Insurance Institute for Highway Safety
Highway Loss Data Institute

Headwinds on the Road to Zero: ADAS, crashworthiness and macro effects

International Center for Automotive Medicine

Ann Arbor, MI

October 5, 2017

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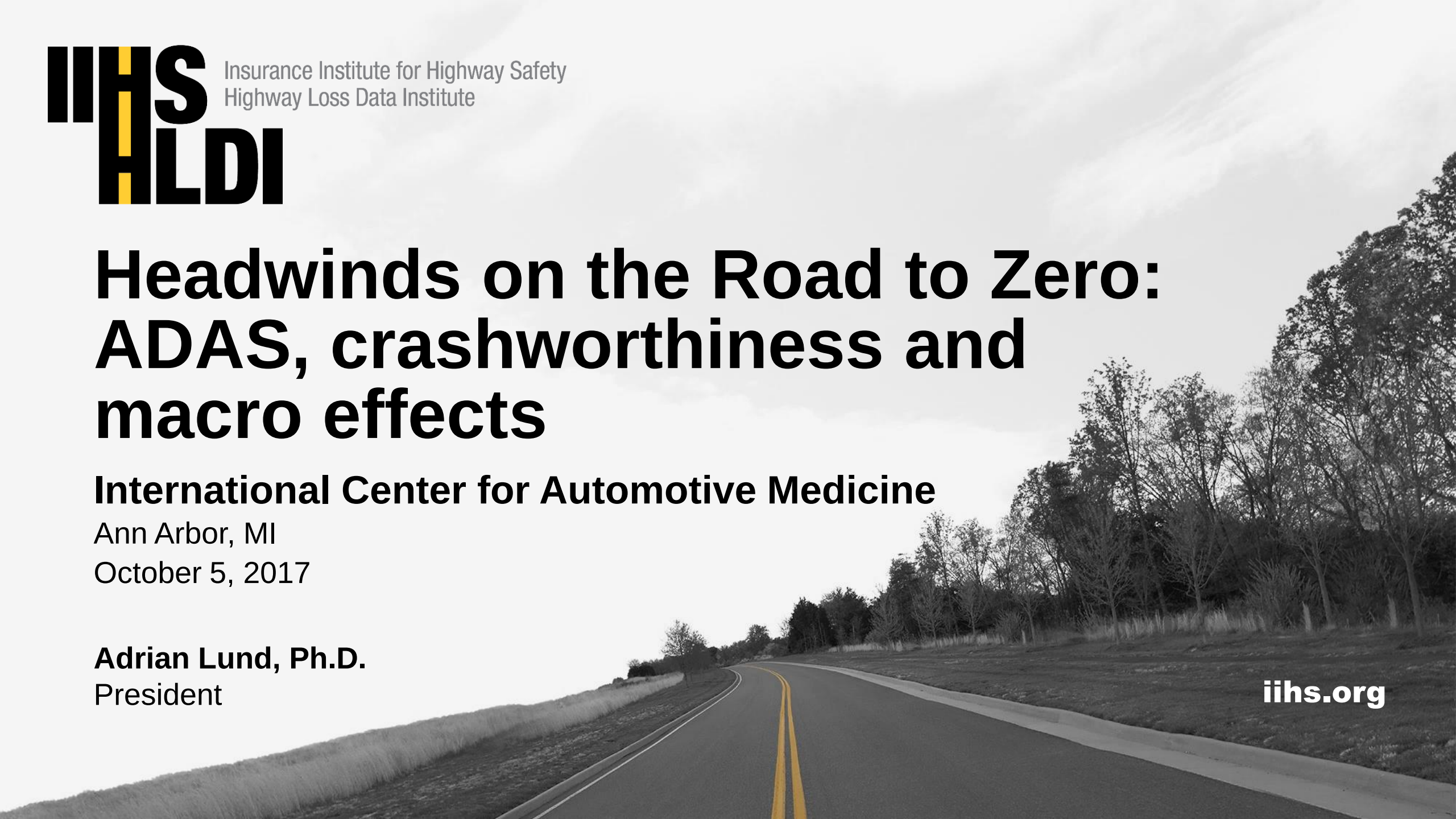
President

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. Established 1959.

HLDI shares this mission by analyzing insurance data representing human and economic losses from crashes and other events related to vehicle ownership. Established 1972.

Both organizations are wholly supported by auto insurers.

Institute activities

We do not lobby, legislate, or litigate

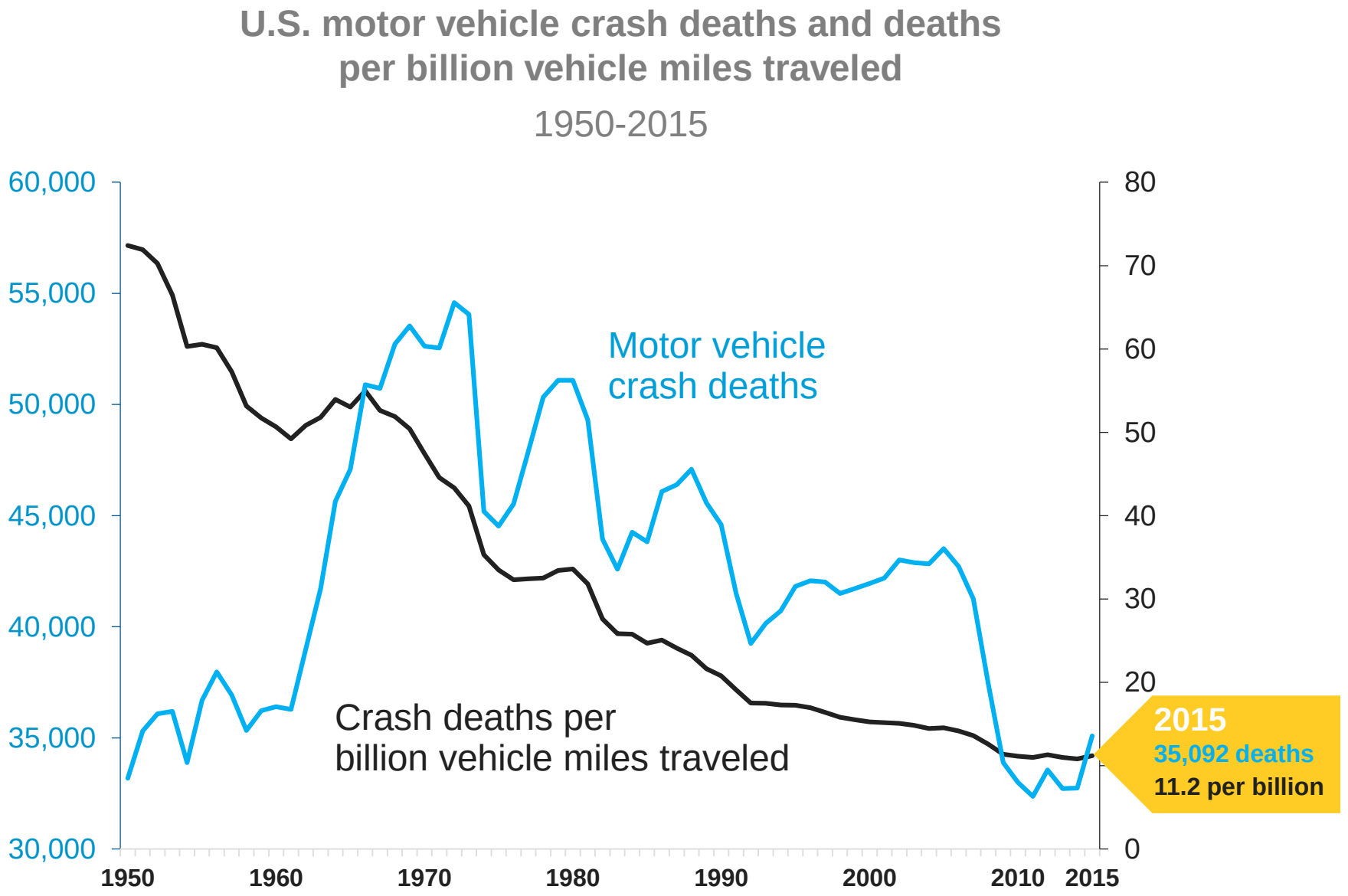
- IIHS and HLDI rely on aggressive research and communications to empower people and policymakers with objective information
- Priority 1 – objective research on policy options to reduce injuries and property damage from motor vehicle crashes
- Priority 2 – effective communications to make research information attractive to news media
  - News releases (TV, print, Internet)
  - Films
  - Testimony at state and federal legislative and regulatory hearings
  - Briefings of other stakeholders, including vehicle manufacturers

Haddon matrix

Recognizing opportunities to make a difference

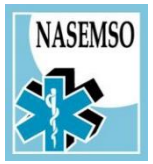
	crash phase			
changes in…	before	during	after	losses
people	•licensing (GDL, elderly) •impaired driving laws •camera enforcement	•restraints (use) •helmets •speed cameras	•alcohol •medical bracelet •general health	•injuries •deaths •income •hospital costs
vehicles	•driver assistance •daytime running lights •electronic stability control •advanced headlights	•restraints (effect) •vehicle structure •bumpers	•automatic crash notification •fuel systems •repairability	•damage •insurance costs
environment	•intersection design •trouble-spot treatment •rumble strips	•roundabouts •breakaway poles •crash cushions	•emergency medicine	•economic •fuel usage (CAFE) •congestion

Motor vehicle crash deaths have declined significantly in the U.S. during the past 50+ years.



