Insurance Institute for Highway Safety
Highway Loss Data Institute

Collision Avoidance Systems and their impact on the Insurance Industry

May 23, 2019

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Senior Vice President

iihs.org

IIHS is an independent, nonprofit scientific and educational organization dedicated to reducing the losses — deaths, injuries and property damage — from crashes on the nation’s roads.

HLDI shares this mission by analyzing insurance data representing human and economic losses from crashes and other events related to vehicle ownership.

Both organizations are wholly supported by auto insurers.

IIHS – HLDI supporting groups

AAA Carolinas
Acceptance Insurance
Alfa Insurance
Allstate Insurance Group
American Agricultural Insurance Company
American Family Mutual Insurance Company
American National
Ameriprise Auto & Home
Amica Mutual Insurance Company
Auto Club Enterprises
Auto Club Group
Auto-Owners Insurance
Bitco Insurance Companies
California Casualty Group
Celina Insurance Group
Censtat Casualty Company
CHUBB
Colorado Farm Bureau Mutual Insurance Company
Commonwealth Casualty Company
Concord Group Insurance Companies
COUNTRY Financial
CSAA Insurance Group
Desjardins Insurance
ECM Insurance Company
Elephant Insurance Company
EMC Insurance Companies
Erie Insurance Group
Esurance
Farm Bureau Financial Services
Farm Bureau Insurance of Michigan
Farm Bureau Mutual Insurance Company of Idaho
Farmers Insurance Group
Farmers Mutual of Nebraska
Florida Farm Bureau Insurance Companies
Frankenmuth Insurance
Gainsco Insurance
GEICO Corporation
The General Insurance
Georgia Farm Bureau Mutual Insurance Company
Goodville Mutual Casualty Company
Grange Insurance
Grinnell Mutual
Hallmark Financial Services
Hanover Insurance Group
The Hartford
Haulers Insurance Company, Inc.
Horace Mann Insurance Companies
Imperial Fire & Casualty Insurance Company
Indiana Farm Bureau Insurance
Indiana Farmers Insurance
Infinity Property & Casualty
Kemper Corporation
Kentucky Farm Bureau Mutual Insurance Companies
La Capitale
Liberty Mutual Insurance Company
Louisiana Farm Bureau Mutual Insurance Company
The Main Street America Group
MAPFRE Insurance Group
Mercury Insurance Group
MetLife Auto & Home
Mississippi Farm Bureau Casualty Insurance Company
MMG Insurance
Munich Reinsurance America, Inc.
Mutual Benefit Group
Mutual of Enumclaw Insurance Company
Nationwide
New Jersey Manufacturers Insurance Group
Nodak Mutual Insurance Company
Norfolk & Dedham Group
North Carolina Farm Bureau Mutual Insurance Company
Northern Neck Insurance Company
Ohio Mutual Insurance Group
Old American Indemnity Company
Oregon Mutual Insurance Company
Pekin Insurance
PEMCO Insurance
Plymouth Rock Assurance
Progressive Insurance
PURE Insurance
Qualitas Insurance Company
Redpoint County Mutual Insurance Company
The Responsive Auto Insurance Company
Rider Insurance
Rockingham Group
RSA Canada
Safe Auto Insurance Company
Safeco Insurance
Samsung Fire & Marine Insurance Company
SECURA Insurance
Selective Insurance Company of America
Sentry Insurance
Shelter Insurance Companies
Sompo America
South Carolina Farm Bureau Mutual Insurance Company
Southern Farm Bureau Casualty Insurance Company
State Farm Insurance Companies
Stillwater Insurance Group
Swiss Reinsurance Company Ltd
Tennessee Farmers Mutual Insurance Company
Texas Farm Bureau Insurance Companies
The Travelers Companies
United Educators
USAA
Utica National Insurance Group
Virginia Farm Bureau Mutual Insurance
West Bend Mutual Insurance Company
Western National Insurance Group
Westfield Insurance

Funding associations

American Property Casualty Insurance Association
National Association of Mutual Insurance Companies

Haddon matrix

Recognizing opportunities to make a difference

	pre-crash	during crash	after crash
people	graduated licensing impaired driving laws automated enforcement	safety belts helmets	medical bracelets general health
vehicles	crash avoidance technology	airbags crashworthiness truck underride guards	automatic collision notification fuel system integrity
environment	roundabouts rumble strips	roadside barriers breakaway poles	emergency medical services long-term rehabilitation

HLDI data providers insure approximately 85% share of PPA

21st Century Insurance
Alfa Alliance Insurance Corporation
Allstate Insurance Group
American Family Mutual Insurance
American National Family of Companies
Amica Mutual Insurance Company
Auto Club Group
Automobile Insurers Bureau of Massachusetts
Chubb & Son
COUNTRY Financial
CSAA Insurance Group
Erie Insurance Group
Esurance
Farm Bureau Financial Services
Farmers Insurance Group of Companies
Florida Farm Bureau Insurance Companies
Foremost
GEICO Corporation
Hanover Insurance Group
The Hartford
Kemper Preferred
Kentucky Farm Bureau Insurance
Liberty Mutual Insurance Company
MetLife Auto and Home
National General
Nationwide
New Jersey Manufacturers Insurance Group
PEMCO Insurance
Plymouth Rock Assurance
Progressive Corporation
Rockingham Group
Safeco Insurance Companies
SECURA Insurance
Sentry Insurance
State Farm Insurance Companies
Tennessee Farmers Mutual Insurance Company
Texas Farm Bureau
The Travelers Companies
USAA

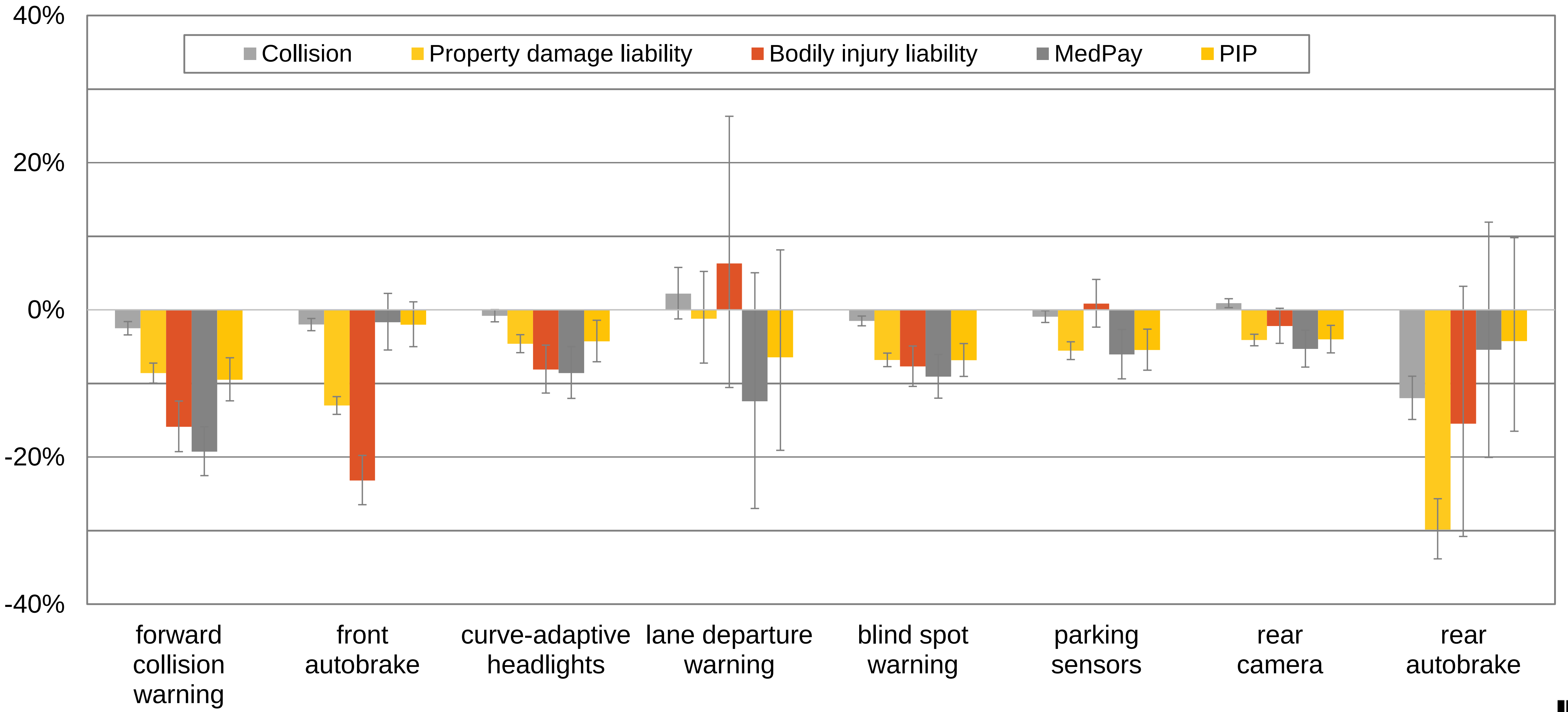
Evaluations of Advanced Driver Assistance Systems (ADAS)

HLDI collision avoidance analysis

- The HLDI database includes data from companies that represent about 85% of private passenger auto insurance in the U.S.
- On a monthly basis, HLDI processes 320 million insurance data transactions
- The insurance data includes the garaging zip code and rated driver demographics
- Manufacturers shared with us 17 digit VINs and information about collision avoidance systems fitted to those vehicles
- Our collision avoidance analysis used the manufacturer supplied feature data along with our geographic and demographic data
- Large amount of timely data
- Limited information on crash circumstances

Effect on claim frequency

Results pooled across automakers



HLDI and police-reported crash data

Insurance data

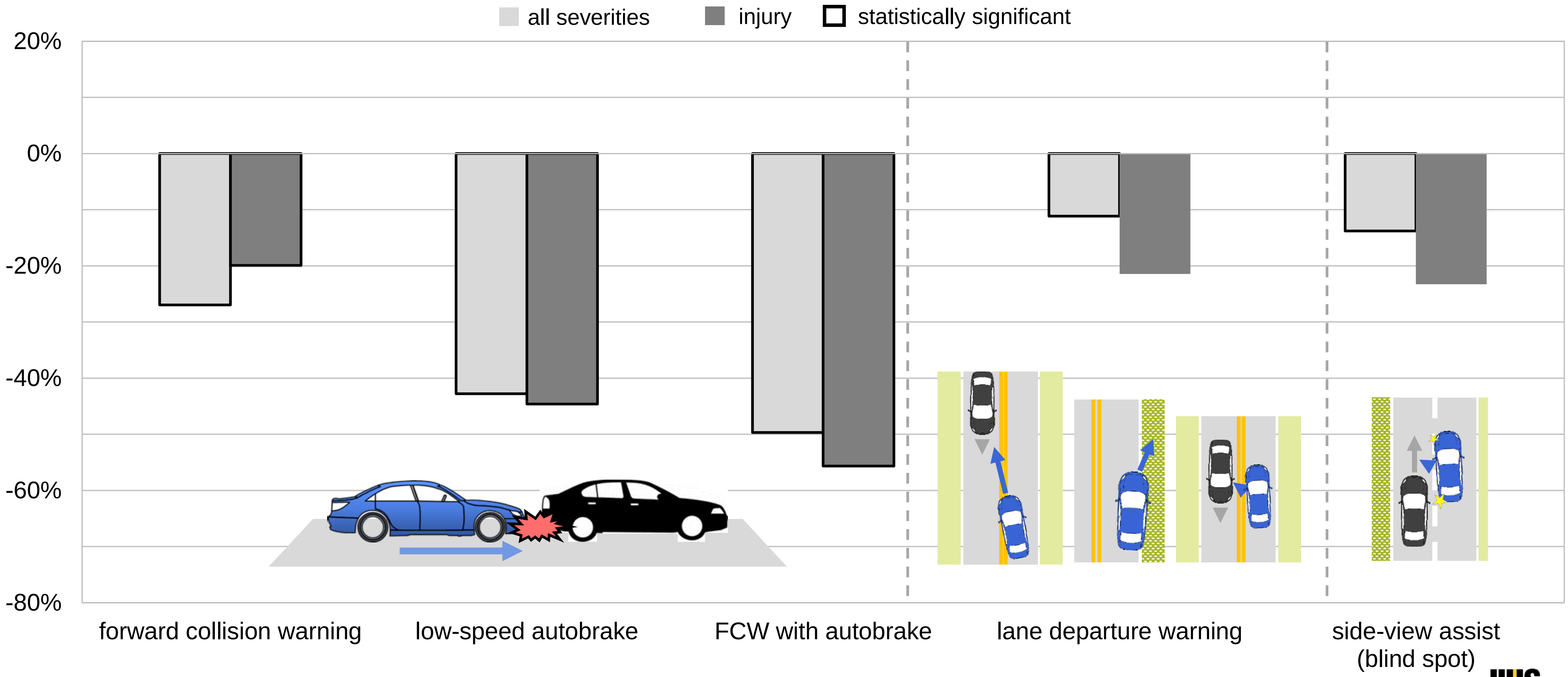
- Large amount of timely data
- Limited information on crash circumstances

Police-reported crash data

- More detailed information on crash type
- Limitations
  - Some crashes not reported to police
  - Delay in obtaining data
  - Data collected not uniform among states, and not all states have information to determine crash types

Most crash avoidance technologies are living up to expectations

Effects on relevant police-reported crash types



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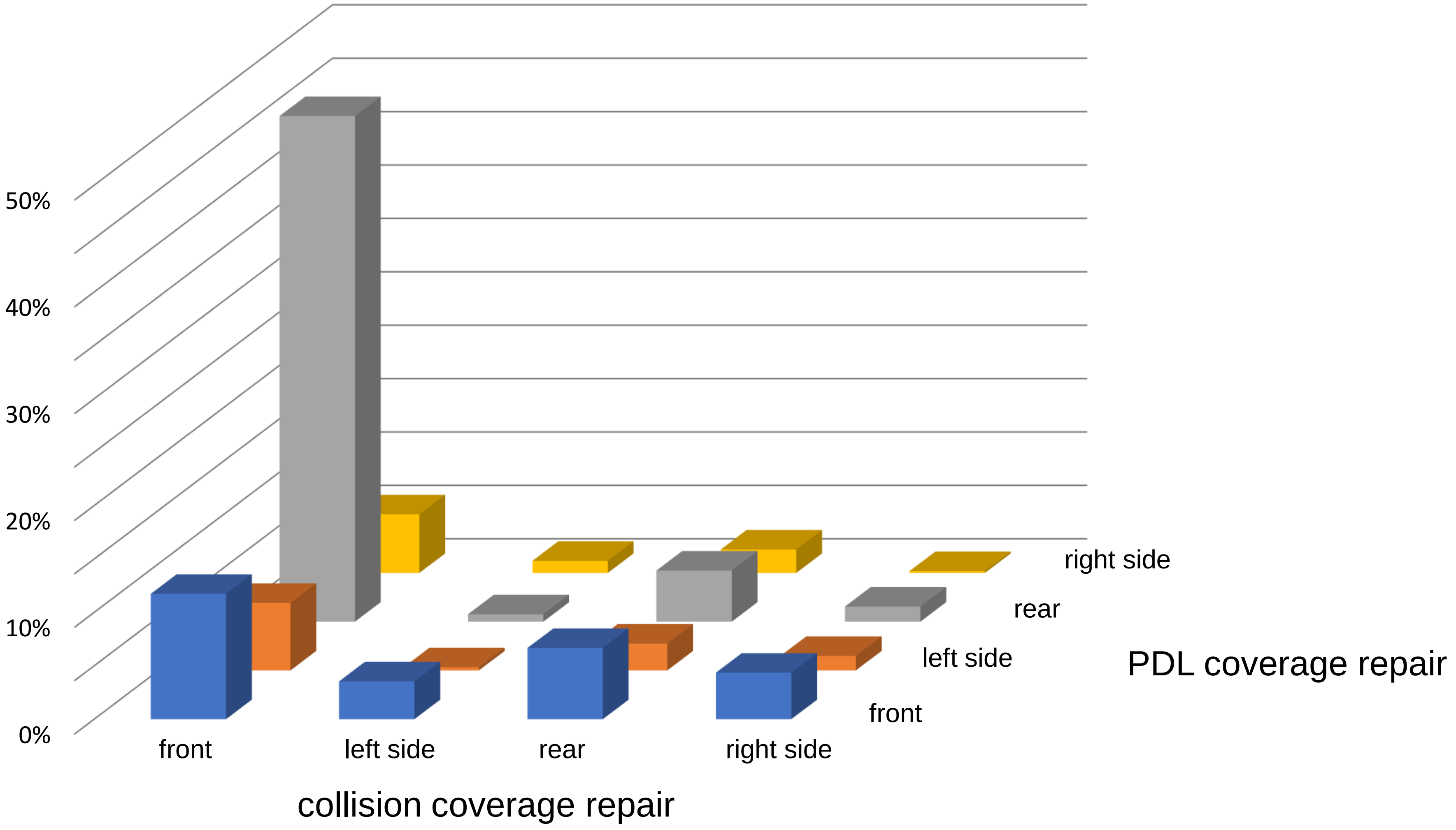
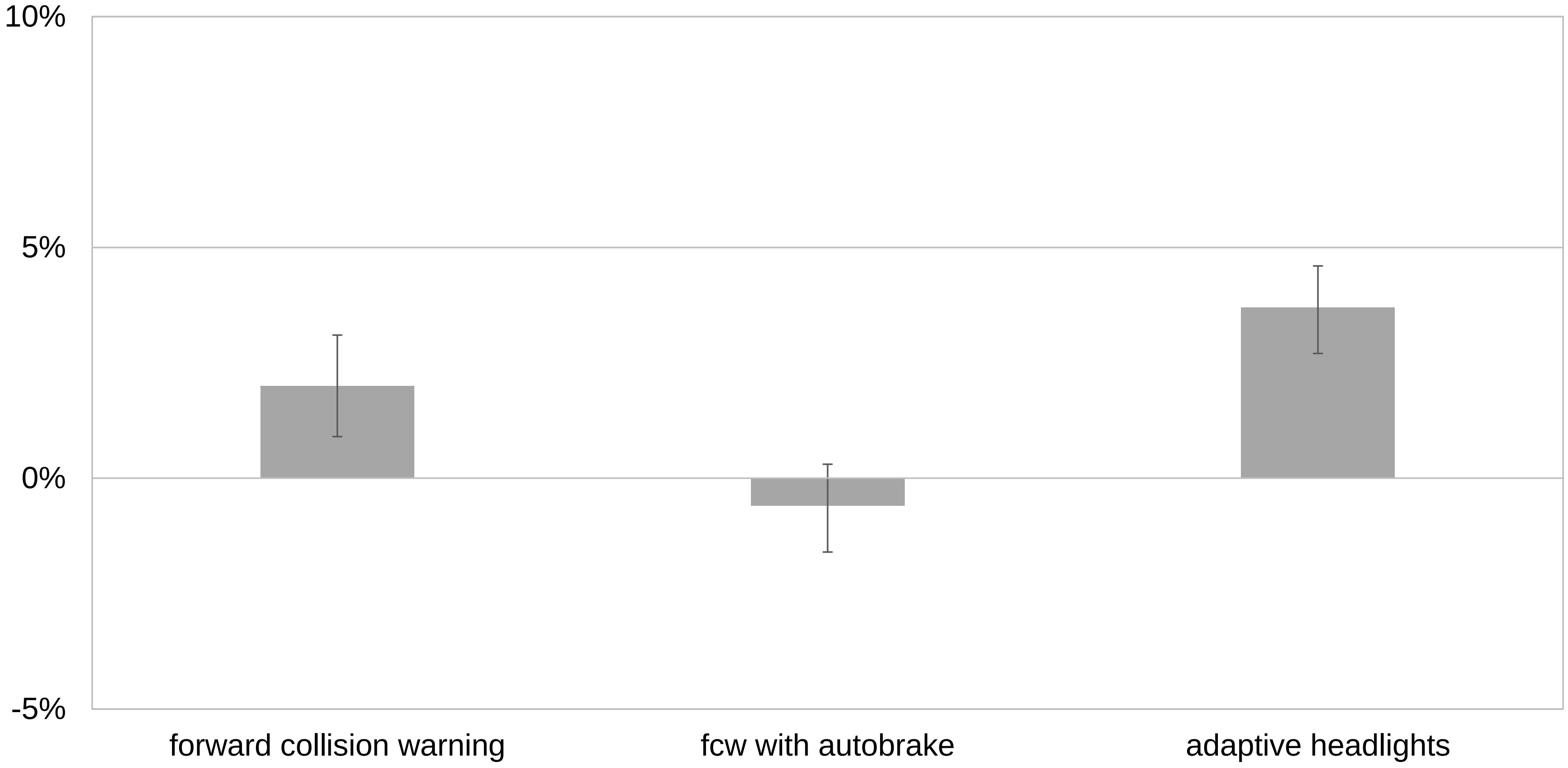
Percent distribution of matched pairs of collision & PDL estimates by point of impact

