Most consumers continue to operate vehicles on U.S. roadways even after a new safety feature is introduced into the stream of commerce and do not perceive their risk in doing so as being unreasonable, for they continue to use motor vehicles that are not fitted with the newest of emerging technologies. Absence of a new safety feature on a vehicle, or provision of that feature as optional rather than standard equipment on a vehicle model, does not render the model on which the feature is not standard equipment to be unreasonably dangerous or defective.

80 In considering defect issues, the decision making body would consider: regulations and requirements applicable to the design, benchmarking competitive product design and performance features, customer use data, and injury patterns. It is not enough to simply opine that a vehicle presents some risk to motor vehicle safety; there must be some evidence that a vehicle is deficient in some characteristic(s) that is identifiable and presents an unreasonable risk to motor vehicle safety. Complaints or observation about the lack of safety equipment is not evidence of defect, particularly when that technology is available for the consumer to choose.

81 In considering these elements for the 2012 Harley-Davidson Electra Glide Classic, I find:

A The motorcycle model is not deficient in equipment offering compared to its peers.
B In 2012, there was no compelling evidence that application of ABS and/or CBS to touring type motorcycles would improve overall crash avoidance performance of riders.

C There is no evidence that had ABS and/or CBS been applied to the subject motorcycle that Mr. Jones would have used the technology in an optimum way and avoided the crash.

D There is no evidence the 2012 Harley-Davidson Electra Glide Classic is unreasonably dangerous or defective.

82 When Plaintiff’s expert Tim Lovett was asked if Mr. Jones had “properly applied his brakes front and rear like you’re supposed to do, you agree with me, don’t you, that this crash would not have occurred?” Mr. Lovett answered, “Yes.”
Observations and Opinions

83 The science of motor vehicle safety has advanced substantially through the application of the public health model for collision safety improvement: data driven research, innovation, countermeasure development and deployment, and assessments of countermeasure safety improvements.

84 Motor vehicle safety is not an absolute; there is no way to provide absolute safety with no collisions and no collision-related occupant injuries. Motor vehicle safety must achieve a reasonable level.

85 Science-driven motor vehicle safety improvements generate technologies for application or collision load cases that can be incorporated into the VDP. Collision load cases are developed and selected for application to be comprehensive of a broad range of collision circumstances, not specific to a singular collision event. This facilitates maximization of the safety benefit.

86 Most motor vehicle safety improvements have been instituted absent a regulatory mandate.

87 Motor vehicle systems have complex interactions. Revisions to one system can interact with and affect multiple other systems. A feature of a system cannot be changed without considerations of other effects.

88 In this case the Plaintiffs’ experts have opined that a motorcycle not equipped with ABS is unreasonably dangerous and defective. That logic dictates that:

A Approximately 55% to 81% of new model motorcycles offered for sale in the U.S. in 2012 were defective.

B At least 91.6% of the motorcycles registered in 2012 were defective. This corresponds to 6.4 million motorcycles in use in that year.

89 Plaintiff’s experts have also opined that a motorcycle not equipped with CBS is unreasonably dangerous and defective. That logic dictates that:

A Approximately 81% to 88% of new model motorcycles offered for sale in the U.S. in 2012 were defective.

90 It is not reasonable to conclude that most new motorcycles sold in the U.S. in 2012 were defective.

91 It is not reasonable to conclude that motorcycles that were not equipped with ABS but manufactured for sale in the U.S. subsequent to first introduction of ABS (1988) are defective.
It is not reasonable to conclude that motorcycles that were not equipped with CBS but manufactured for sale in the U.S. subsequent to the first introduction of CBS (1975) are defective.

Harley-Davidson’s implementation of both optional and standard ABS on its motorcycles is reasonable and appropriate.

Harley-Davidson’s implementation of independent braking systems on its motorcycles is reasonable and appropriate.

ABS and CBS effectiveness on touring motorcycles is not well established in science.

Had the subject 2012 Harley-Davidson Electra Glide Classic been purchased new by Mr. Jones equipped with ABS, this crash would not necessarily have been avoided. Collision avoidance in this crash would have been contingent upon the action of Mr. Jones as the motorcycle rider.

There is no affirmative evidence the 2012 Harley-Davidson Electra Glide Classic without ABS and/or CBS is defective.
References


3 Mark Jones and Pamela Jones, Plaintiffs, v Harley-Davidson, Inc. In The United States District Court For The Eastern District of Texas, Civil Case No. 2: 14-CV-000694.

4 Deposition of Mark Jones, April 6-7, 2015.

5 Deposition of Robert Vivano, July 2, 2015.

6 Deposition of Noemi Martinez, July 2, 2015.

7 Deposition of Steve Rosales, Date Unknown.

8 Texas Peace Officer’s Crash Report, Case ID 1300009855, crash date July 6, 2013.


32 See Appendix B – Materials Received, folder “Literature/From Plaintiff.”

33 Deposition of Tim Lovett, June 30, 2015


36 “Registration Analysis” folder.

37 “Pre-2002 ABS Data” folder includes spreadsheet with ABS motorcycles and supporting documentation, in “ABS Availability” folder.


39 “CBS References” folder

40 “CBS Functionality” folder


50 Walker, Mick, “Moto Guzzi Twins Restoration,” 2004