Established October 2016

450 members



Headwinds on the Road to Zero

Wednesday, February 15, 2017

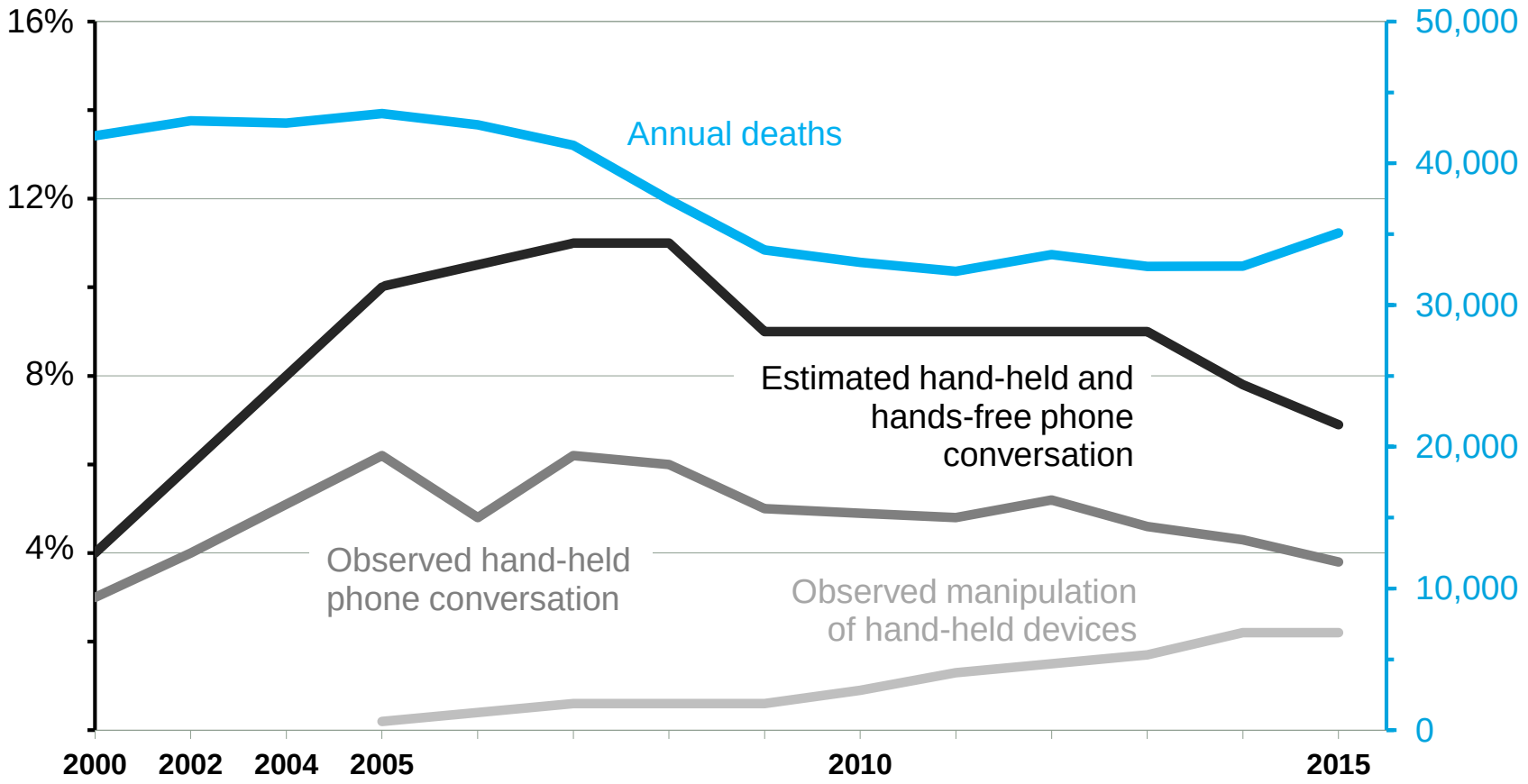
Motor Vehicle Deaths in 2016 Estimated to be Highest in Nine Years

NSC offers insight into what drivers are doing and calls for immediate implementation of proven, life-saving measures.

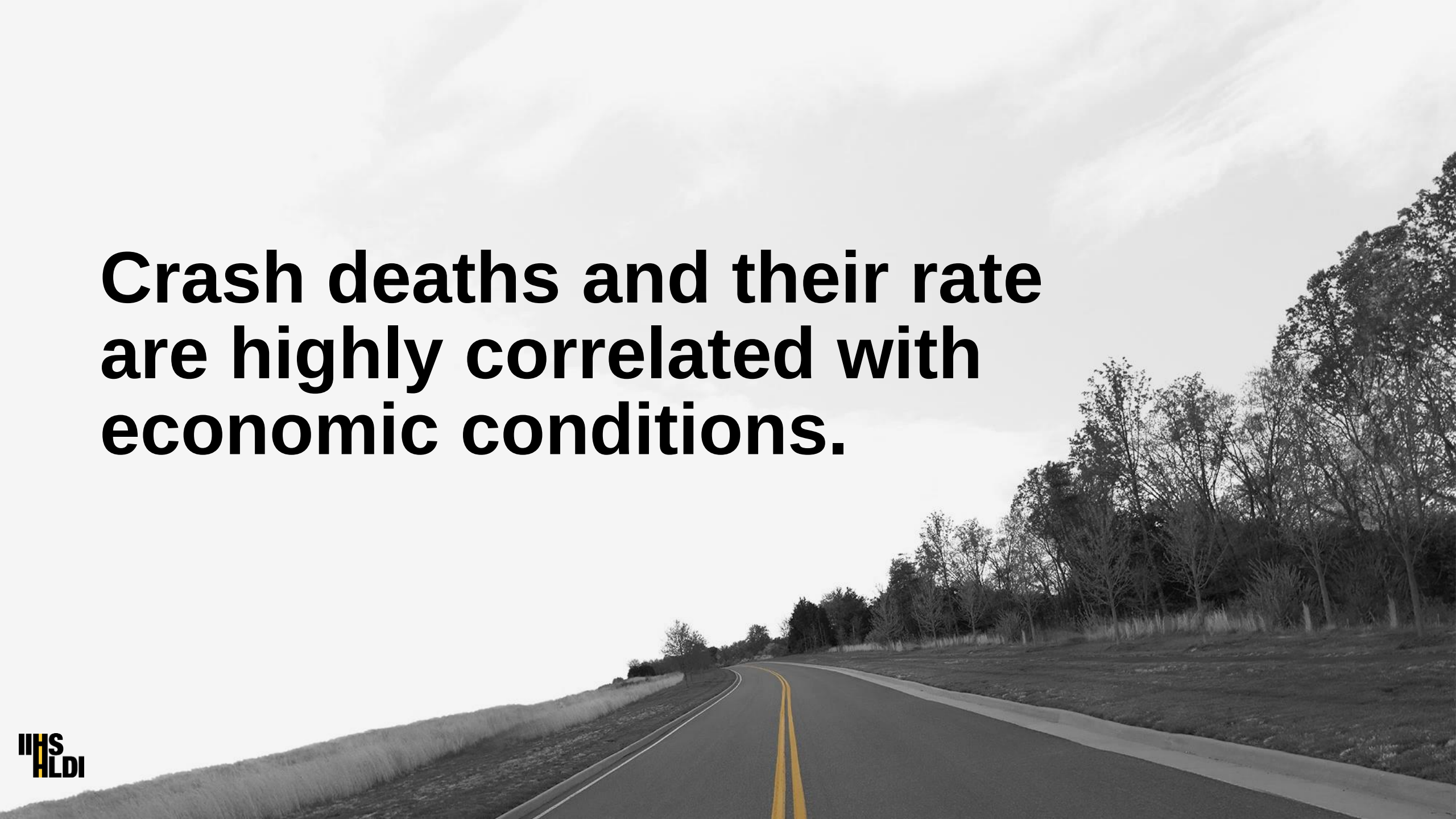
Itasca, IL – For the first time in nearly a decade, preliminary 2016 data from the National Safety Council estimates that as many as 40,000 people died in motor vehicle crashes last year. That marks a 6% increase over 2015, and a 14% increase over 2014 – the most dramatic two-year escalation since 1964 – 53 years. The preliminary estimate means 2016 may have been the deadliest year on the nation's roads since 2007. An estimated 4.6 million roadway users were injured seriously enough to require medical attention in 2016, and estimated cost to society was $432 billion.