1981–2018 models, 2017 calendar year



Summary of technology effects on collision claim severity

Results pooled across automakers



GM collision avoidance features

Change in insurance losses for GM vehicles

With parking sensors and rearview camera

	claim frequency			claim severity			overall losses		
collision	-9.3%	-7.1%	-4.8%	$151	$283	$418	-$21	-$7	$9
property damage liability	-19.9%	-16.6%	-13.2%	$7	$139	$277	-$20	-$15	-$9

	claim frequency			low severity frequency			high severity frequency		
bodily injury liability	-23.3%	-14.2%	-4.0%	-28.2%	-11.7%	8.6%	-21.5%	-3.7%	18.2%
medical payment	-21.5%	-12.6%	-2.7%	-31.9%	-7.9%	24.6%	-23.6%	-10.6%	4.7%
personal injury protection	-12.1%	-4.6%	3.5%	-29.4%	-12.3%	9.1%	-16.3%	-6.7%	4.0%

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Change in insurance losses for GM vehicles

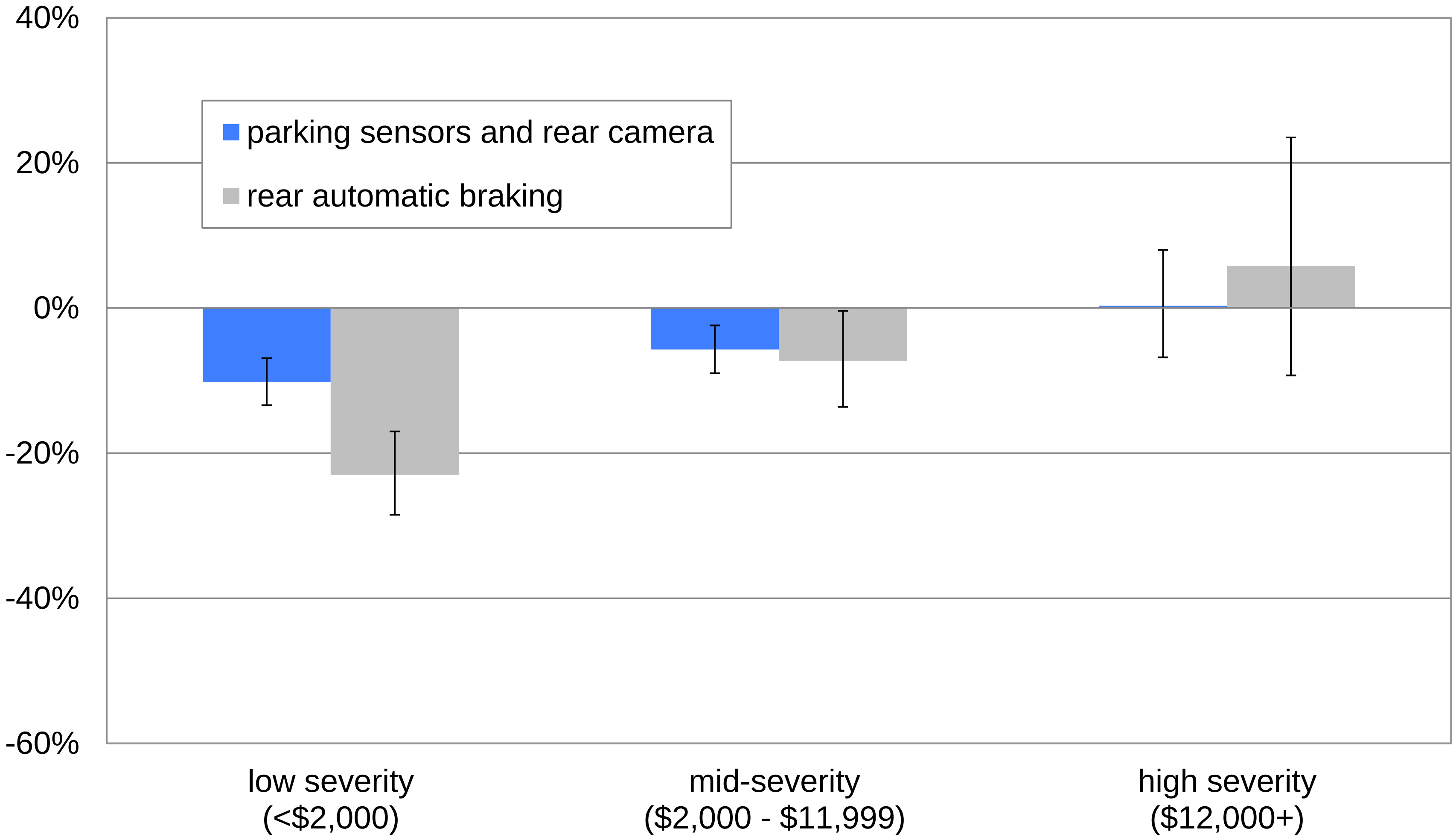
With rear automatic braking

	claim frequency			claim severity			overall losses		
collision	-17.2%	-13.1%	-8.7%	$537	$846	$1,173	-$21	$7	$37
property damage liability	-32.1%	-26.3%	-20.1%	$300	$601	$926	-$22	-$13	-$3

	claim frequency			low severity frequency			high severity frequency		
bodily injury liability	-28.8%	-8.9%	16.5%	-30.5%	8.3%	68.8%	-46.5%	-15.1%	34.8%
medical payment	-22.6%	-1.5%	25.4%	-63.4%	-23.8%	58.3%	-32.4%	-4.5%	34.9%
personal injury protection	-19.9%	-1.8%	20.4%	-46.0%	-7.9%	57.1%	-17.0%	9.6%	44.7%

Change in collision claim frequency

By severity range



Front crash prevention testing and rating

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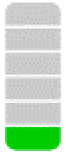
Front crash prevention ratings

NOT AVAILABLE

vehicles without forward collision warning or autobrake; or vehicles equipped with a system that doesn’t meet NHTSA or IIHS criteria

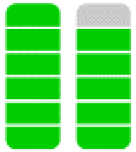


BASIC

vehicles earning 1 point for forward collision warning or 1 point in either 12 or 25 mph test

ADVANCED

vehicles with autobrake that achieve 2-4 points for forward collision warning and/or performance in autobraking tests



SUPERIOR

vehicles with autobrake that achieve 5-6 points for forward collision warning and/or performance in autobraking tests

25 mph

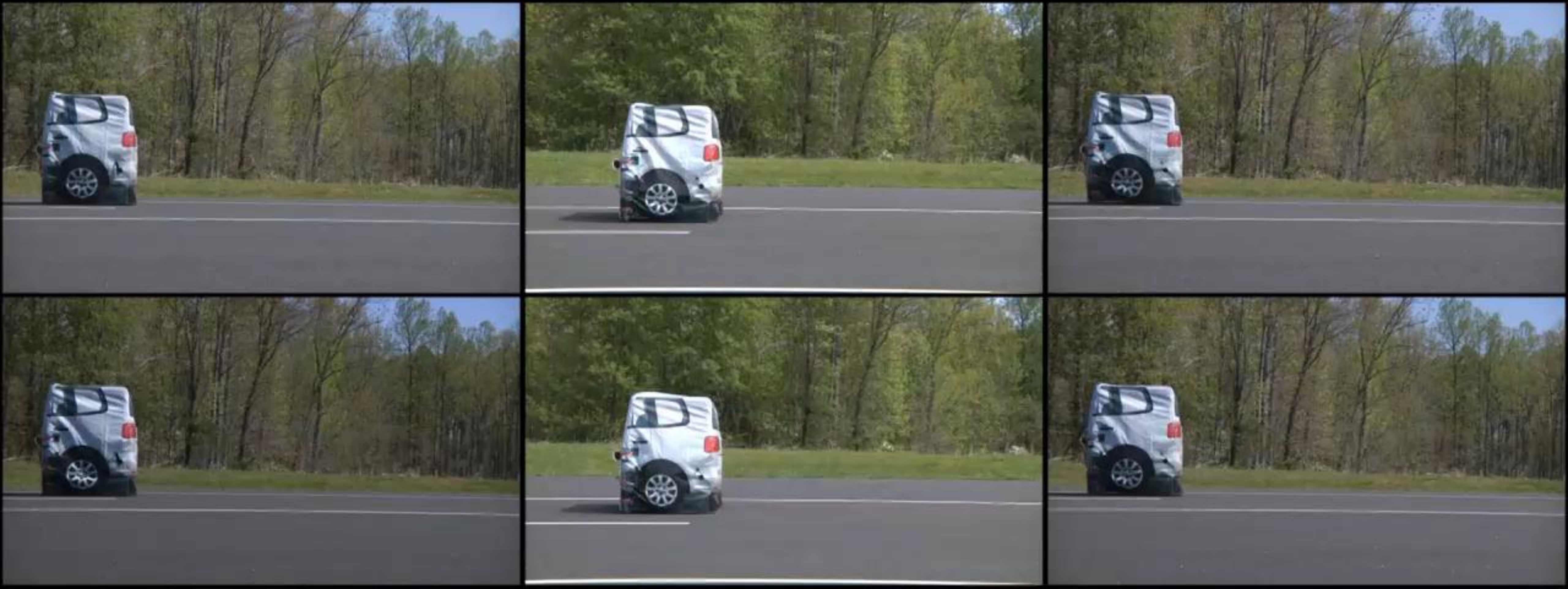
$28,131

12 mph

$5,715

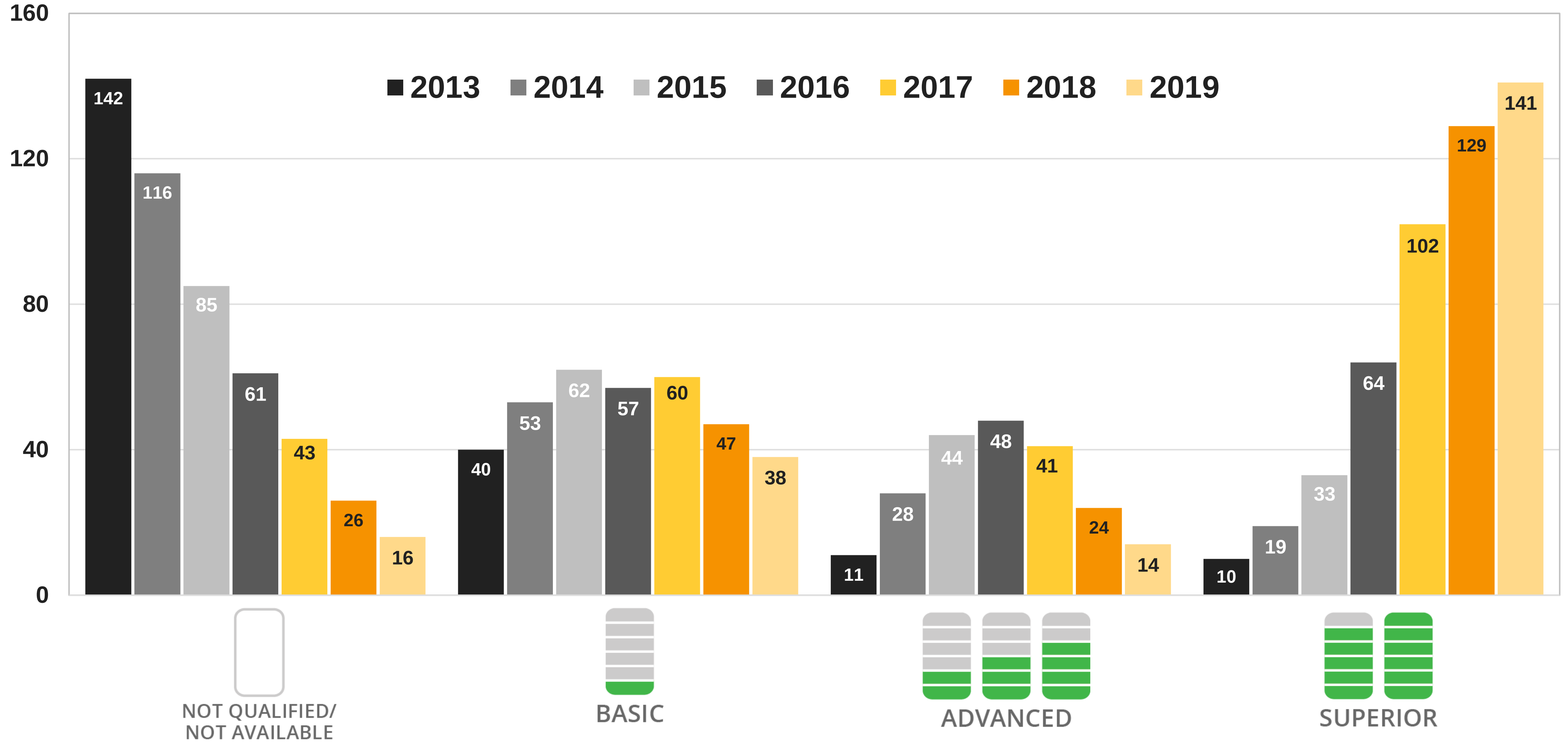
Speed reduction in 12 and 24 mph tests

Volvo S60	Dodge Durango	Subaru Outback
2 point advanced	3 point advanced	6 point superior



Front crash prevention ratings

2013-19 models, as of May 2019



20 automakers have committed to make AEB a standard feature by September 2022

99+% of
U.S. market

Hyundai advertisement

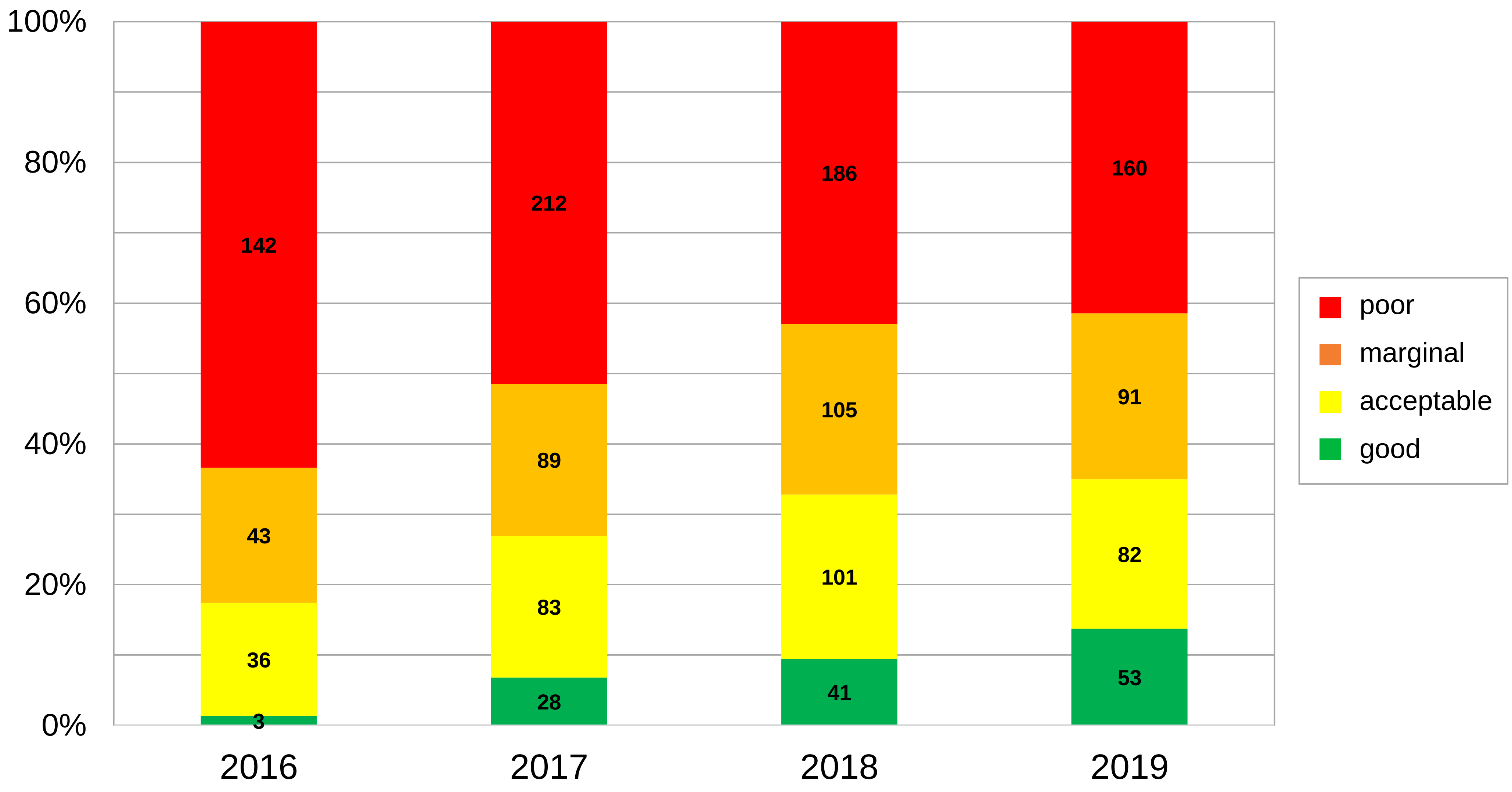
Headlight testing and ratings

Toyota Prius v LED and BMW 3 series halogen

On-road comparison

Headlight ratings (as of May 2019)

2016-19 model years – all headlight variants



Consumer comments on headlight ratings

I wanted to thank IIHS for the headlight ratings report that you released last week.