Percent U.S. drivers using cellphones at any given daylight time and motor vehicle crash deaths

2000-15

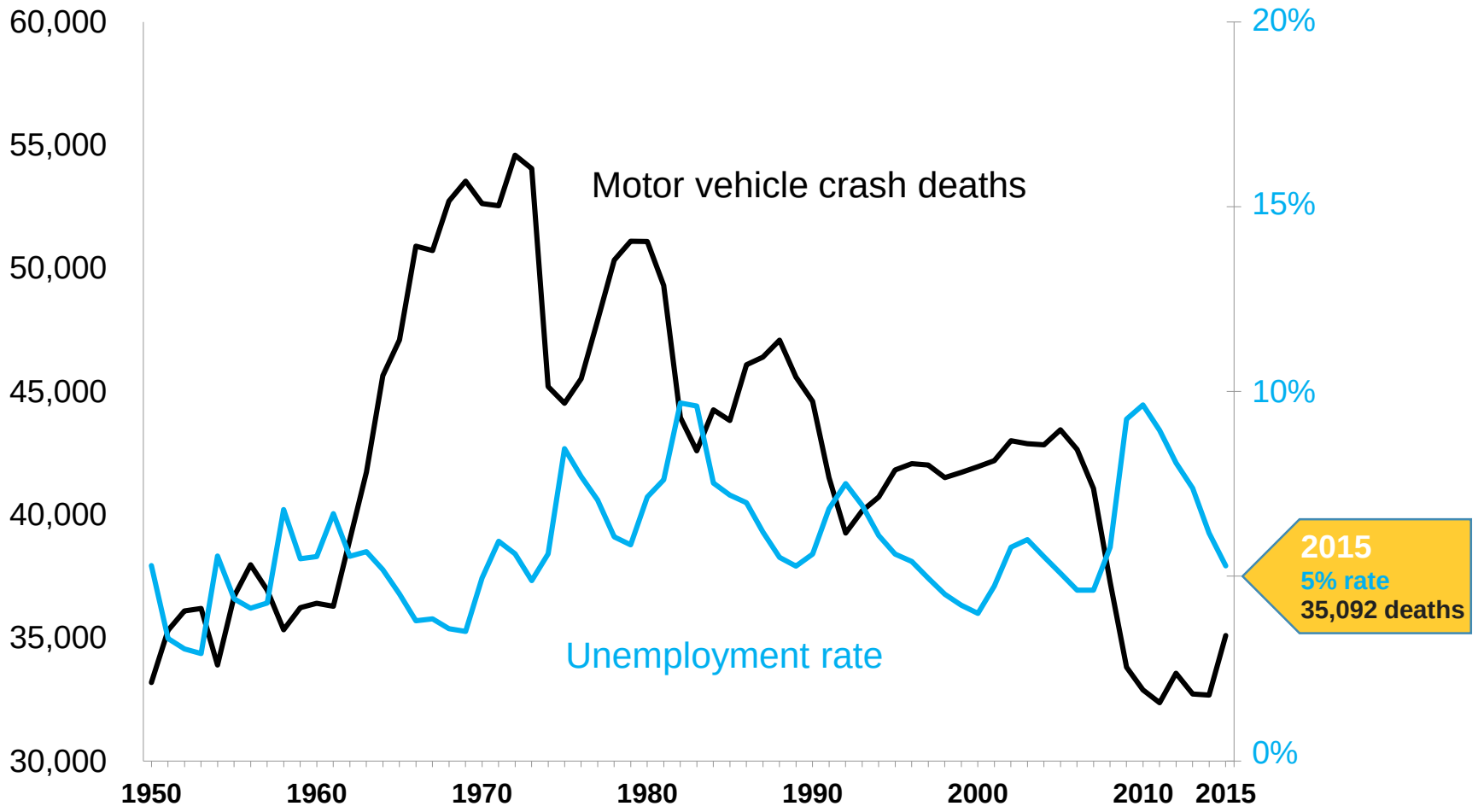


Crash deaths and their rate are highly correlated with economic conditions.



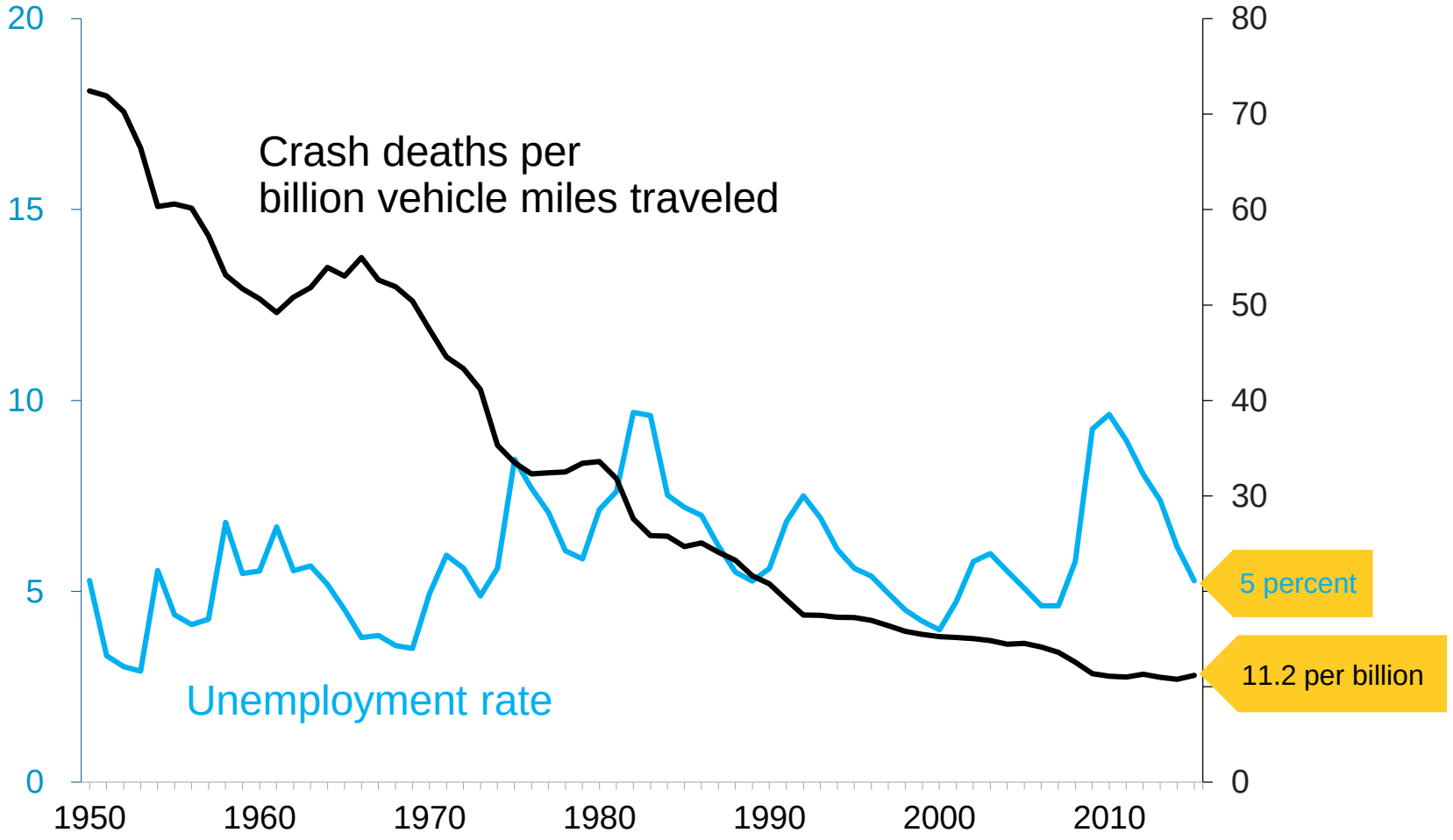
U.S. motor vehicle crash deaths and unemployment rate

1950-2015



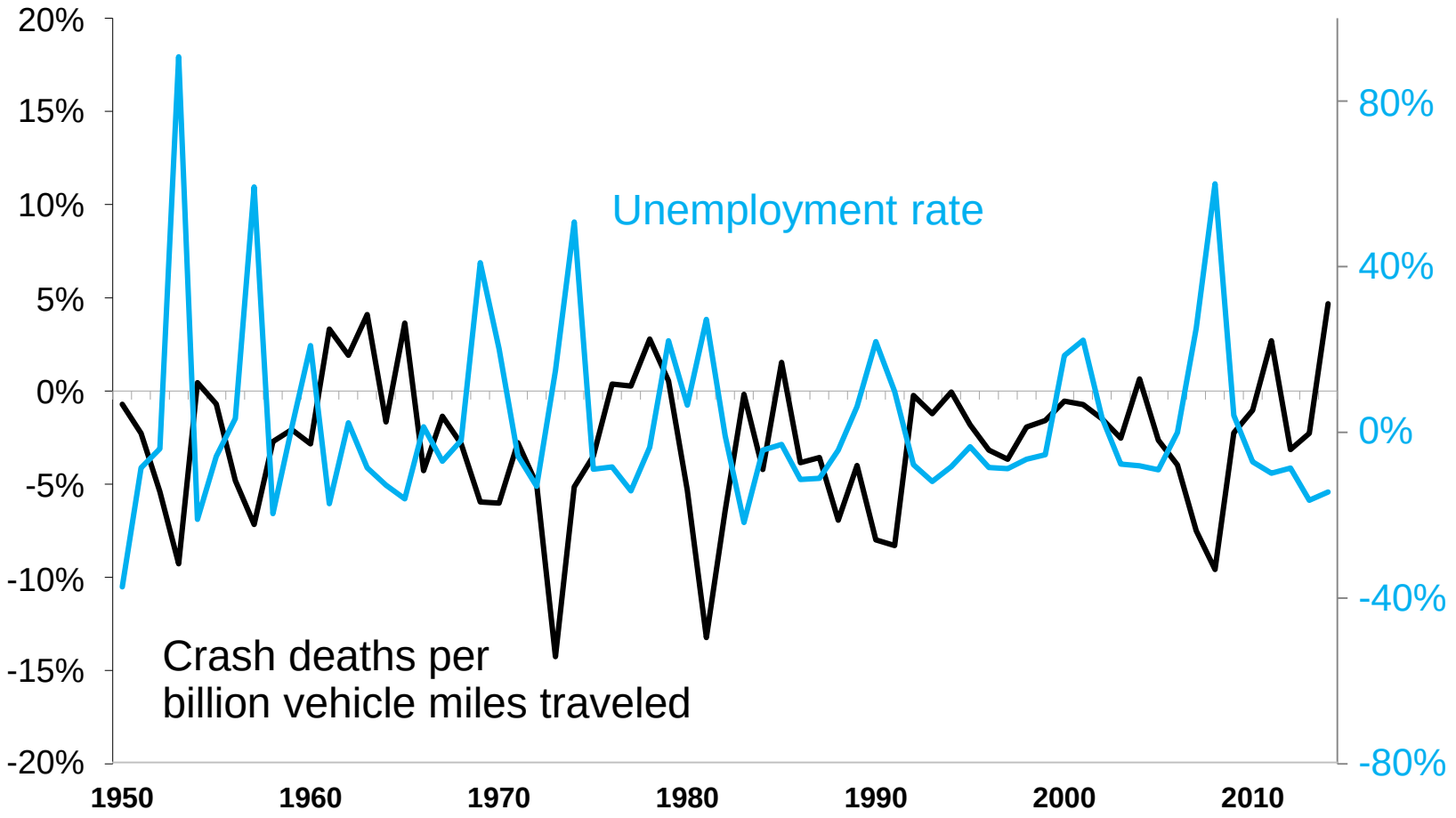
U.S. motor vehicle crash deaths per billion vehicle miles traveled and unemployment rate

1950-2015



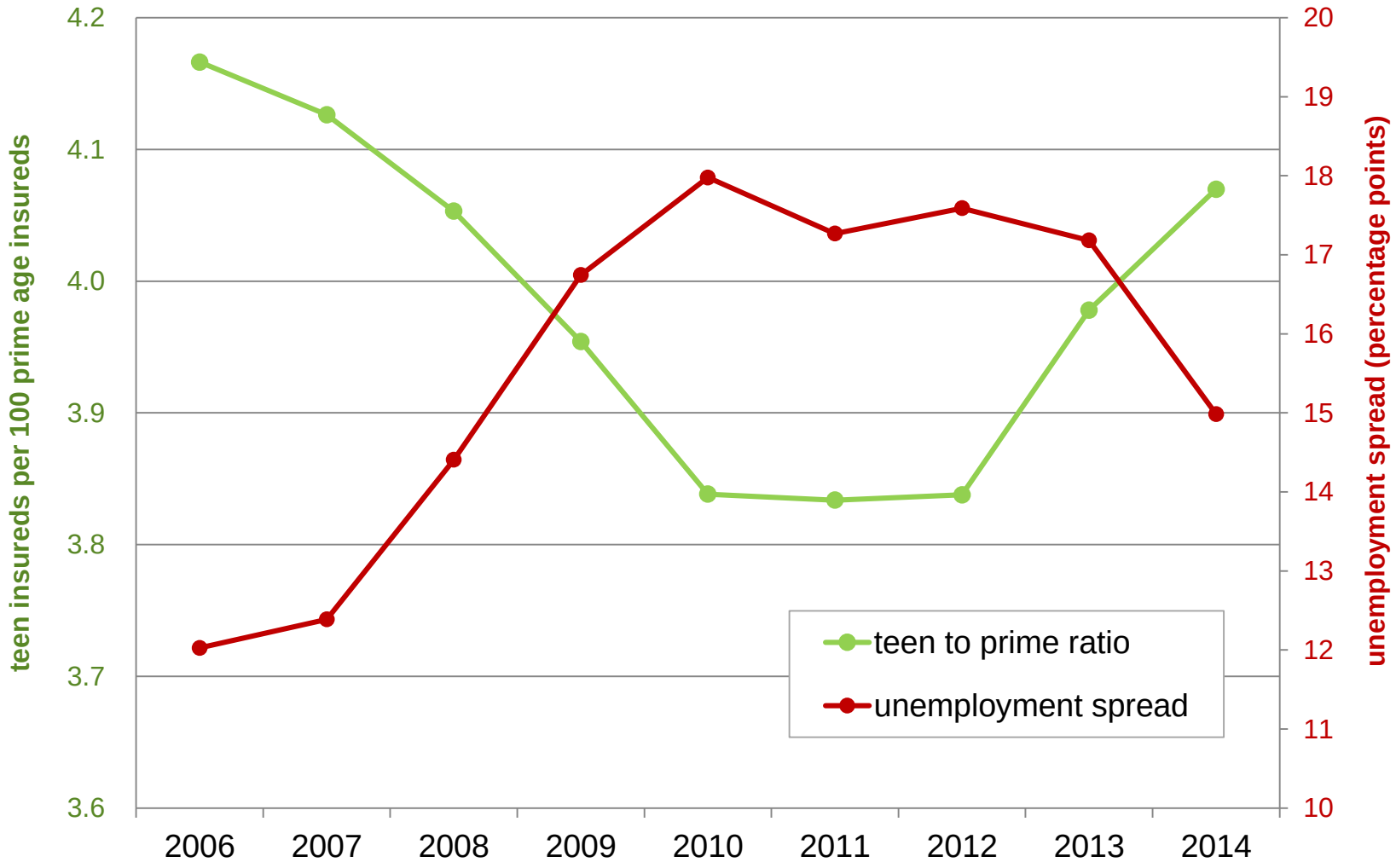
Change in U.S. motor vehicle crash deaths per billion miles traveled and unemployment rate