-EH (Medford, New Jersey)

I own a 2013 Ford Edge. It should have come with a Seeing Eye Dog. For the first time in my life, I am afraid to drive at night.

-AM (Buckingham, Virginia)

Thank you for proving to my friends that I'm not crazy or blind.

-RW (Mentor, Ohio)

Thanks for the great work!

-RV (Tiverton, Rhode Island)

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Evaluations of system status

On-off status of front crash prevention systems

By manufacturer

	percent with system on	number observed
Cadillac	92	206
Chevrolet	87	142
Honda	98	239
Mazda	95	20
Volvo	94	52
total	93	659

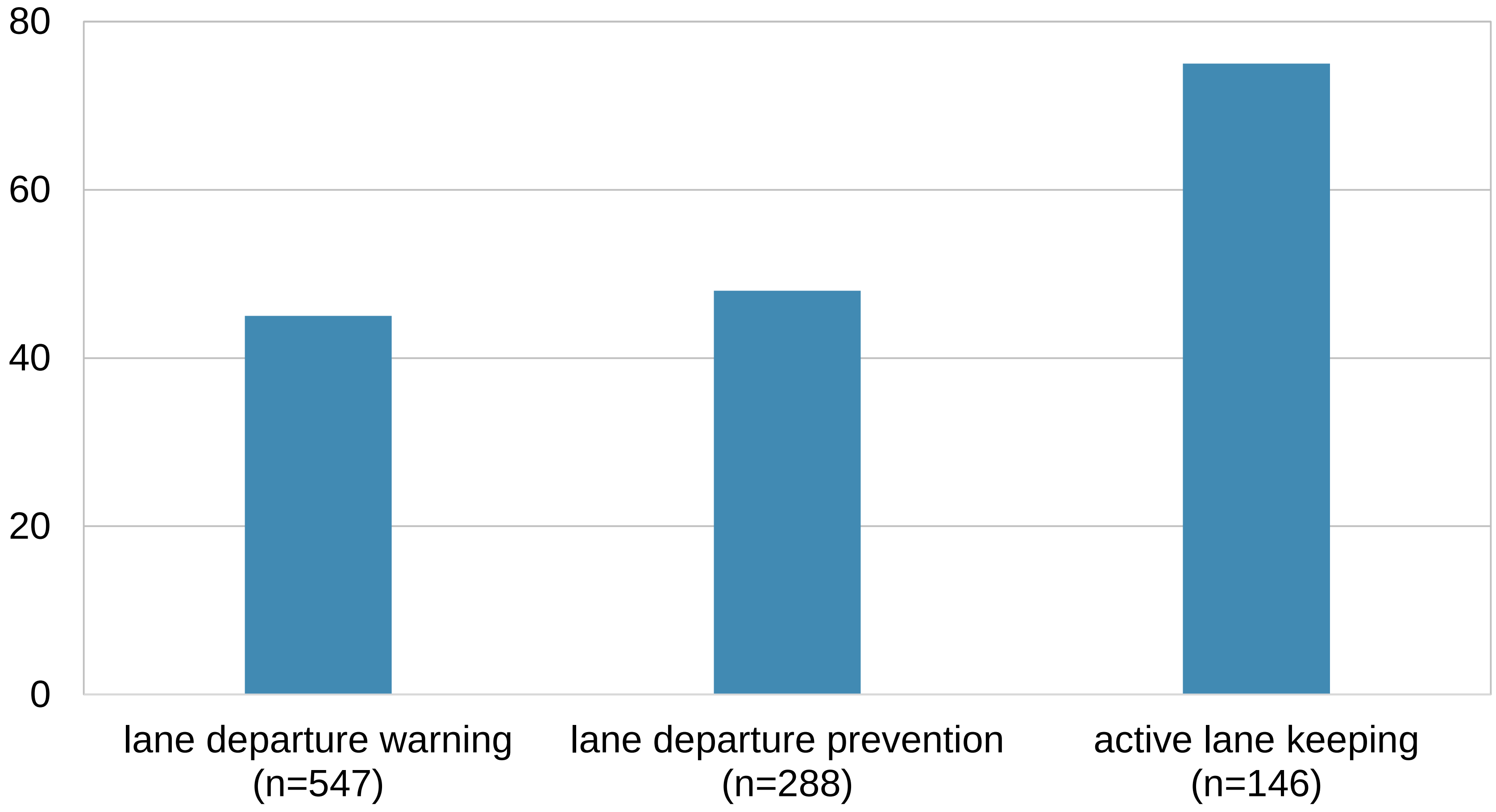
On-off status of lane-maintenance systems

By manufacturer

	percent with system on	number observed
Cadillac	56	204
Chevrolet	50	147
Ford/Lincoln	21	115
Honda	36	239
Lexus/Toyota	68	147
Mazda	77	26
Volvo	75	105
total	51	983

On-off status by maximum observable lane-maintenance intervention level

Percent with system on



GM lane departure warning on-off status by warning modality

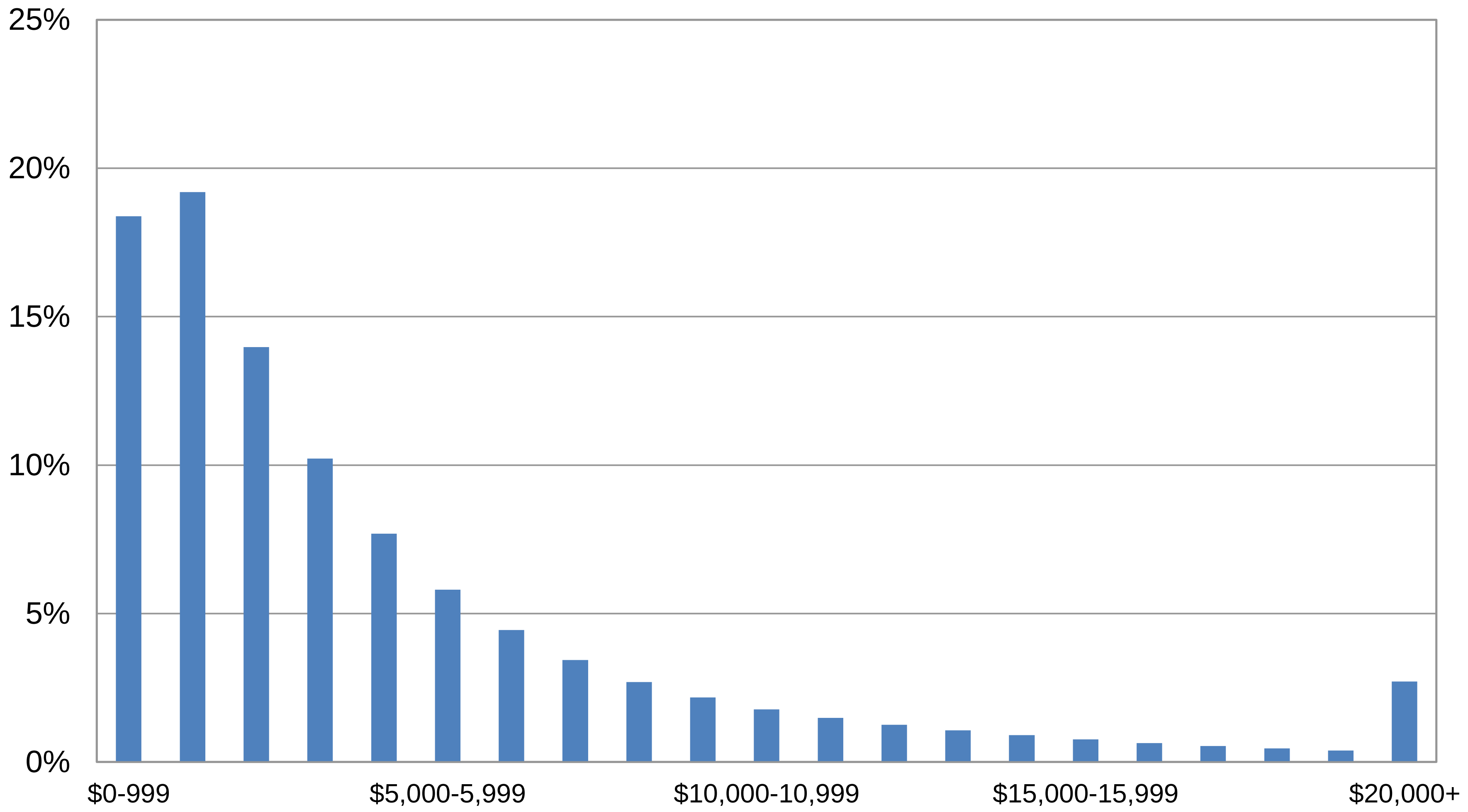
		percent with system on	number observed
beep	Cadillac	33	18
	Chevrolet	39	66
	total	38	84
vibrating seat	Cadillac	58	142
	Chevrolet	49	49
	total	56	191


Advertisement:
Lane valet

Park assist systems

Distribution of collision claims, 2017 calendar year

By claim size, 1981–2018 models



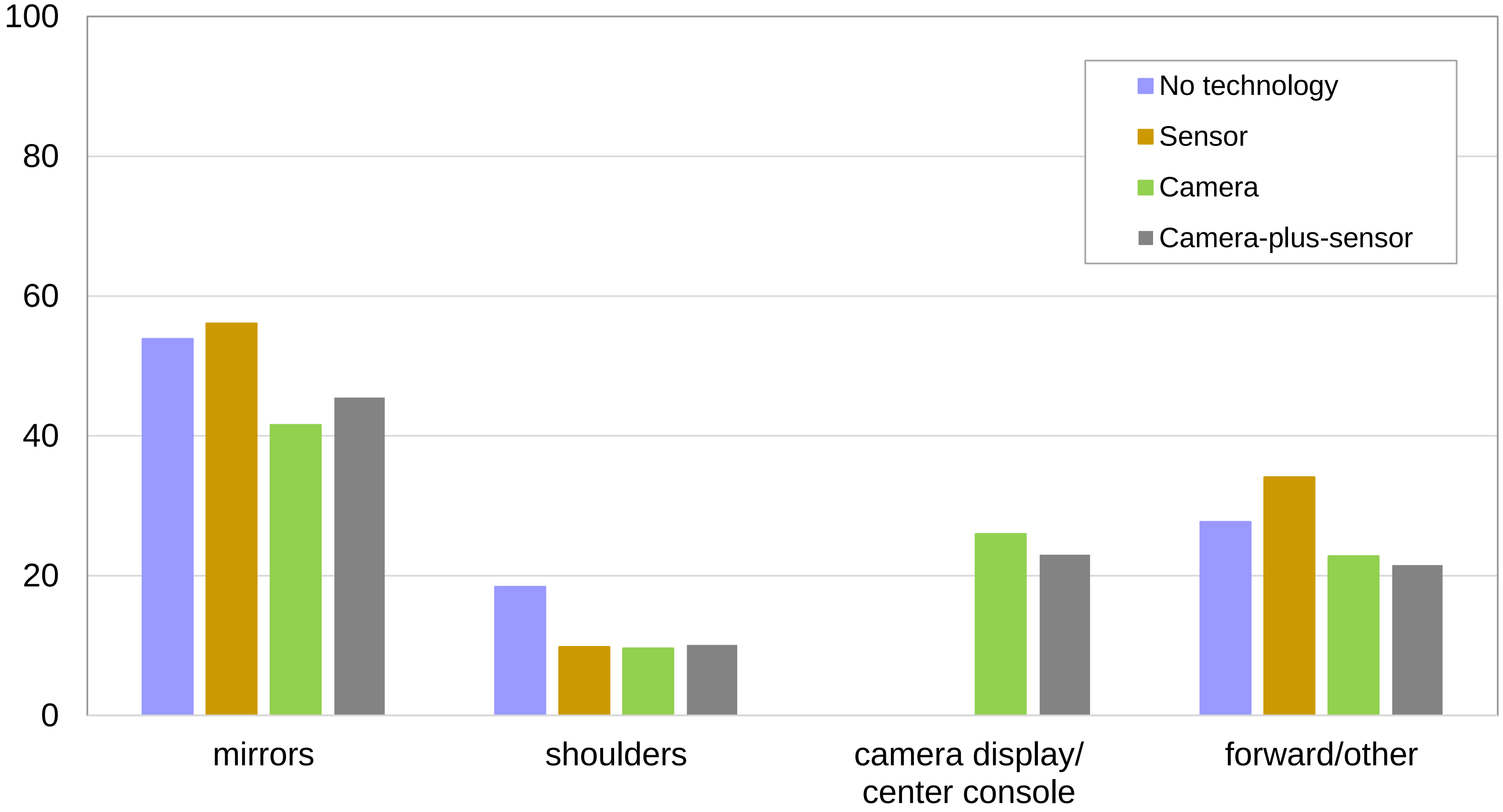
Drivers must respond to sensors for them to work

Objects are not always easy to see in the camera display

Rearview cameras can help drivers avoid backing over objects in reverse

Technology influences the way we look around the vehicle while backing

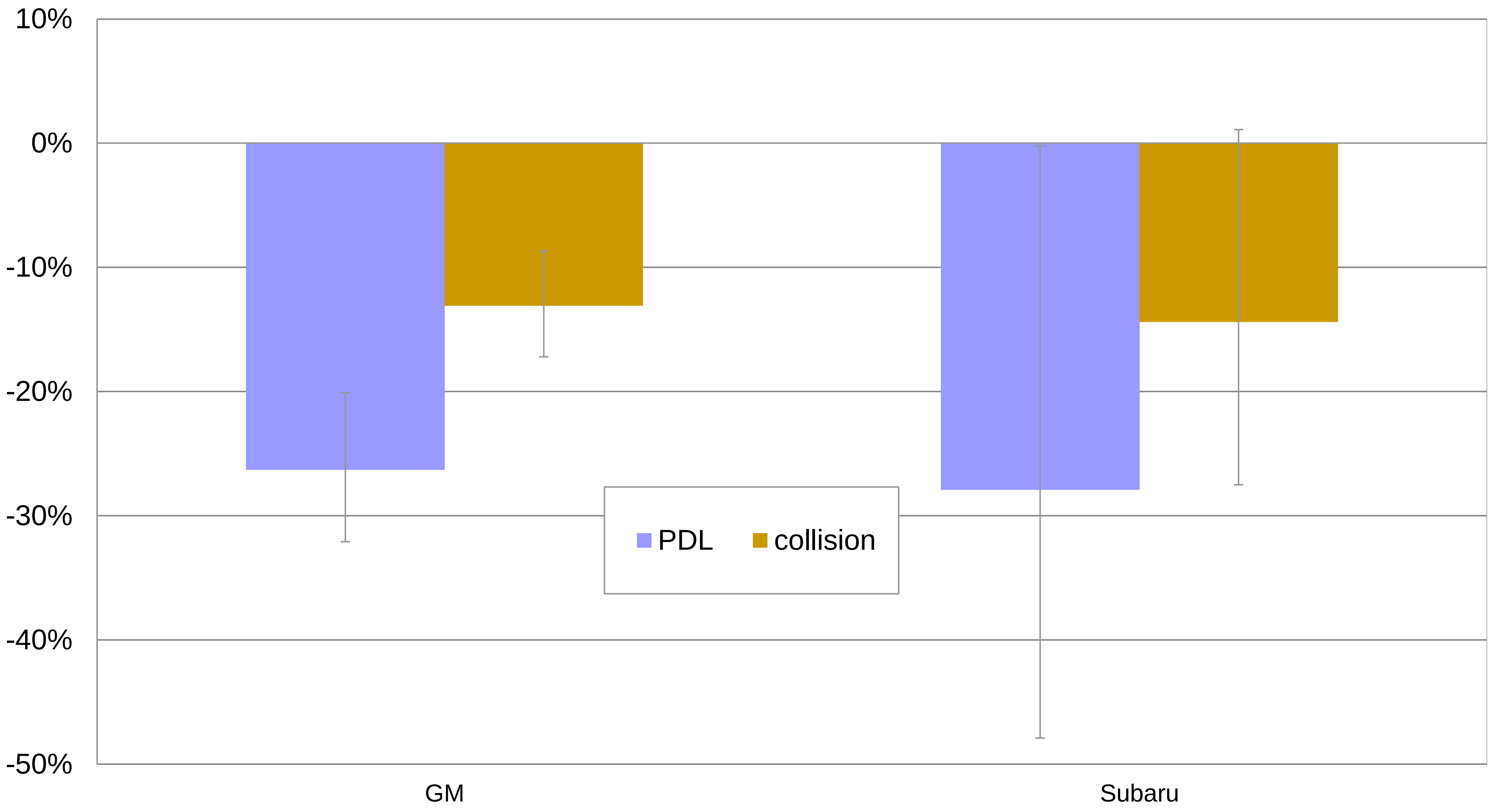
Percentage of time spent looking at different fields of view