1950-2015



Youth are returning to cars after recession

Insurance exposure and unemployment 2006-14



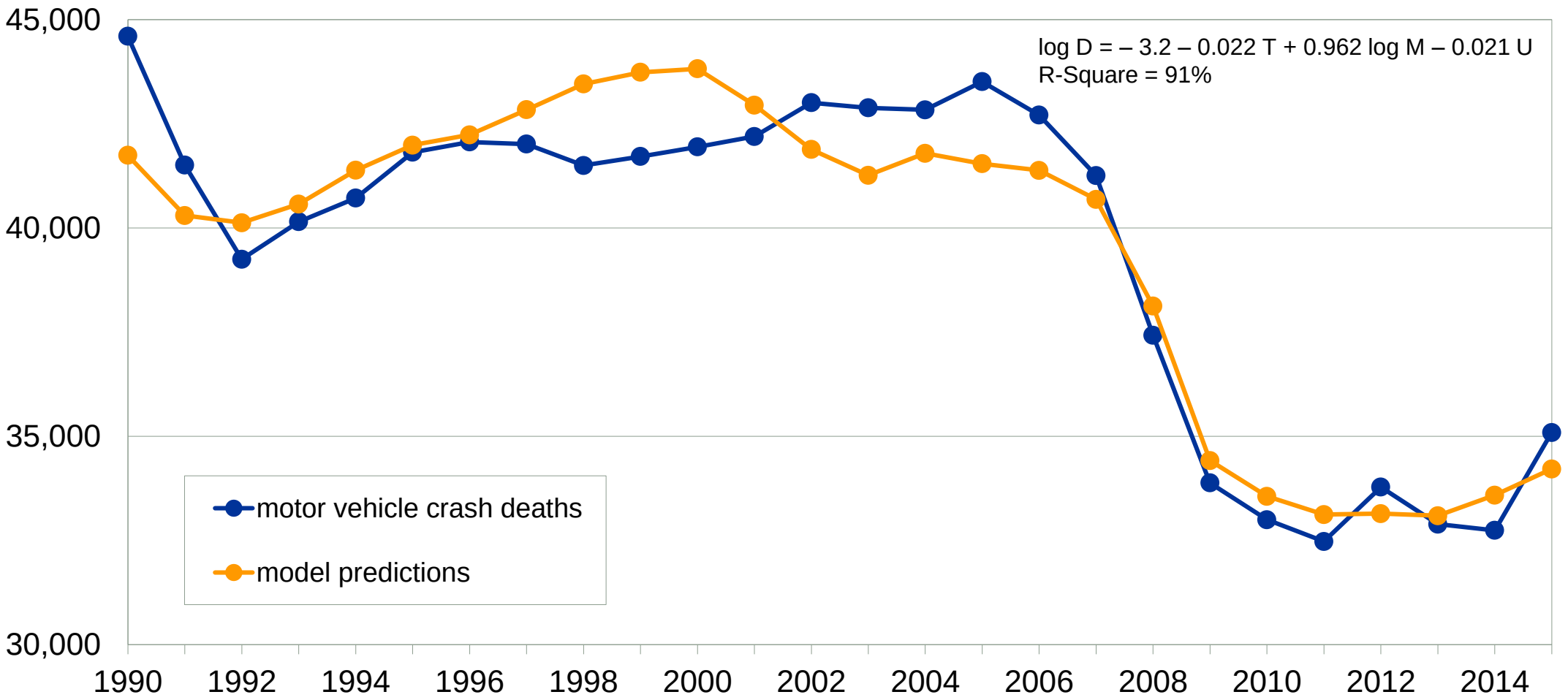
Effects of economy on miles traveled and crash deaths

1990-2015

- Miles traveled
  - Increase by 1.5% each year, on average
  - Increase by another 1.8% for each 1 percentage point decline in unemployment
- Crash deaths
  - Decrease by 2% each year, on average
  - Increase by 1% for each 1% rise in miles
  - Increase by another 2% for each 1 percentage point decline in unemployment
- Combined with the effect on miles traveled, each 1 percentage point decline in unemployment is associated with about a 4% increase in crash deaths