Rear automatic braking

Rear automatic braking

Change in claim frequency



Test vehicles

2017 BMW 5 series

2017 Cadillac XT5

2017 Infiniti QX60

2017 Jeep Cherokee

2017 Subaru Outback

2017 Toyota Prius

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Benefit of rear autobrake

Benefit of rear autobrake

Insurance results for Level 2 systems


Tesla Model S driver
assistance technologies
IIHS
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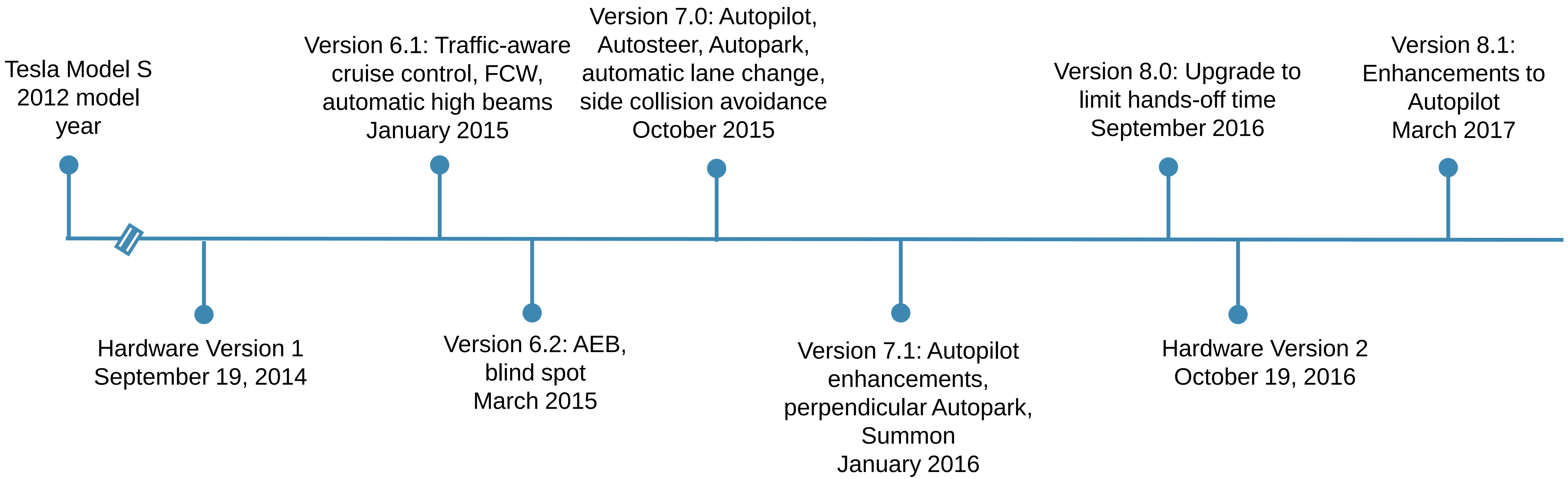
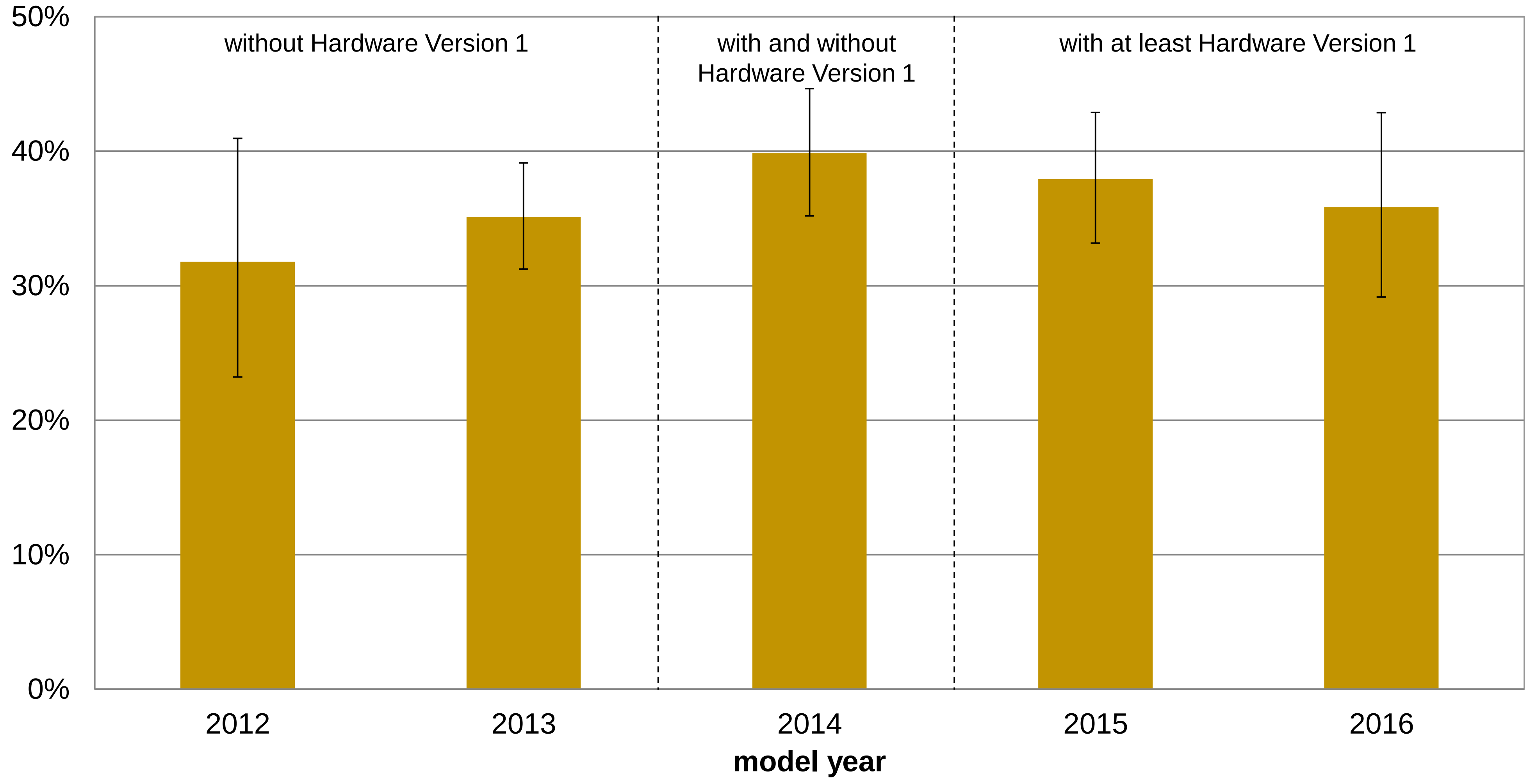
Tesla timeline



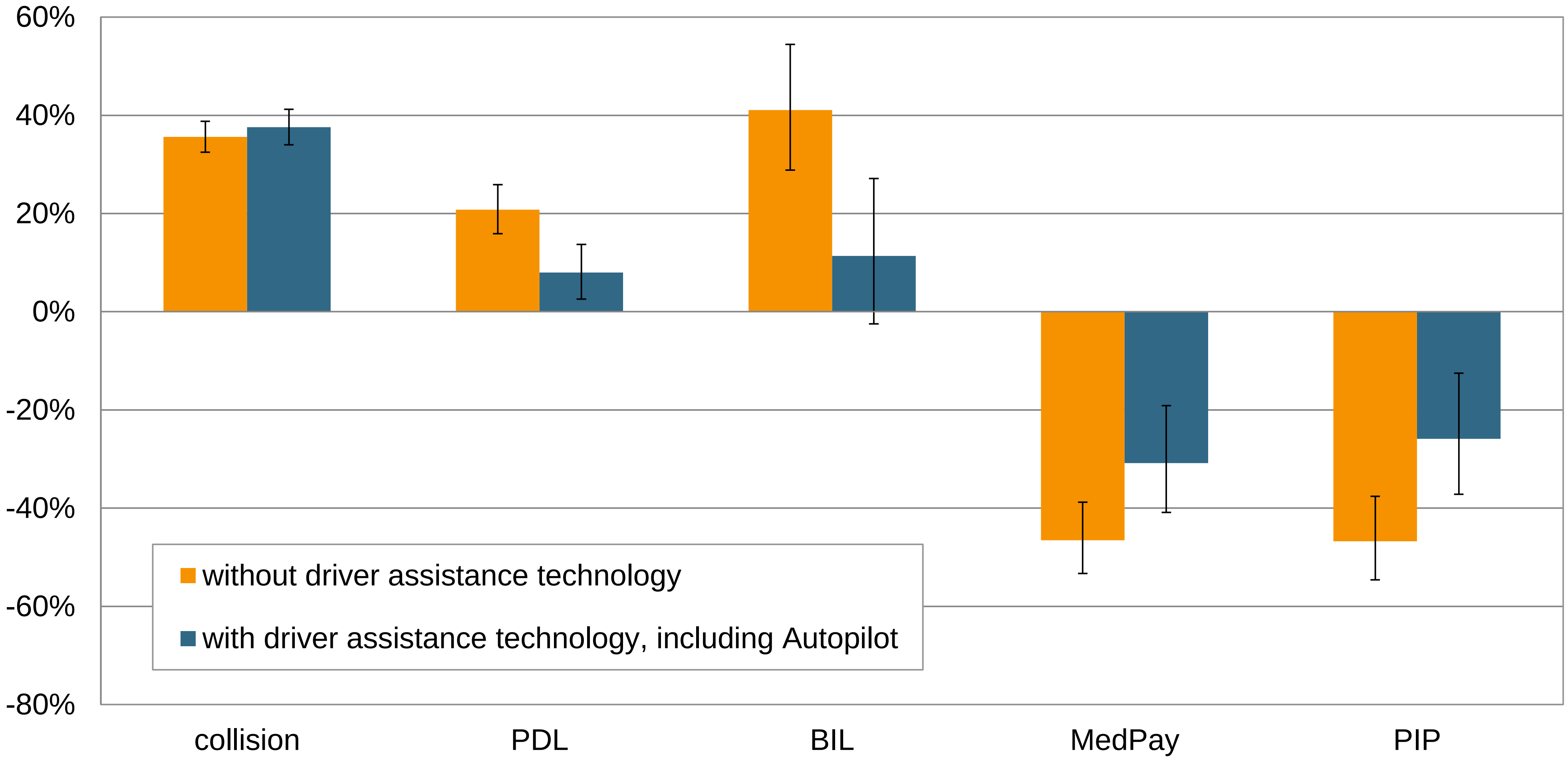
Tesla Model S versus large luxury vehicles

Collision claim frequency, by model year



Tesla Model S claim frequencies with and without driver assistance technology versus large luxury vehicles

Effect of driver assistance technology, including Autopilot



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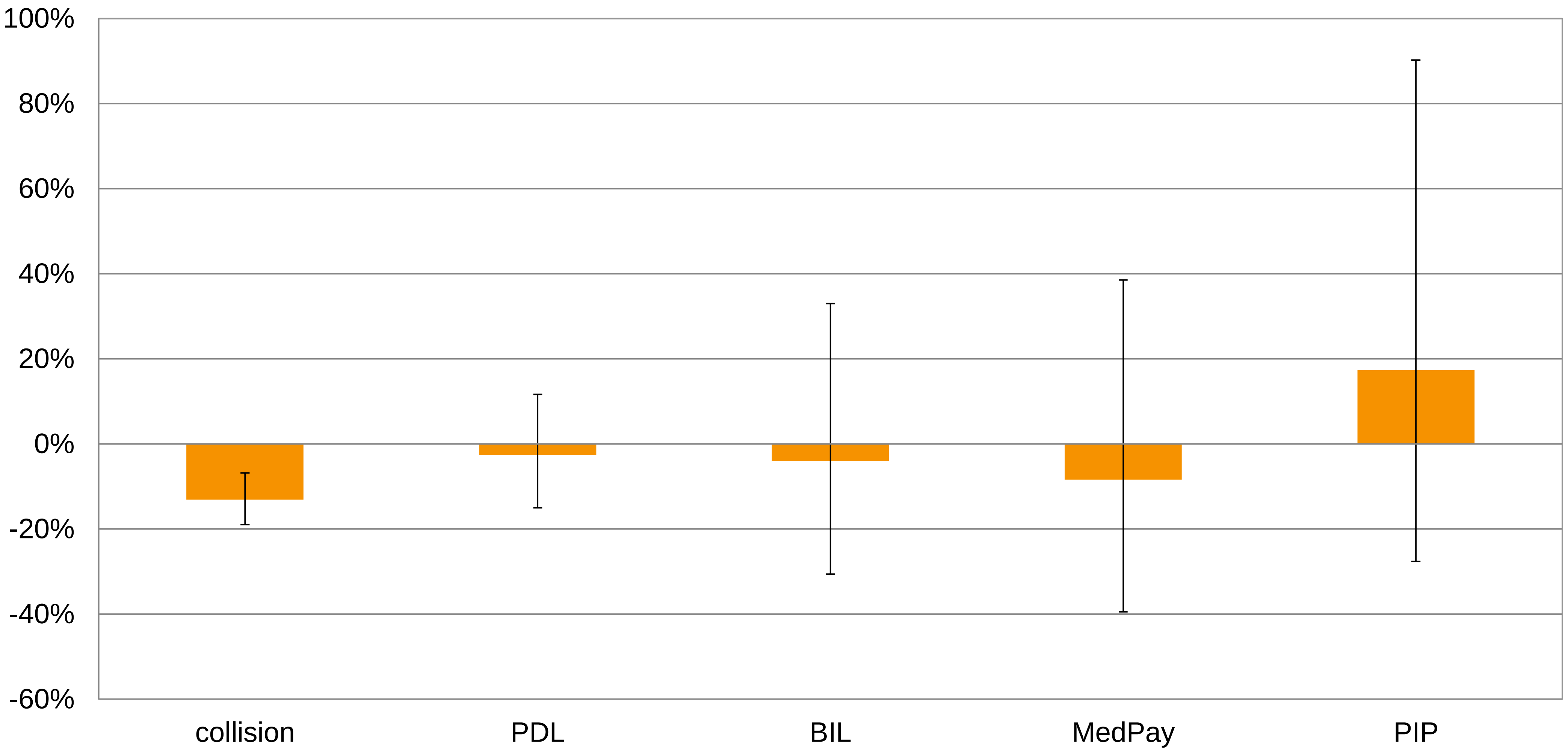
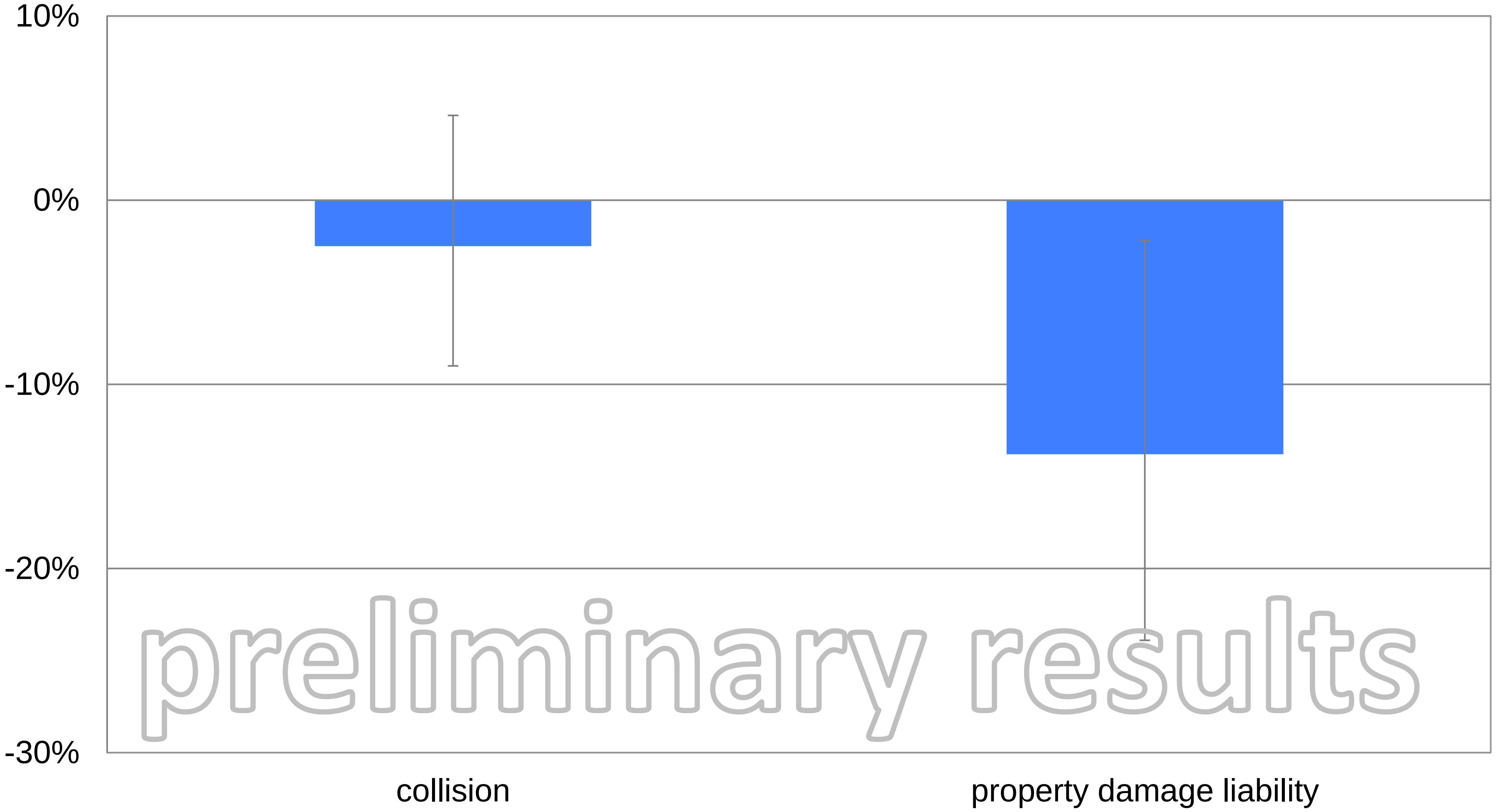
Estimated effect of Tesla Model S Autopilot on claim frequency

Driver assistance technology plus Autopilot vs. early driver assistance technology alone



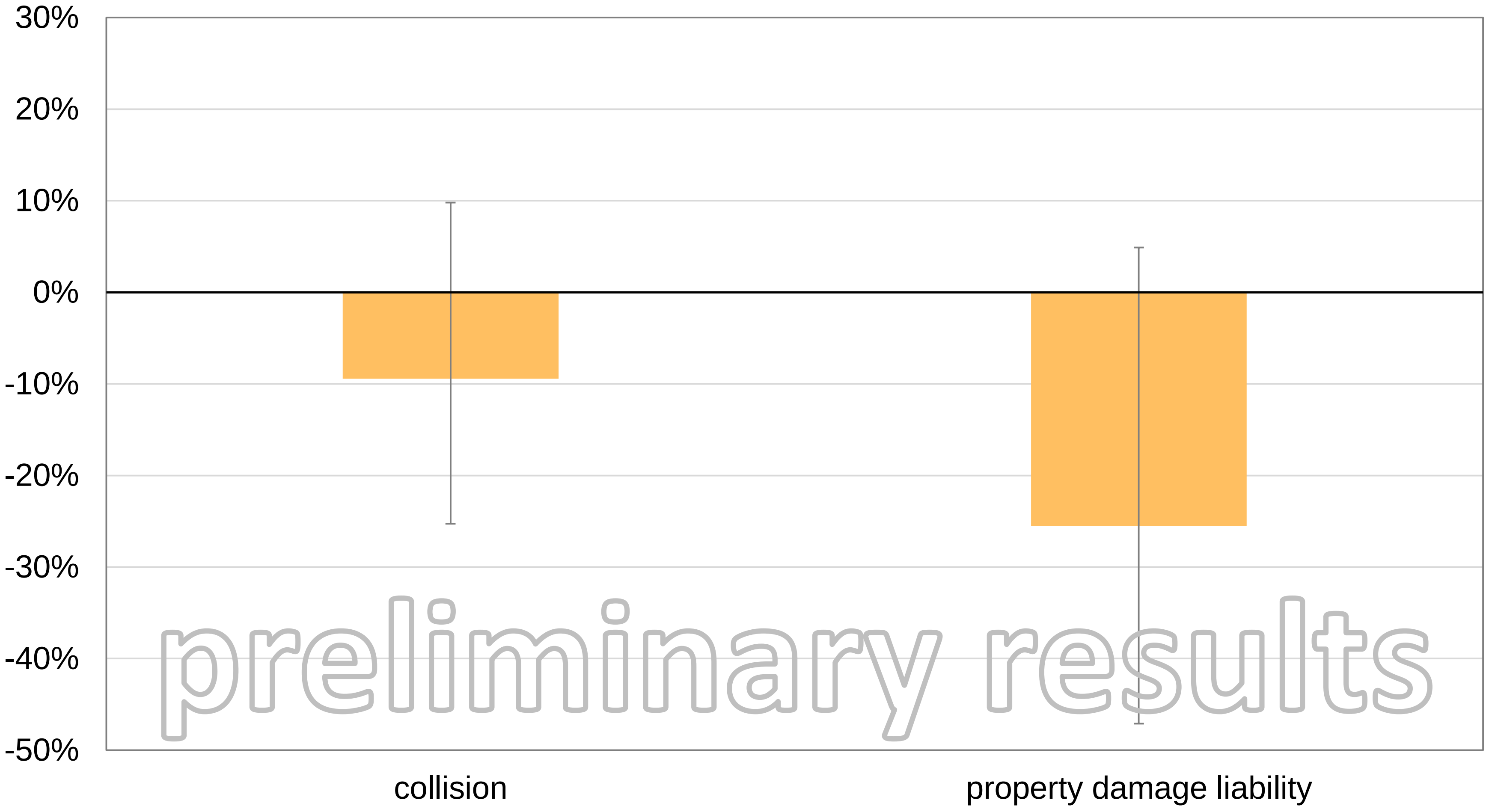
Effect of Audi Traffic Jam Assist, adaptive cruise control, active lane assist and high-beam assist on claim frequency

2017 Audi A4 and Q7, by insurance coverage type



Effect of Nissan ProPilot Assist on claim frequency

2016–18 Leaf and 2017–18 Rogue, by insurance coverage type



Lane keeping on hills

On-road testing – Tesla Model S

Tesla “Autopilot” crash – crash site

IIHS HLDI

Problems: turn lanes

On-road testing – Mercedes-Benz E-Class

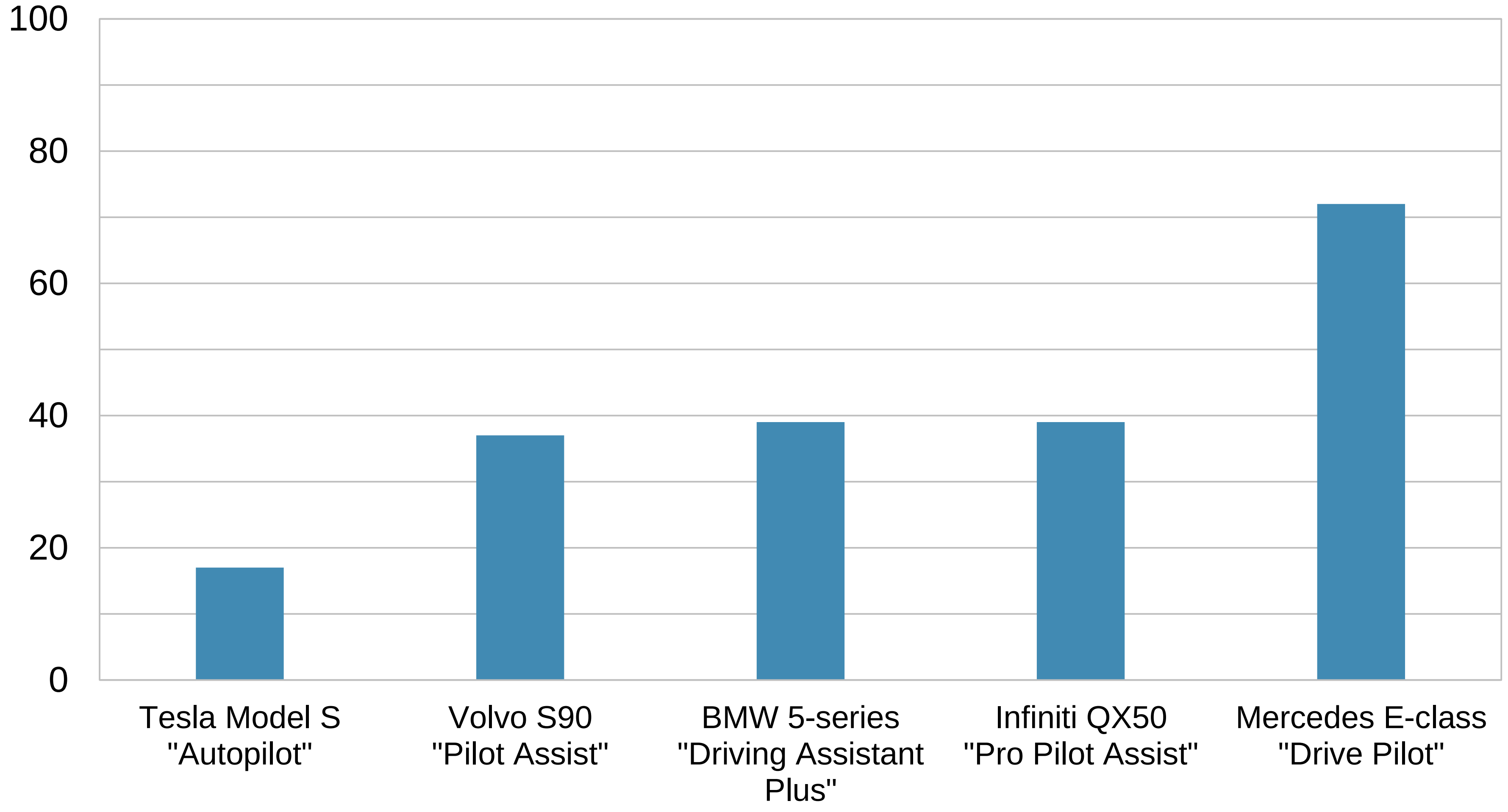
Experiences with driving automation

Opinions of level 2 driving automation technology after brief use

- 17-20 employees drove each vehicle on a 20-mile route while using level 2 driving automation the entire drive
- Completed a survey about their experience after the drive
- Five vehicles:
  - 2017 BMW 5 series with “Driving Assistant Plus”
  - 2017 Mercedes E-Class with “Drive Pilot”
  - 2016 Tesla Model S with “Autopilot”
  - 2018 Volvo S90 with “Pilot Assist”
  - Pre-production 2019 Infiniti QX50 with “Pro Pilot Assist”

Overall, I felt the automation improved my driving experience

Percentage of drivers who agreed or strongly agreed



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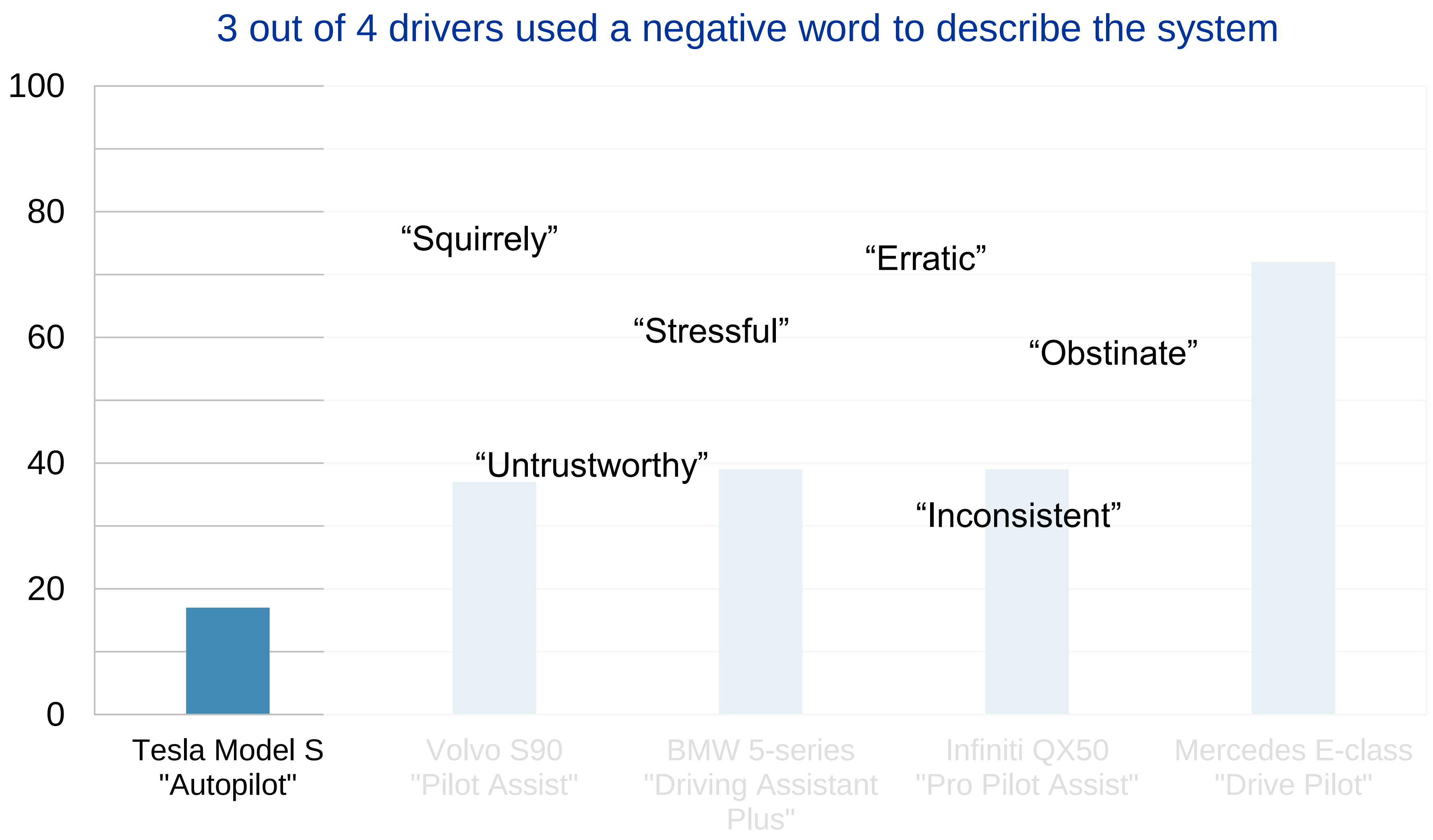

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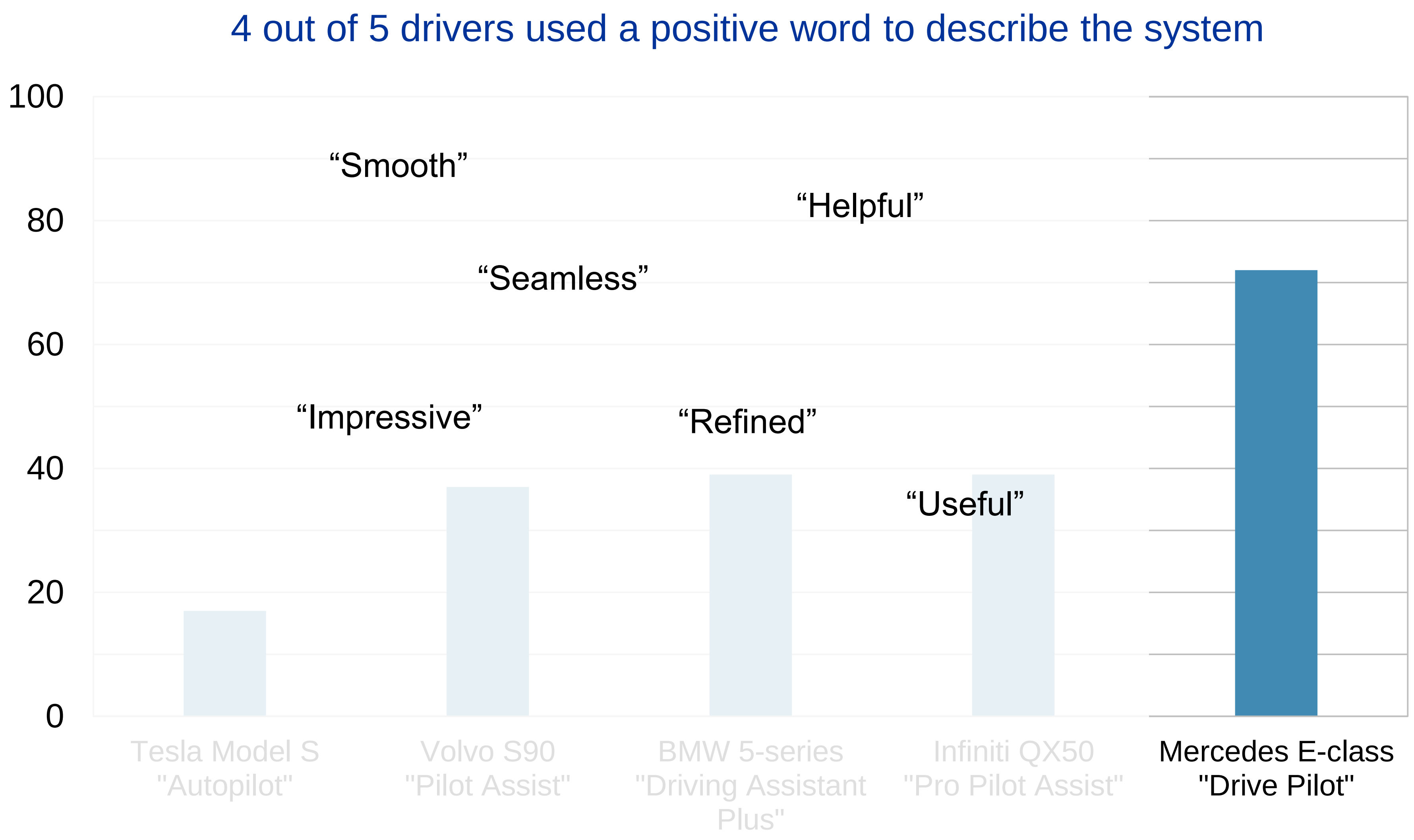
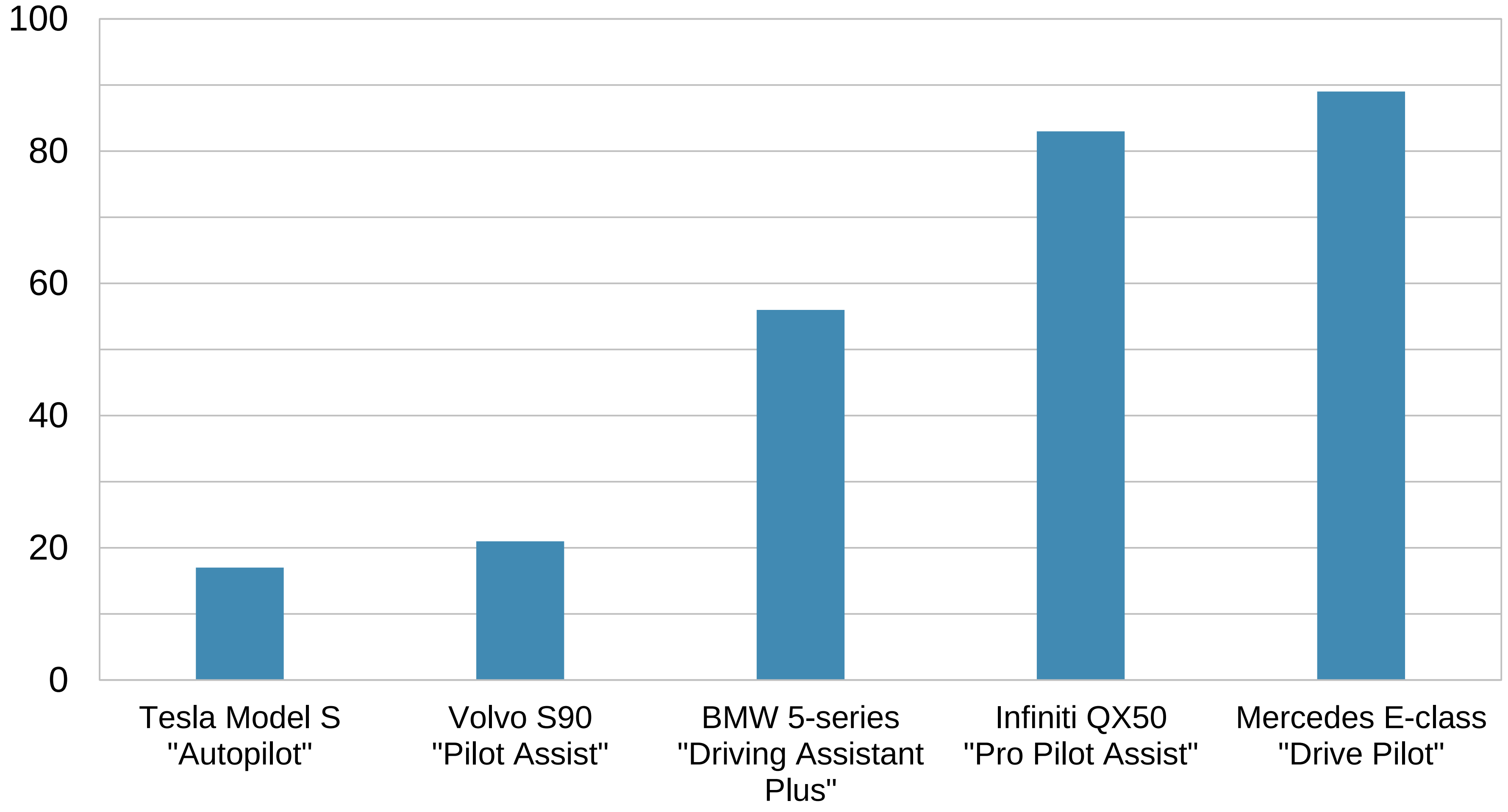


Which driving automation attributes predicted if automation improved driving experience?