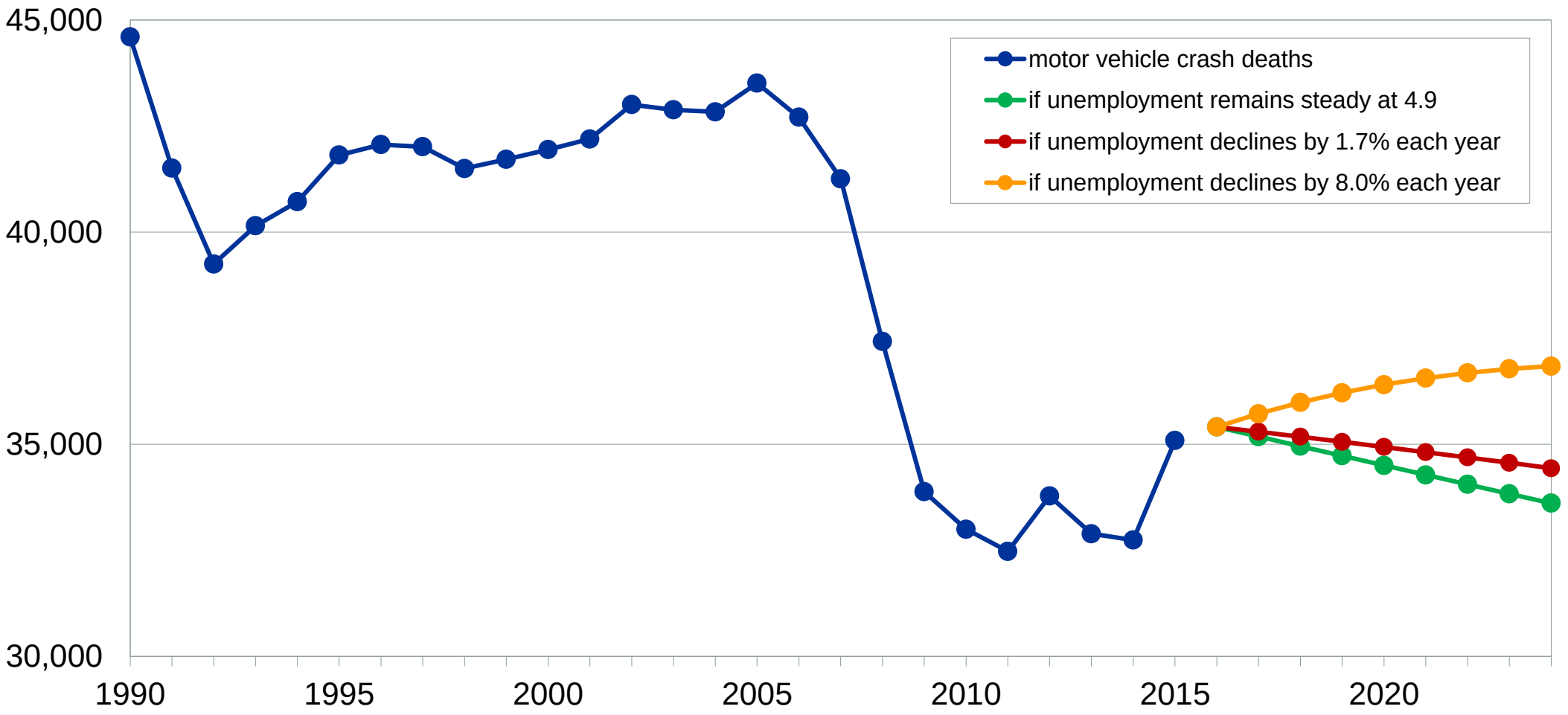
Motor vehicle crash deaths, 1990-2015

Actual vs. model containing time trend, miles traveled and unemployment



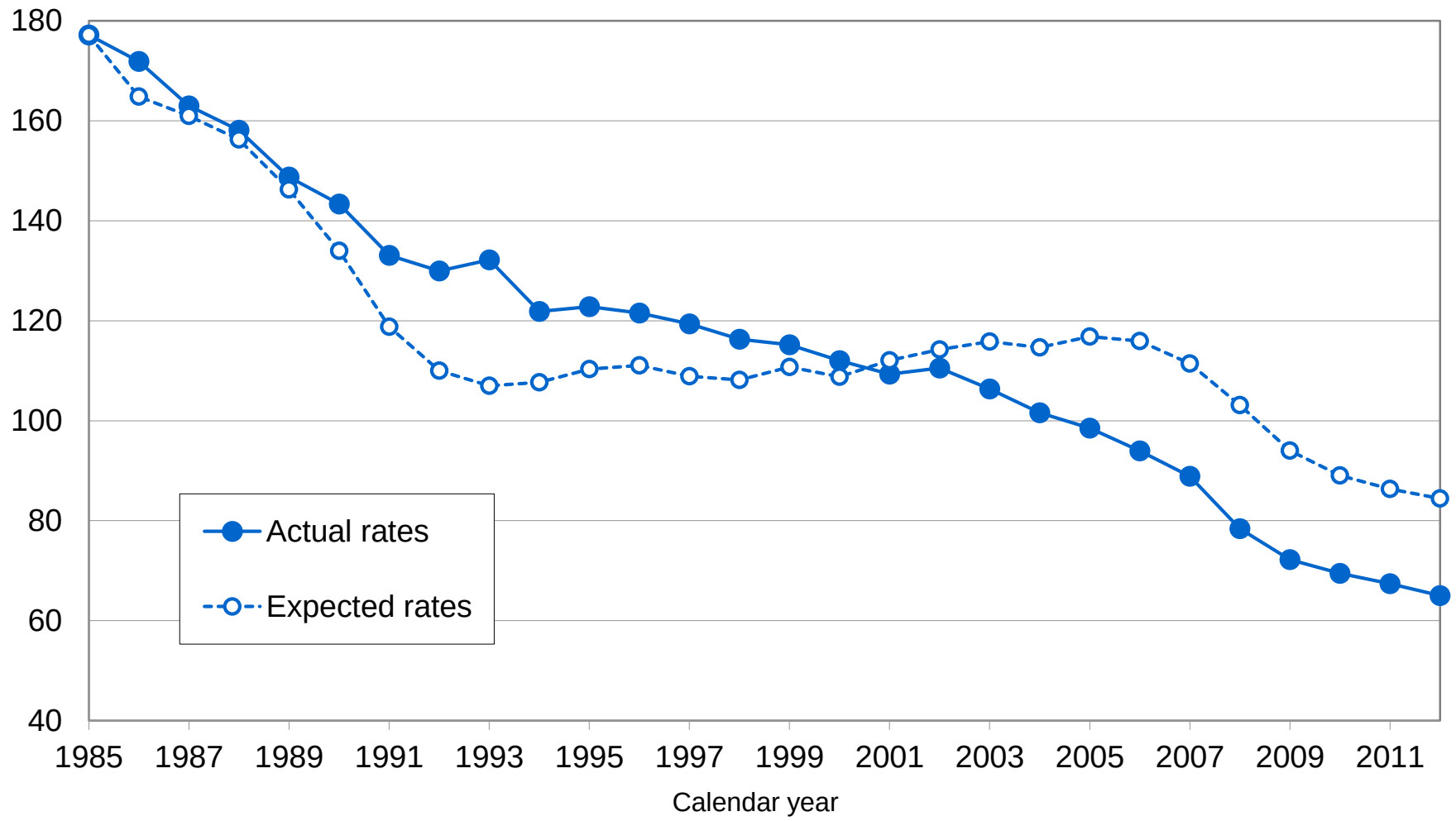
Motor vehicle crash deaths, 1990-2015

With projections for 2016-24



Vehicle and non-vehicle factors and highway safety

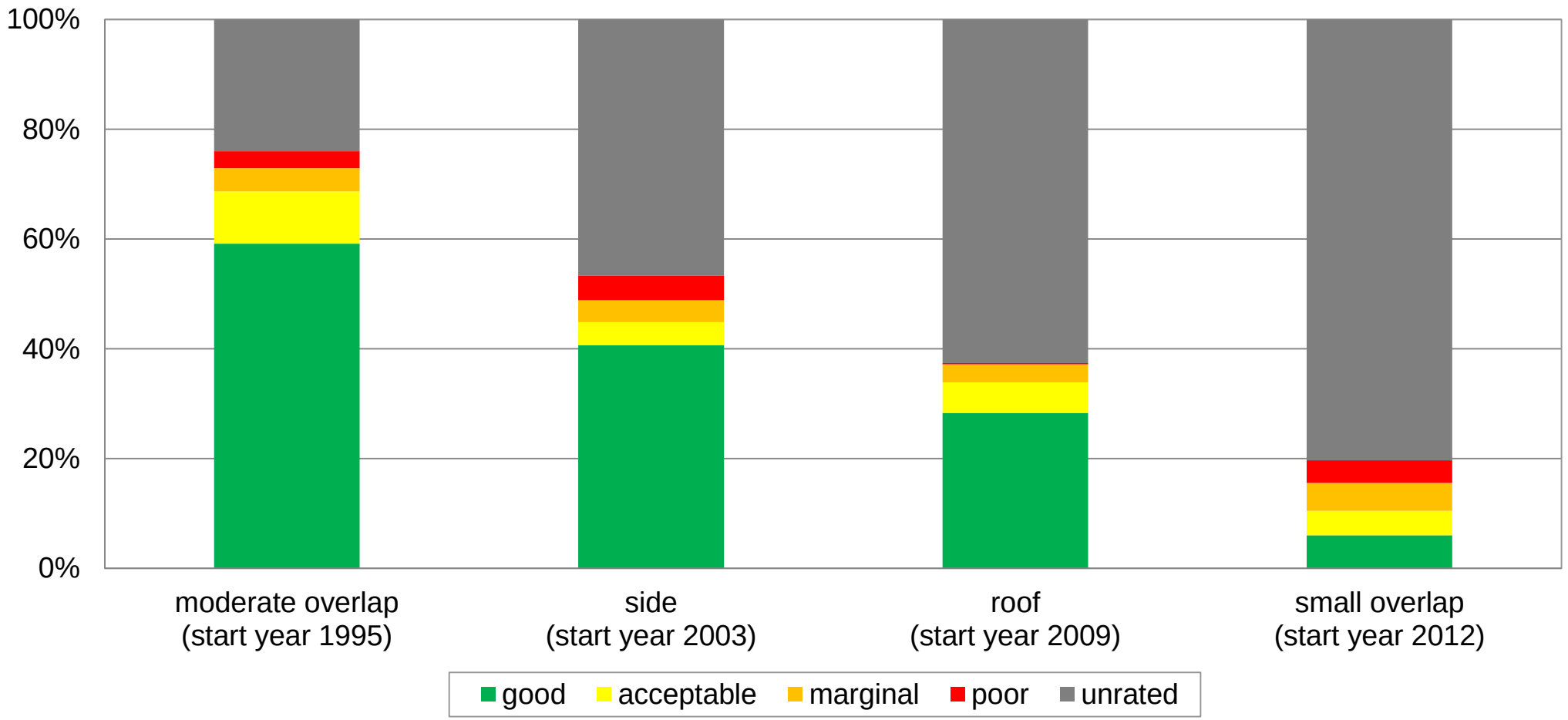
Passenger vehicle driver deaths per million vehicles, actual vs. expected for 1985 fleet