- Drivers reported their level of agreement with statements about the automation:
  - Accelerated and decelerated the vehicle smoothly
  - Made smooth, gentle steering corrections
  - Made infrequent steering corrections
  - Always knew whether the vehicle ahead was detected
  - Always knew whether the lane markings were detected
  - Consistently detected lane markings
  - Detected moving vehicles ahead
  - Detected stopped vehicles ahead

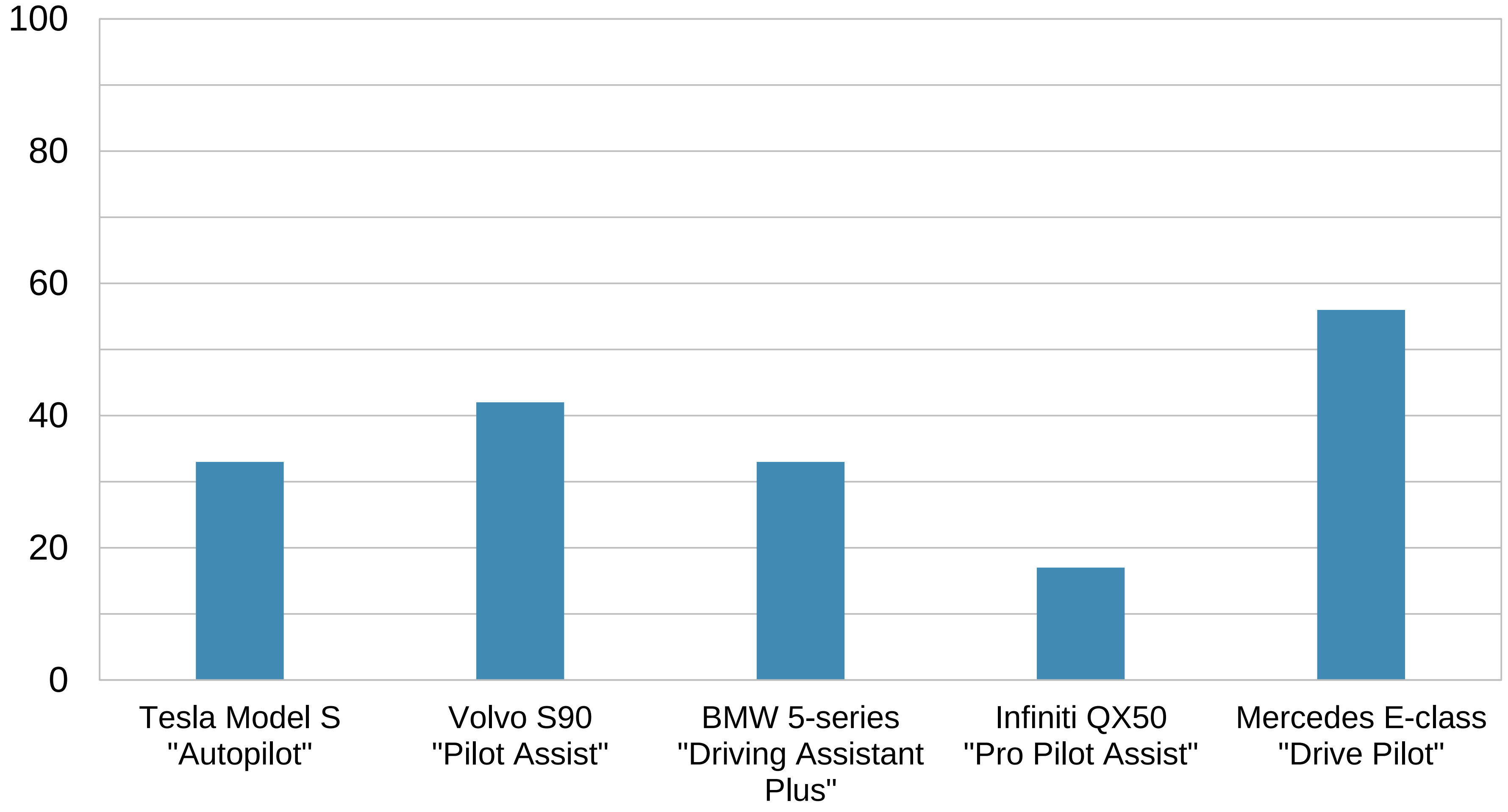
The automation made smooth, gentle steering corrections

Percentage of drivers who agreed or strongly agreed



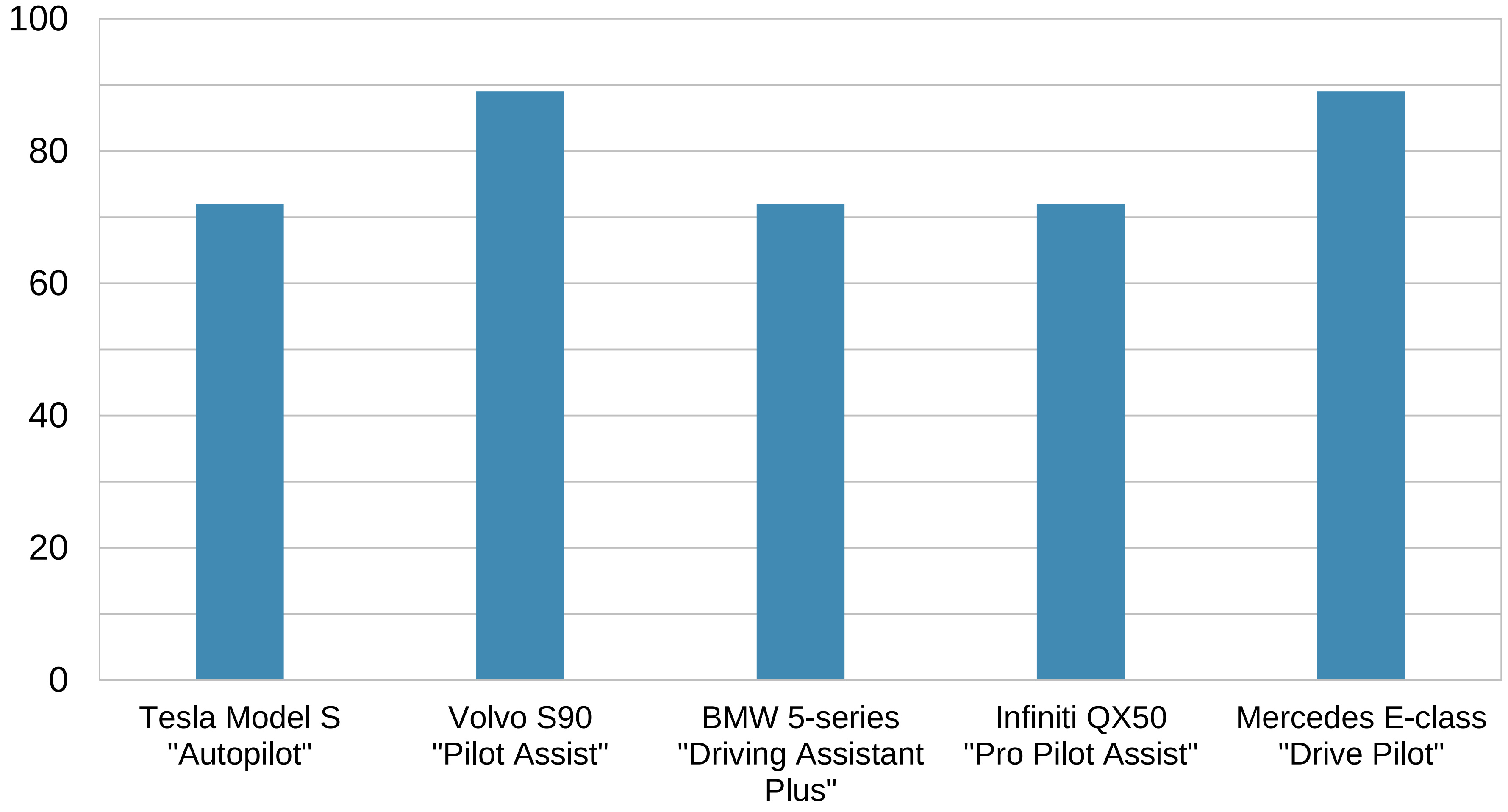
The automation consistently detected lane markings on the roadway

Percentage of drivers who agreed or strongly agreed



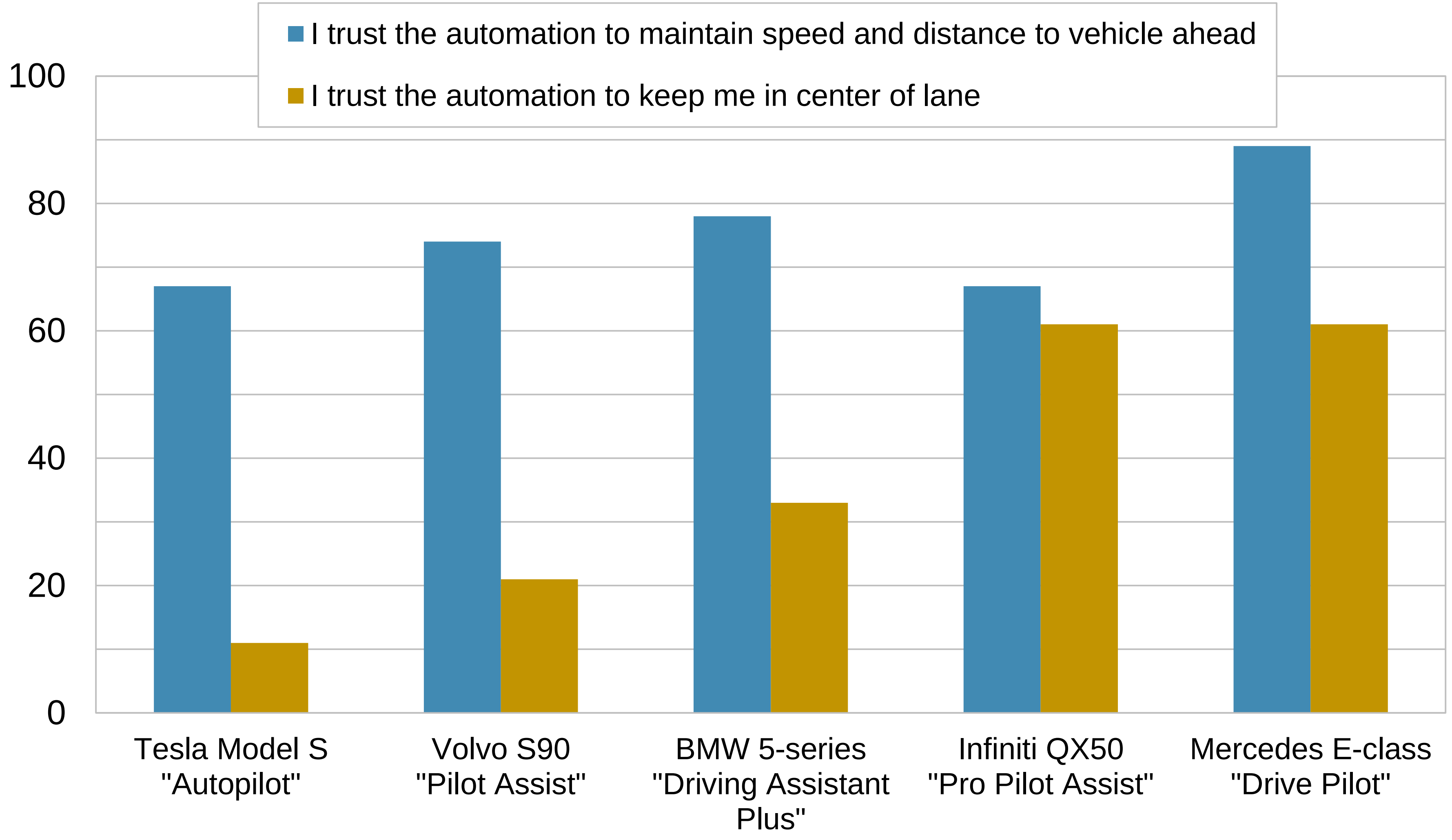
The automation detected moving vehicles ahead in my lane

Percentage of drivers who agreed or strongly agreed



Adaptive cruise control trusted more than active lane keeping

Percentage of drivers who agreed or strongly agreed



Functional performance of adaptive cruise control

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Functional performance testing of adaptive cruise control

2016 Tesla Model S with Autopilot software ver. 7.1

2017 BMW 5 series with Driving Assistant Plus

2017 Mercedes E-Class with Drive Pilot

2018 Volvo S90 with Pilot Assist

2018 Tesla Model 3 with Autopilot software ver. 8.1

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Functional performance testing of adaptive cruise control

- Combination of track and on-road tests
- Adaptive cruise control scenarios
  - Stopped lead vehicle
  - Vehicle exiting lane
  - Acceleration/deceleration profiles

Approach stationary target with ACC on

ACC acceleration from stop

Revealed stationary vehicle

Track test summary

- S90 has AEB-like deceleration (~1g) for stationary vehicles; other vehicles have peak decelerations closer to 0.2–0.3g
- Peak deceleration approaching moving target similar for all 4 vehicles
- Distance settings
  - Deceleration approaching stationary target: no effect of distance setting on braking time to collision
  - Deceleration approaching a moving vehicle: Distance setting affects peak deceleration in the Model S (braking happens earlier for farthest distance setting), possibly affects peak deceleration in the S90
- Drive mode affects acceleration for E-Class only; no effect on peak deceleration for any vehicle

Test track performance was not necessarily replicated on road

On-road testing – approaching stationary vehicles

Less common hazards may or may not be detected

On-road testing

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Functional performance of lane-keeping systems

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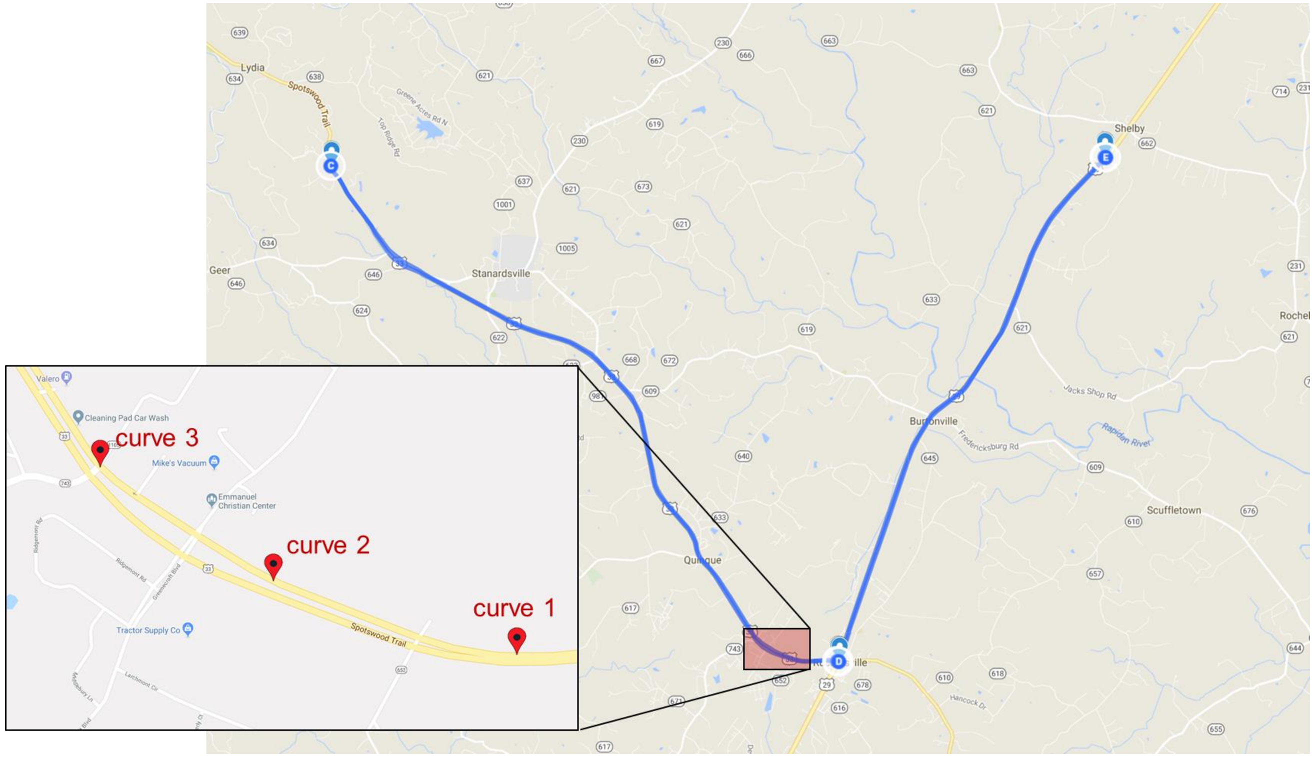
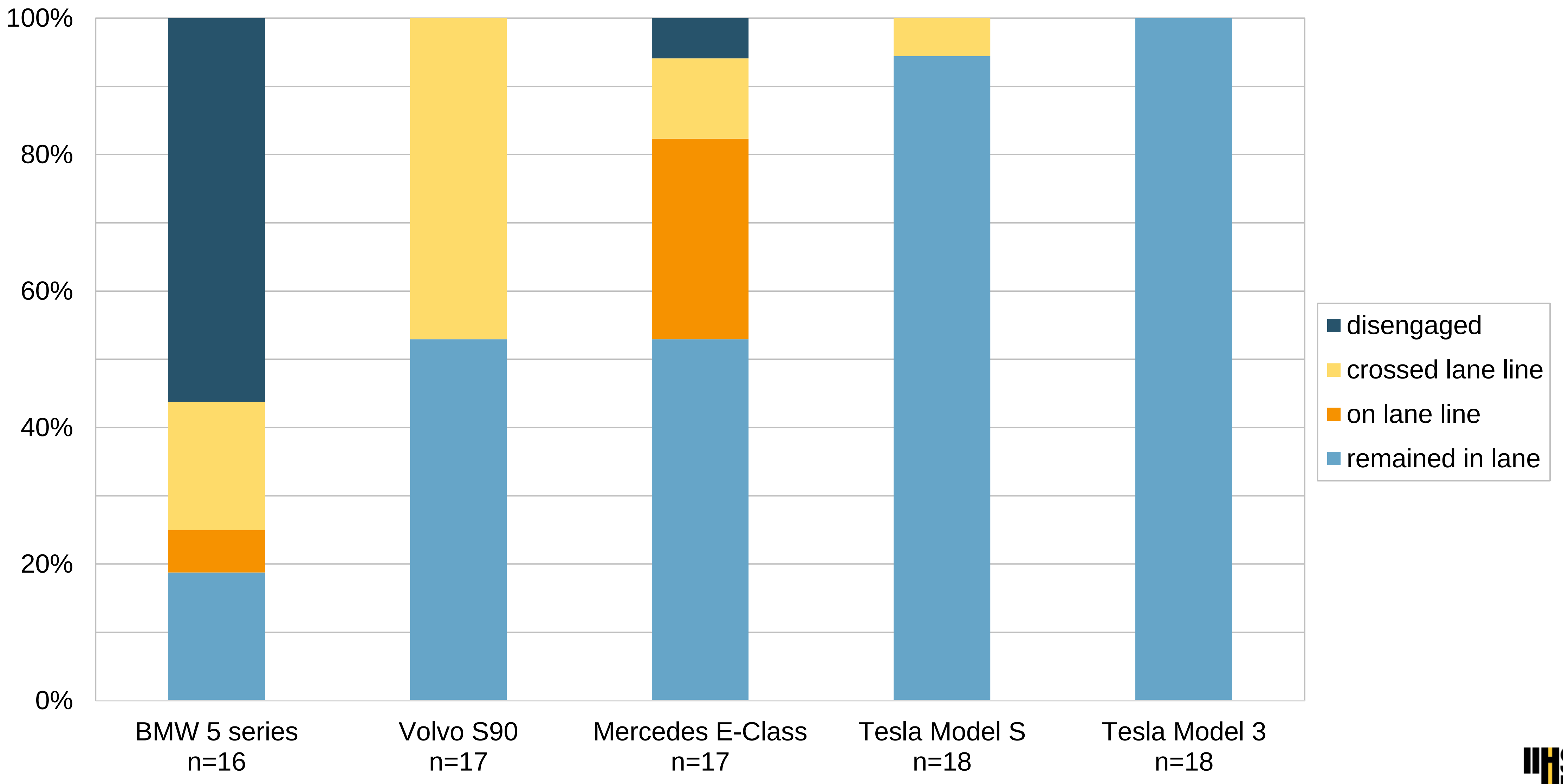
Functional performance testing of active lane-keeping systems

- Active lane-keeping scenarios
  - Lane tracking and lane position
  - Curve handling
  - Hill capability



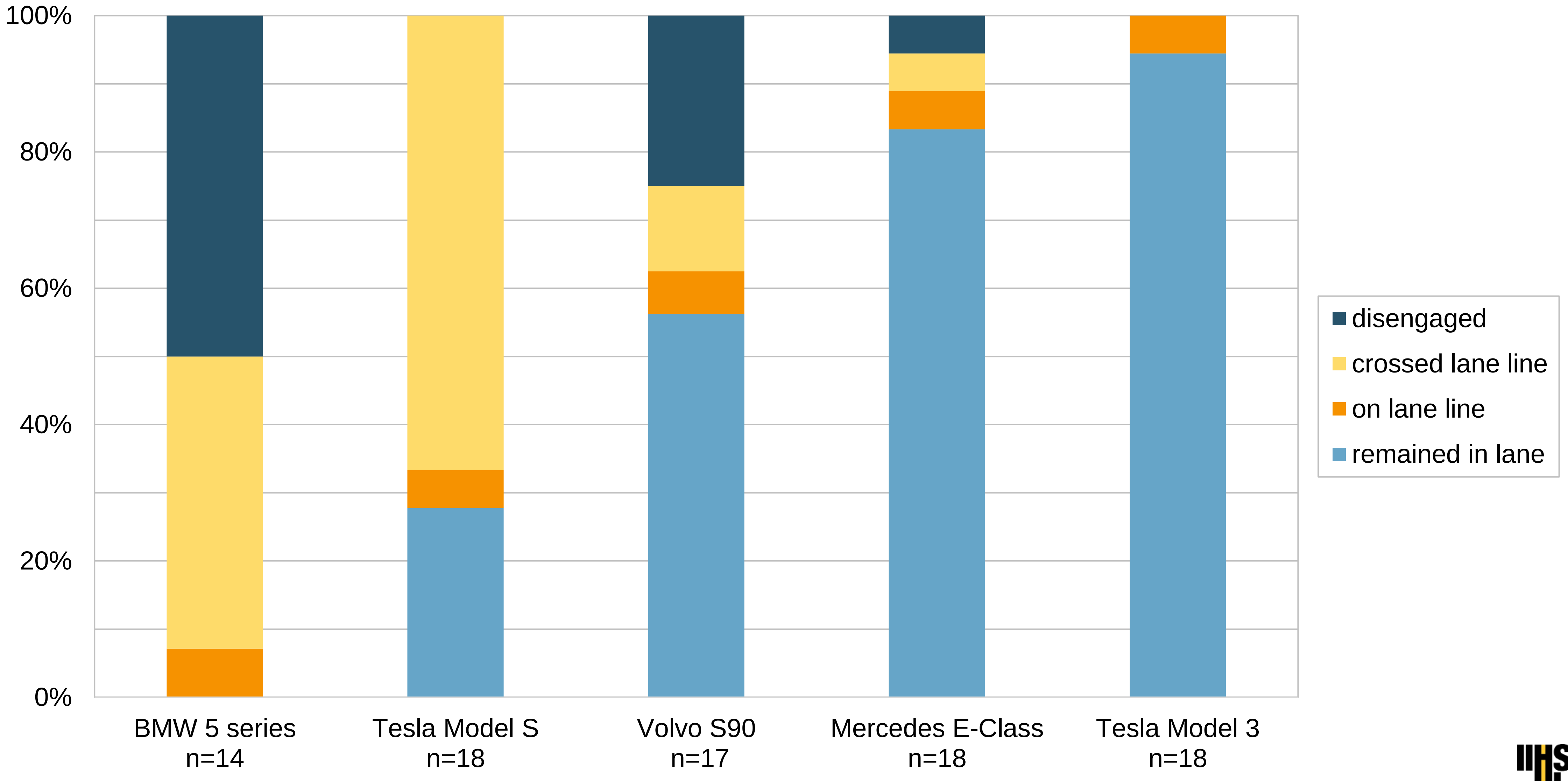
Lane keeping in curves

Lane keeping in curves



Lane keeping on hills

Lane keeping on hills



Can automation eliminate all crashes caused by human error?

Human error contributes to most crashes

Necessary conditions for automation to be safer than human drivers

- Better than human driver crash rates.[1] Fewer than...
  - 560 people in police-reported crashes
  - 99 injuries
  - 1.2 fatalities

  ...per 100 million miles travelled
- The critical precrash event was attributed to drivers in 94 percent of crashes[2]

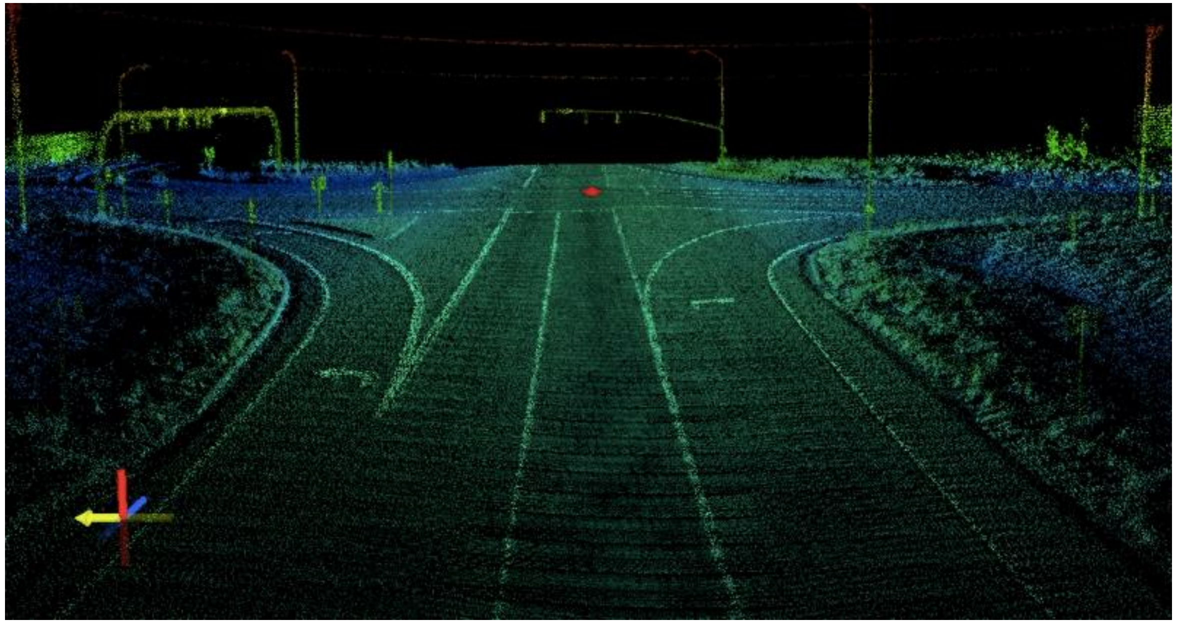
1. NHTSA, Police-Reported Motor Vehicle Traffic Crashes in 2016 (DOT HS 812 501)
2. NHTSA, Critical Reasons for Crashes Investigated in the National Motor Vehicle Crash Causation Survey (DOT HS 812 115)

Forty-one percent were recognition errors

Automated driving systems need to reliably "recognize" and avoid critical situations better than humans

- Inadequate surveillance
- Distraction
- Inattention
- Other

what humans see



what robo-cars see

Thirty-three percent were decision errors

ADS need to make better decisions, obey traffic laws and predict the future better than humans

- Speed
- Wrong assumptions about other road users
- Illegal maneuver
- Aggressive driving

Eleven percent performance and 7 percent nonperformance errors

ADS need to reliably control the vehicle better than humans

- No or insufficient braking
- Over or under steering
- Freezing
- Other

Did the Uber self-driving system avoid humanlike errors?

PRELIMINARY REPORT
HIGHWAY
HWY18MH010

The information in this report is preliminary and will be supplemented or corrected during the course of the investigation.

About 9:58 p.m., on Sunday, March 18, 2018, an Uber Technologies, Inc. test vehicle, based on a modified 2017 Volvo XC90 and operating with a self-driving system in computer control mode, struck a pedestrian on northbound Mill Avenue, in Tempe, Maricopa County, Arizona. The Uber test vehicle was occupied by one vehicle operator, a 44-year-old female. No passengers were in the vehicle.

In the area of the crash, northbound Mill Avenue consists of two left-turn lanes, two through lanes, and one bike lane. The crash occurred before the formation of a right-turn lane. Roadway lighting was present. The posted speed limit was 45 mph.

The crash occurred as the pedestrian, a 49-year-old female, walked a bicycle east across Mill Avenue. The Uber test vehicle was traveling in the right through lane when its right front side struck the pedestrian (see figure 1). As a result of the crash, the pedestrian died. The vehicle operator was not injured.

In this area, northbound Mill Avenue is separated from southbound Mill Avenue by a center median containing trees, shrubs, and brick landscaping in the shape of an X. Four signs at the edges of the brick median, facing toward the roadway, warn pedestrians to use the crosswalk. The nearest crosswalk is at the intersection of Mill Avenue and Curry Road, about 360 feet north of where the crash occurred.

Figure 1. (Left) Location of the crash on northbound Mill Avenue, showing the paths of the pedestrian in orange and of the Uber test vehicle in green. (Right) Postcrash view of the Uber test vehicle, showing damage to the right front side.

- Recognition error?
  - Uber's AV detected pedestrian and classified her as an unknown object, then a vehicle, finally a bicycle
  - Paths were converging at 6 seconds before impact, but Uber's AV computed varying expectations of future path
- Decision error?
  - Six seconds before impart, Uber's AV was moving 43 mph in 45 mph zone
  - Impact speed was 39 mph
    - NTSB preliminary report gives no explanation for speed change
    - Should Uber's AV have slowed more?
- Performance error?
  - Emergency braking maneuvers were disabled

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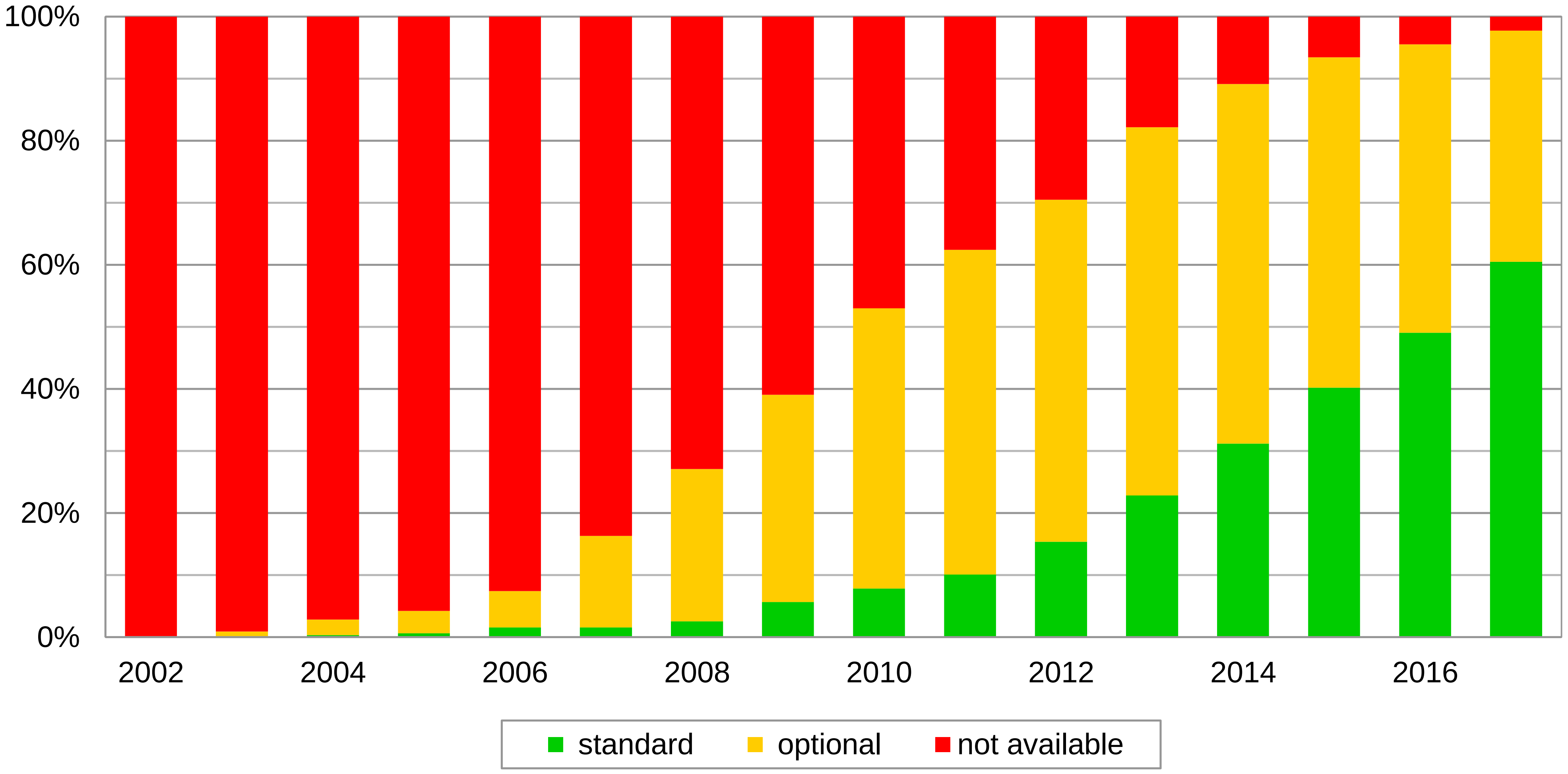
Fleet fitment of ADAS