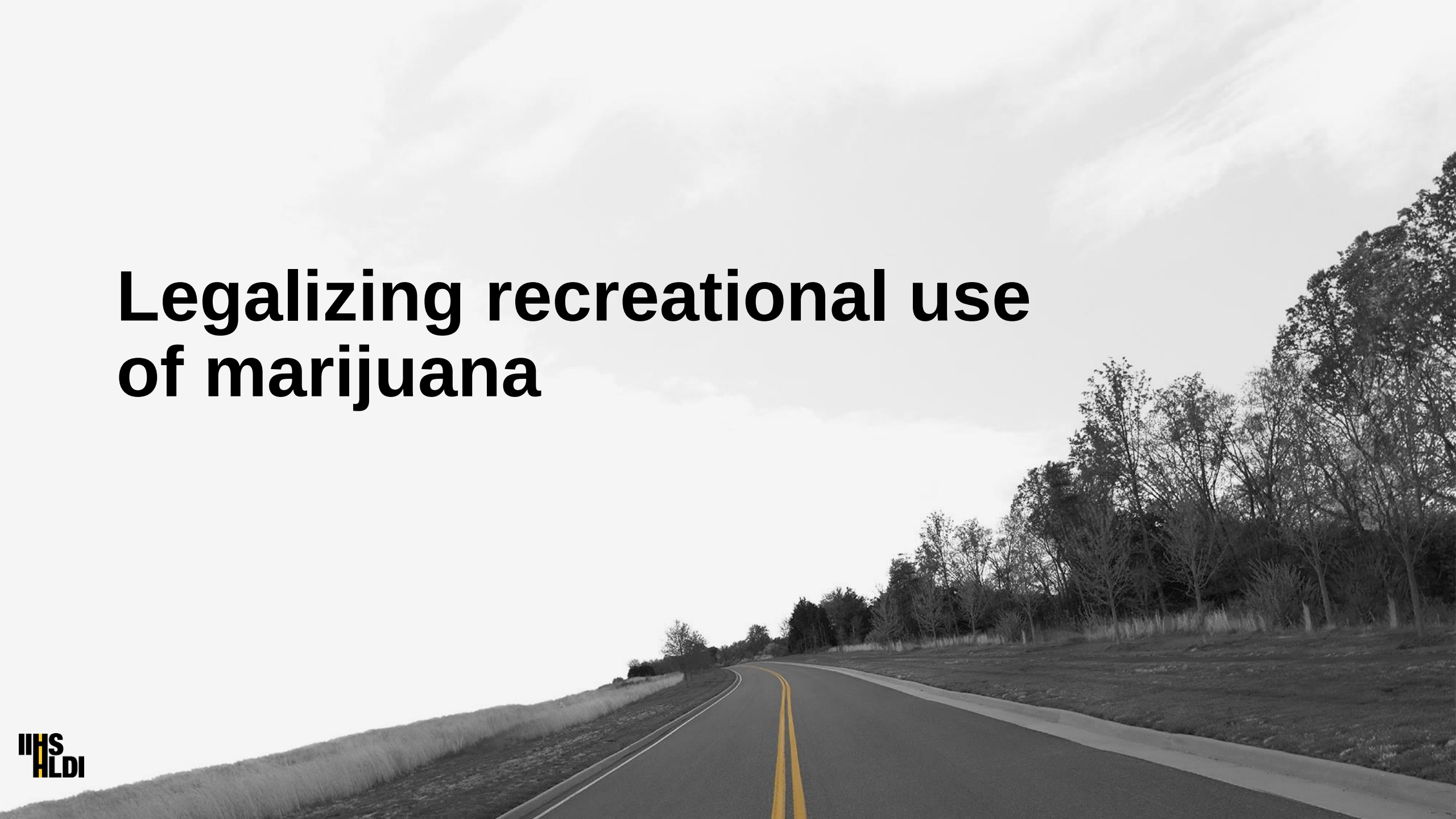
Crashworthiness in 1959 and 2009

2016 ratings for registered vehicles

All registered vehicles

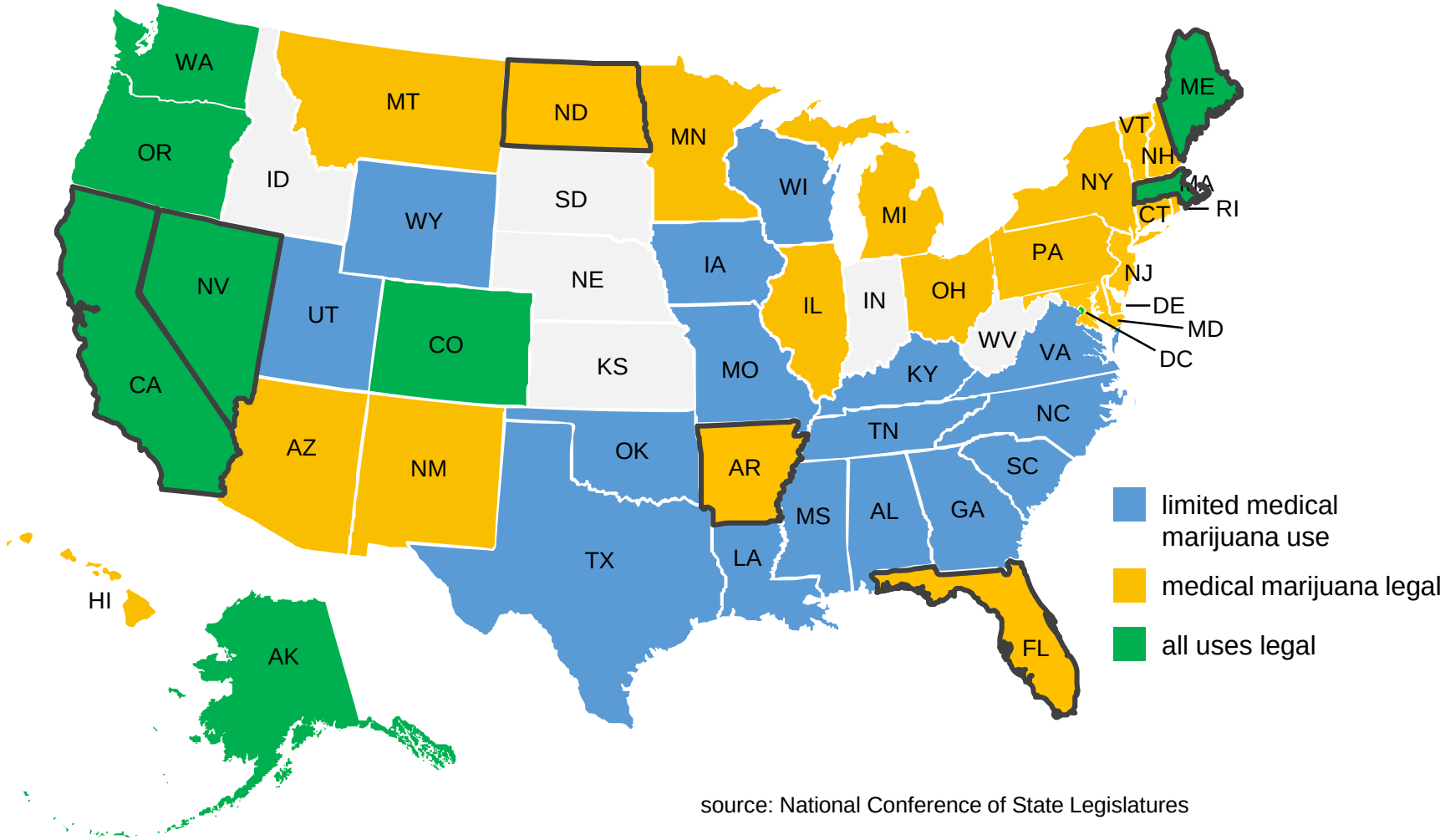


Legalizing recreational use of marijuana



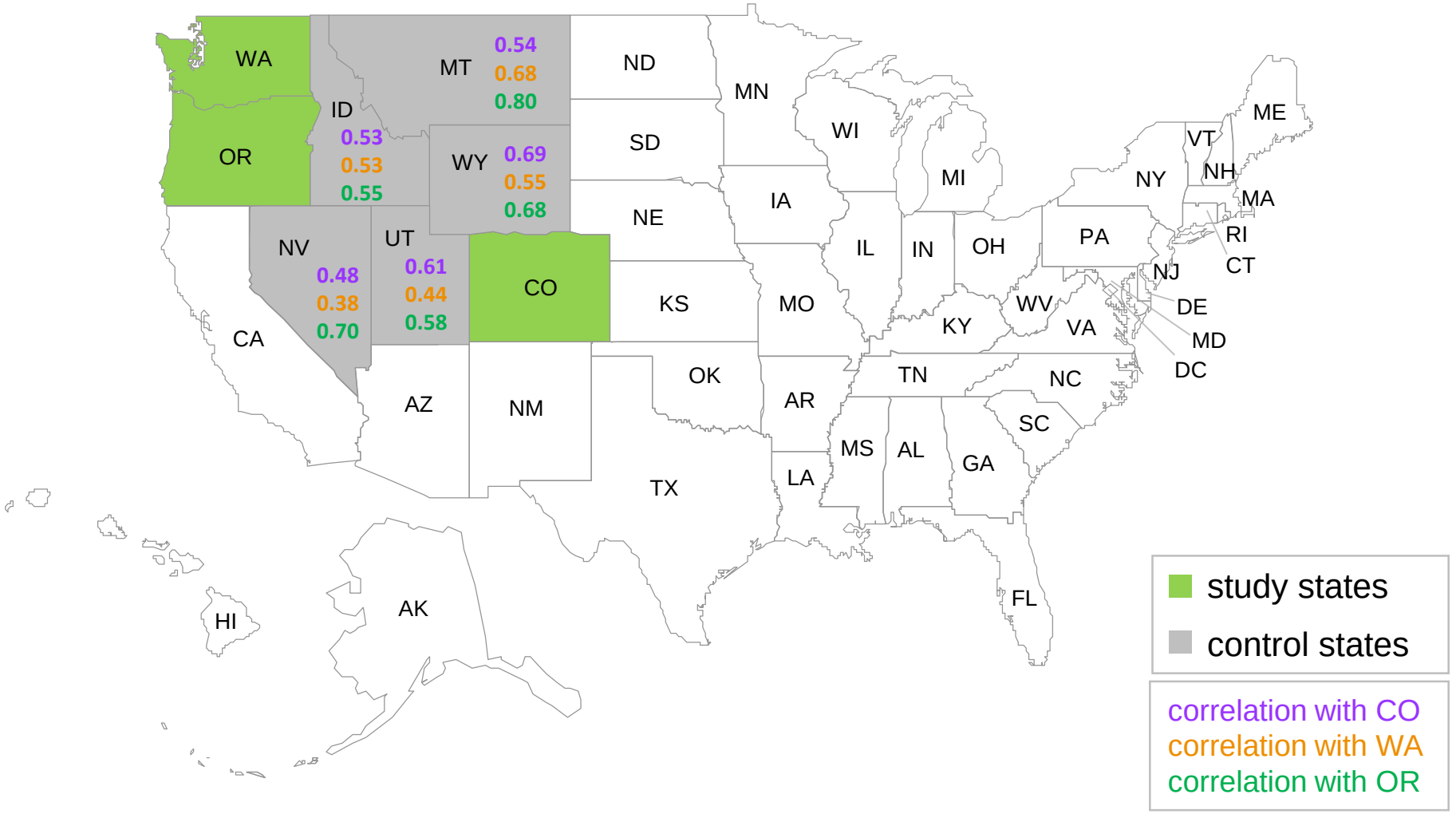
Laws legalizing some uses of marijuana

After 2016 general election



source: National Conference of State Legislatures

Combined evaluation of legal recreational-use states



Collision claims after legalization of recreational marijuana use

Combined analysis of Colorado, Oregon, and Washington – HLDI 2017

study states	Colorado, Washington, Oregon
additional control states	Idaho, Montana, Nevada, Utah, Wyoming
calendar years	January 2012-October 2016
exposure	49,225,462 vehicle years for vehicles up to 33 years of age
total number claims	2,494,668
outcome measure	changes in collision claims per insured vehicle year
result	2.7% increase in collision claims (statistically significant)

IIHS HLDI

Two U.S. studies differ over effects of marijuana on drivers

U.S. News & World Report, June 22, 2017

Studies offer conflicting conclusions on marijuana legalization's role in car crashes, fatalities