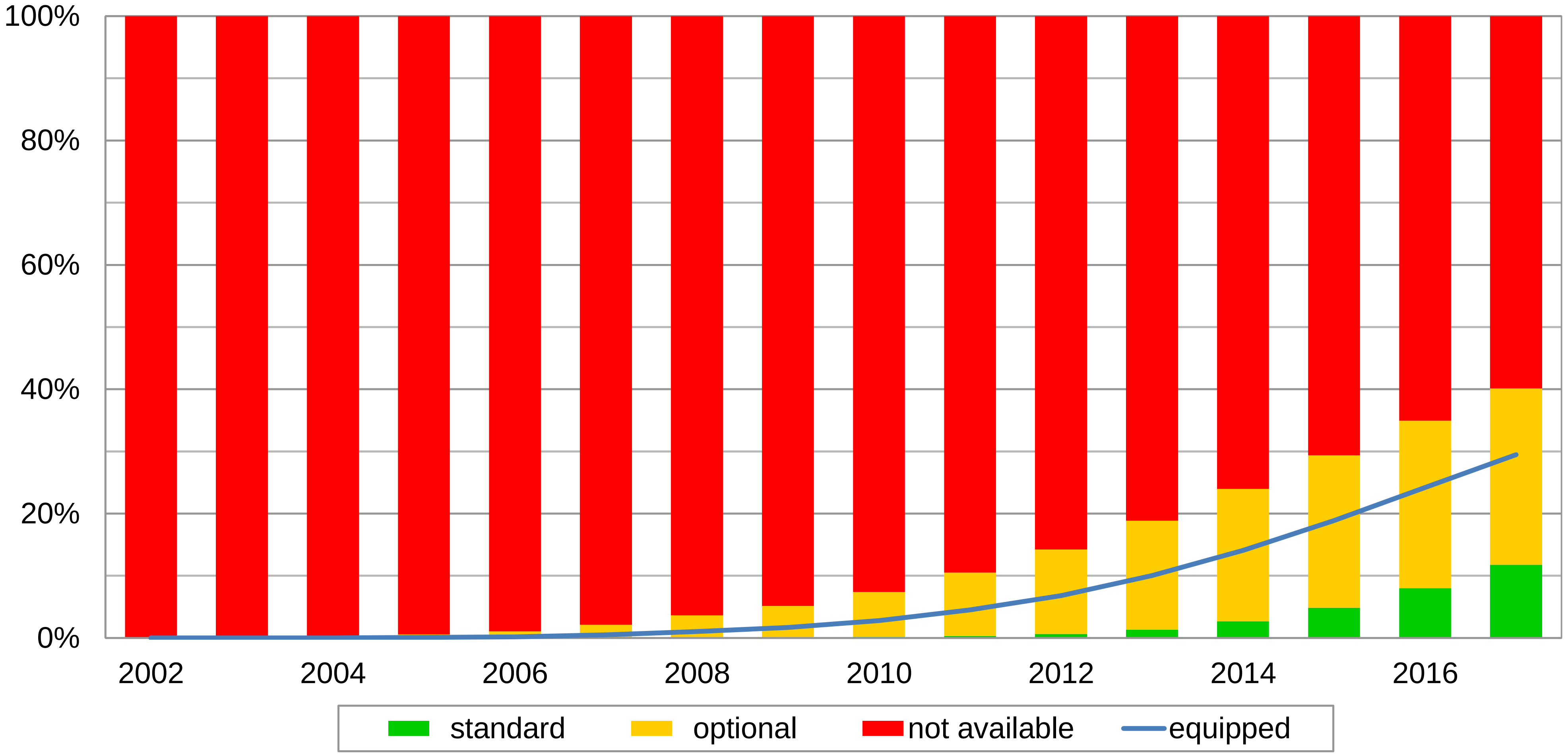
New vehicle series with rear camera

By model year



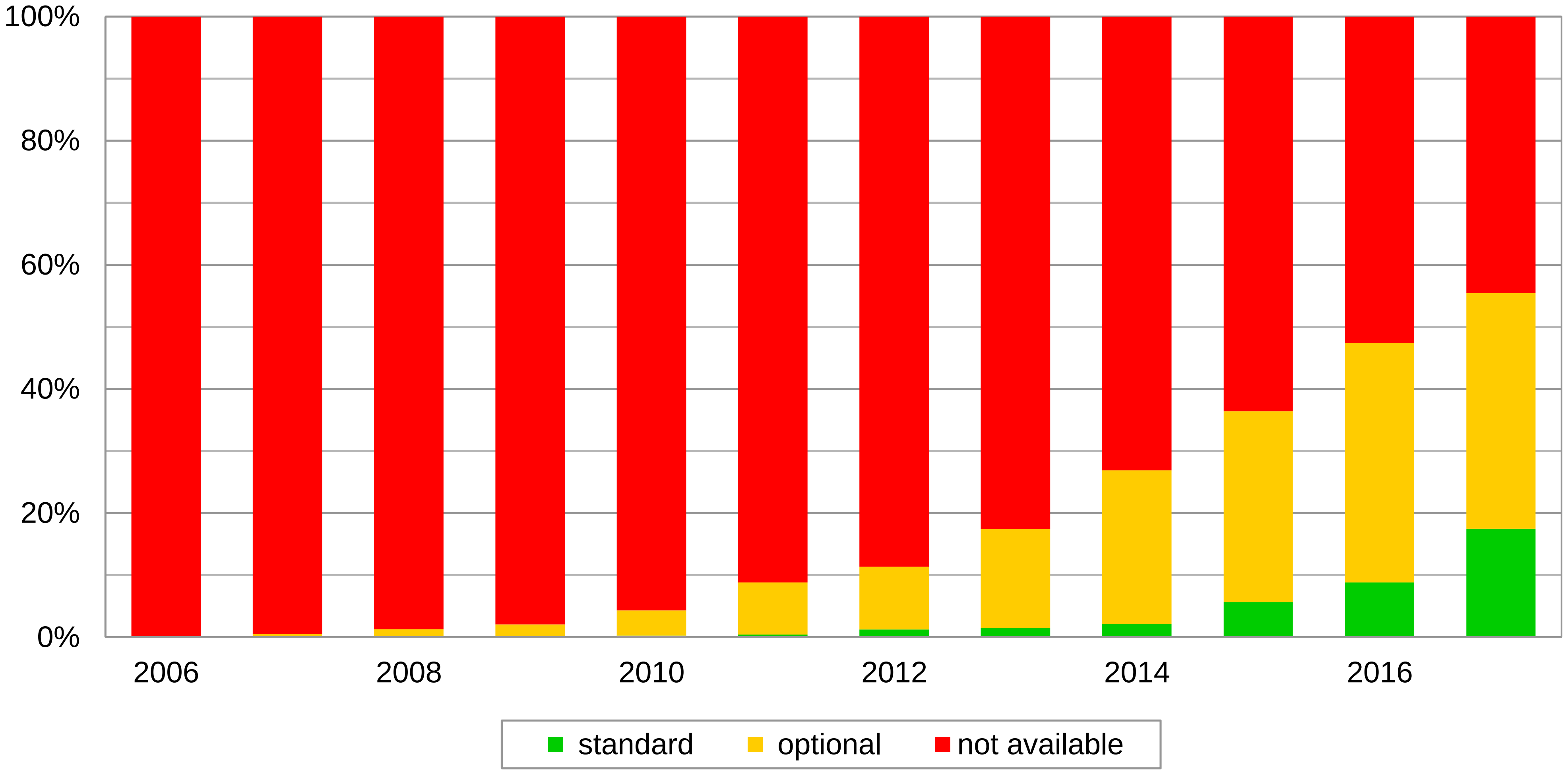
Registered vehicles with rear camera

By calendar year



New vehicle series with autonomous emergency braking

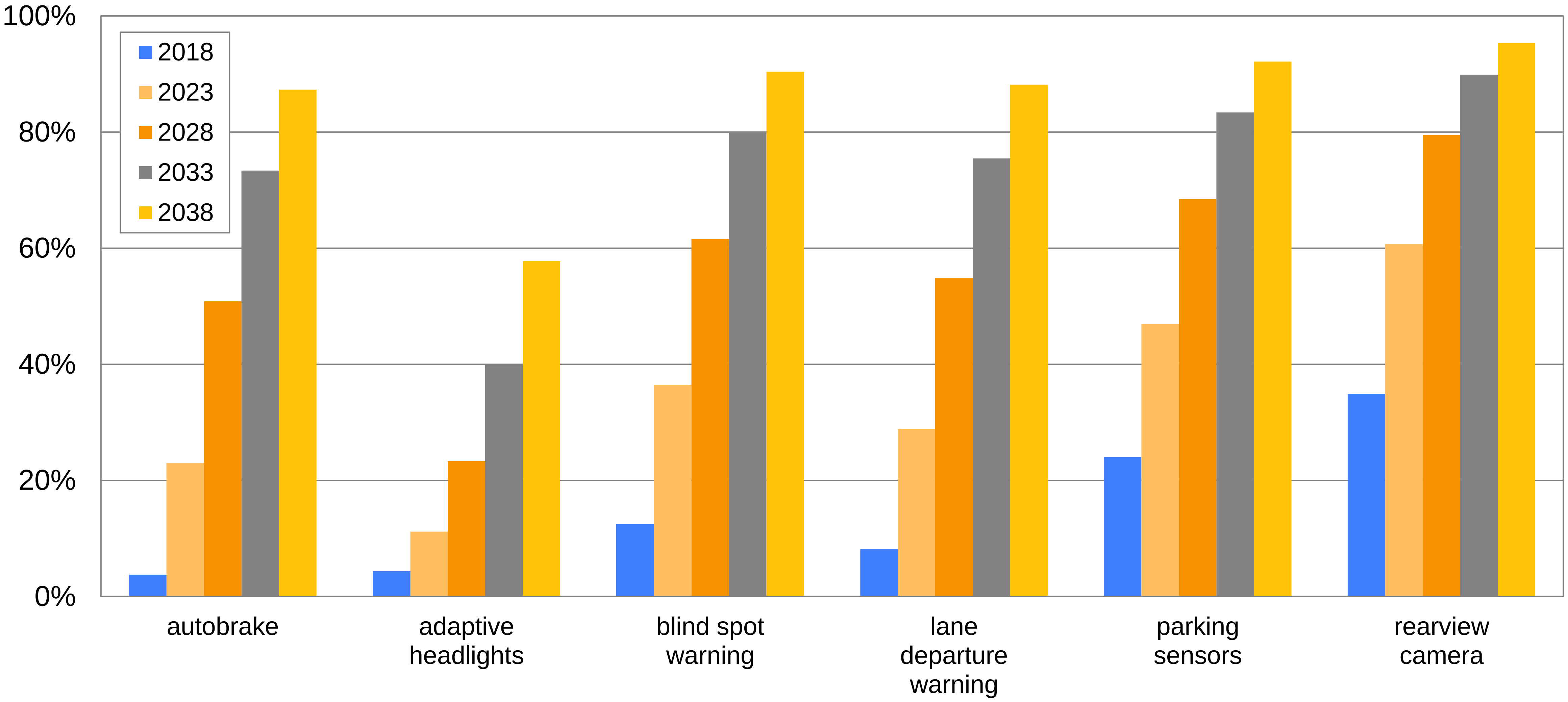
By model year



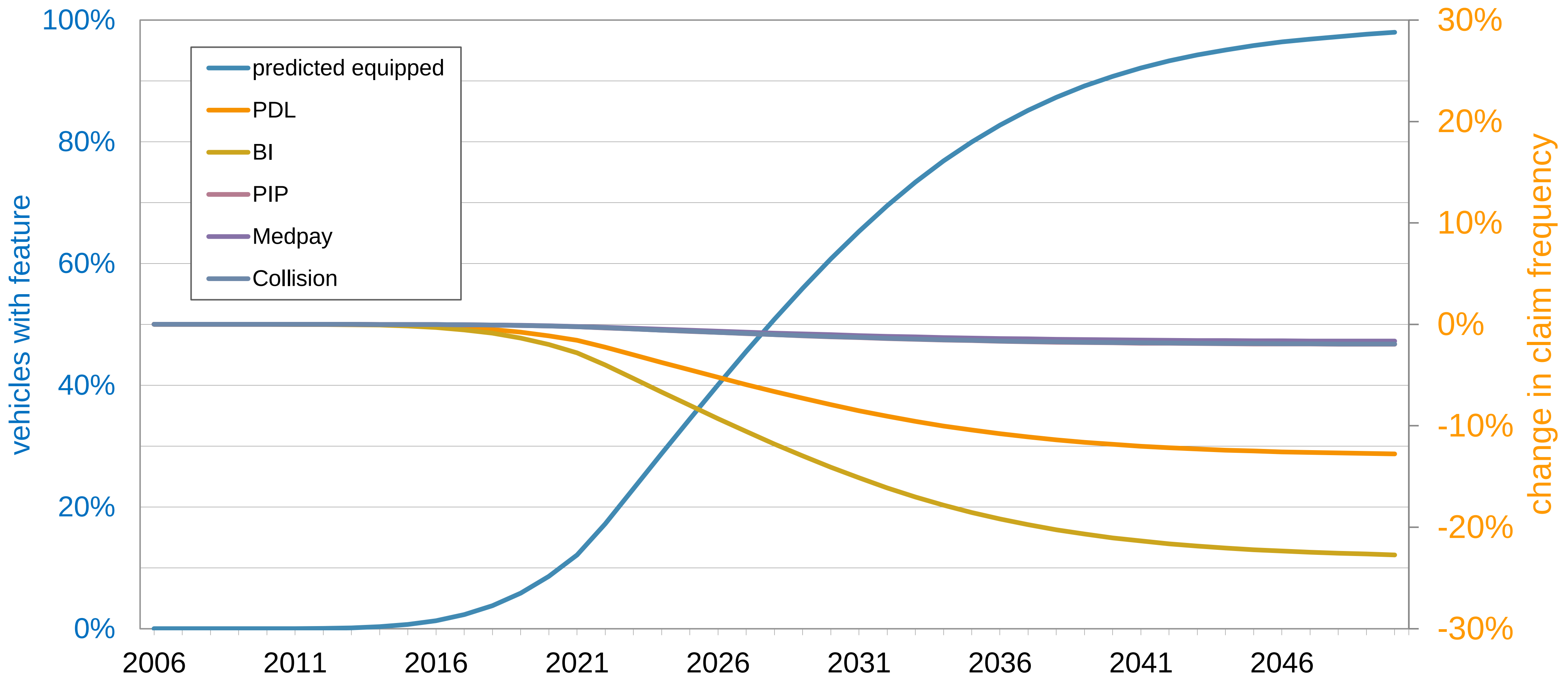
Registered vehicles with autonomous emergency braking

By calendar year

Predicted registered vehicles by feature by calendar year



Estimated change in claim frequency due to increased fitment of front autobrake systems



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Other concerns

Amping up horsepower increases the odds that a vehicle will exceed speed limits.

The effect is stronger for exceedances by more than 10 mph.

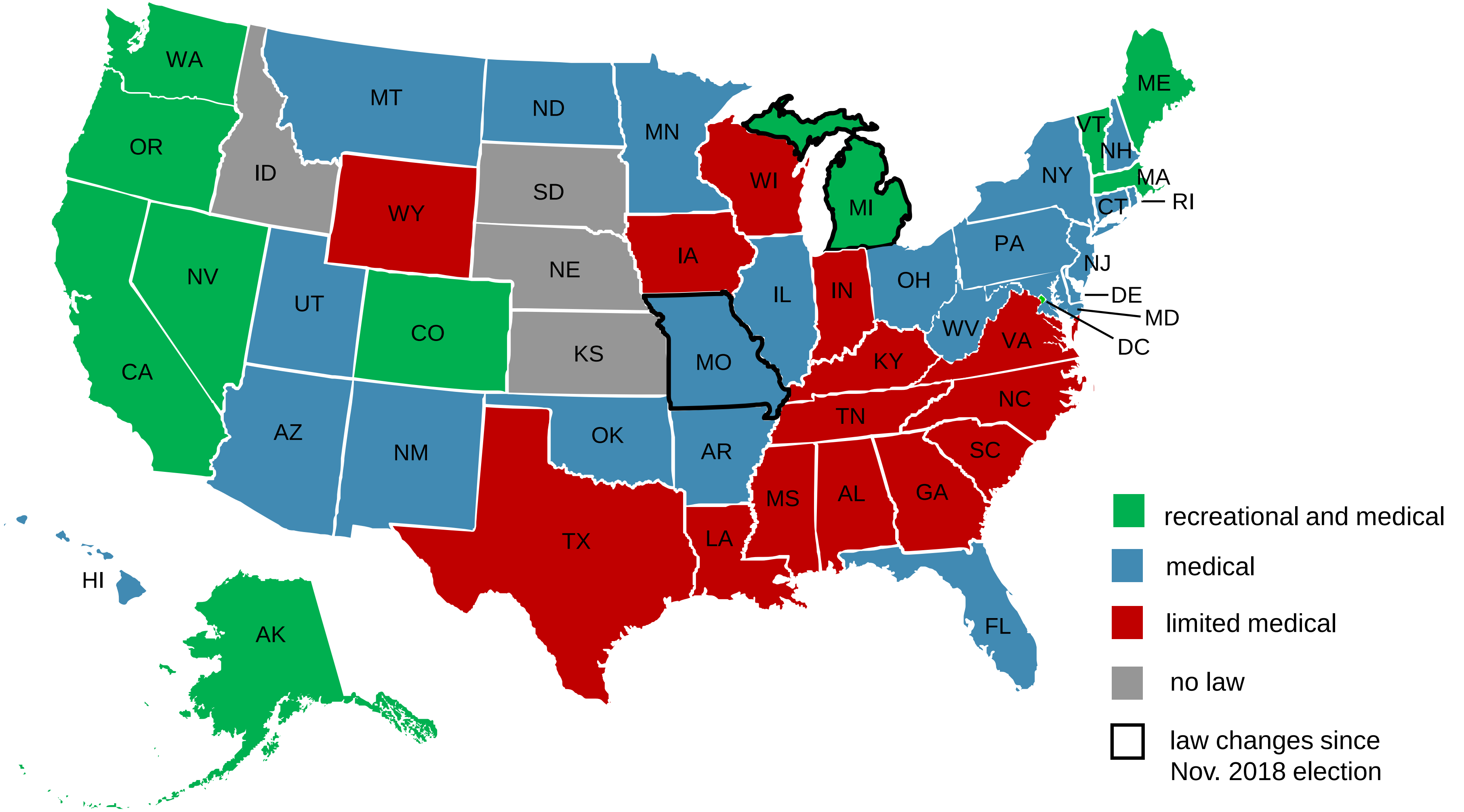

Do not attempt. Professional driver on closed course.

Speed limit increases 1993-2013 resulted in an estimated 33,000 extra deaths that wouldn't have occurred had limits remained unchanged

IIHS HLDI

Laws legalizing some uses of marijuana

November 2018



Increased crash risk associated with marijuana

- Collision claim frequency in CO, WA, OR and NV increased approximately 6% since legalization
- Crash rates increased 5% in CO, OR and WA after retail sales began

Insurance Institute for Highway Safety
Highway Loss Data Institute

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