The Cannabist, June 23, 2017

After-legalization traffic studies draw conflicting conclusions

Ganjapreneur, June 26, 2017

Studies differ over impact of legalized pot on highway crash numbers

Portland Press Herald, June 26, 2017

The jury is still out on legalizing marijuana impacting road collision rates

Auto Evolution, June 28, 2017

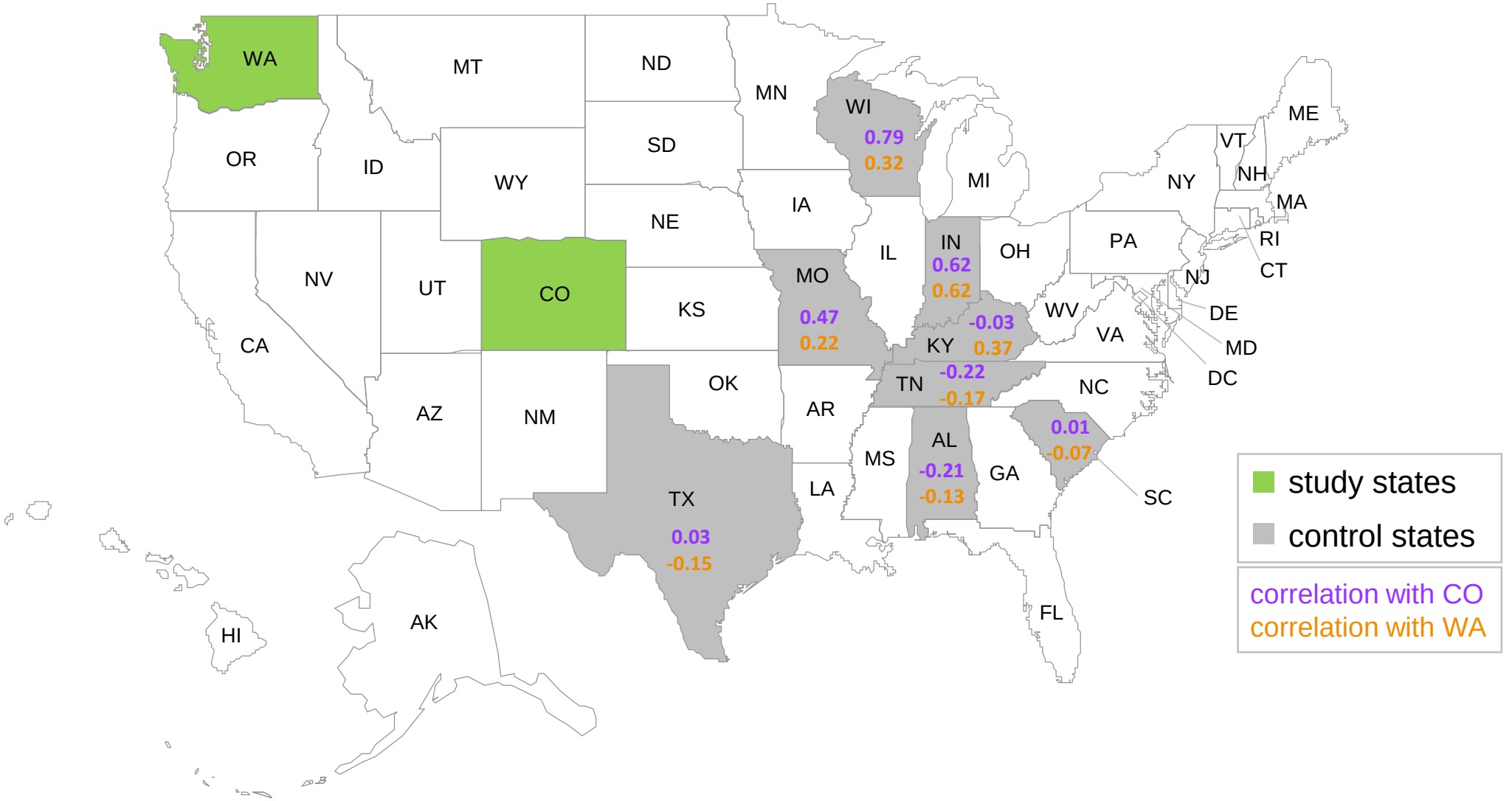
Two studies about driving and marijuana have very different results

Emerald Report, June 29, 2017

Competing studies leave haze of uncertainty connecting marijuana to traffic accidents

Colorado Politics, July 3, 2017

Pre-period correlations of collision claim rates between study states and control states used by Aydelotte et al. 2017, *AJPH*

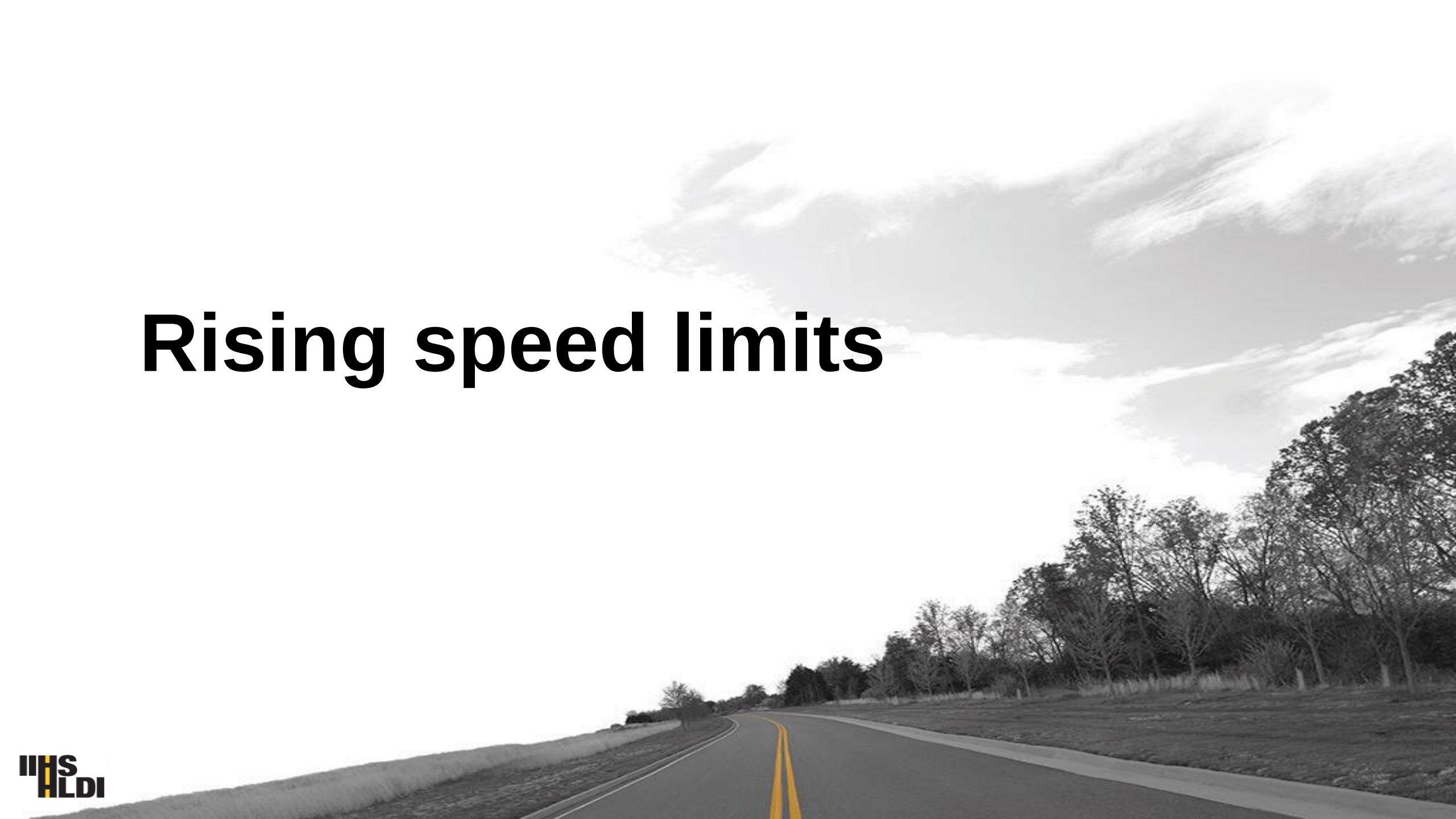


Crash deaths after legalization of recreational marijuana use

Colorado and Washington – Aydelotte et al. 2017, *AJPH*

study states	Colorado and Washington
control states	Alabama, Indiana, Kentucky, Missouri, South Carolina, Tennessee, Texas, Wisconsin
calendar years	January 2009-December 2015
outcome measure	changes in annual motor vehicle crash fatality rates per billion miles traveled
result	2.7% increase in fatalities (not statistically significant)

Rising speed limits

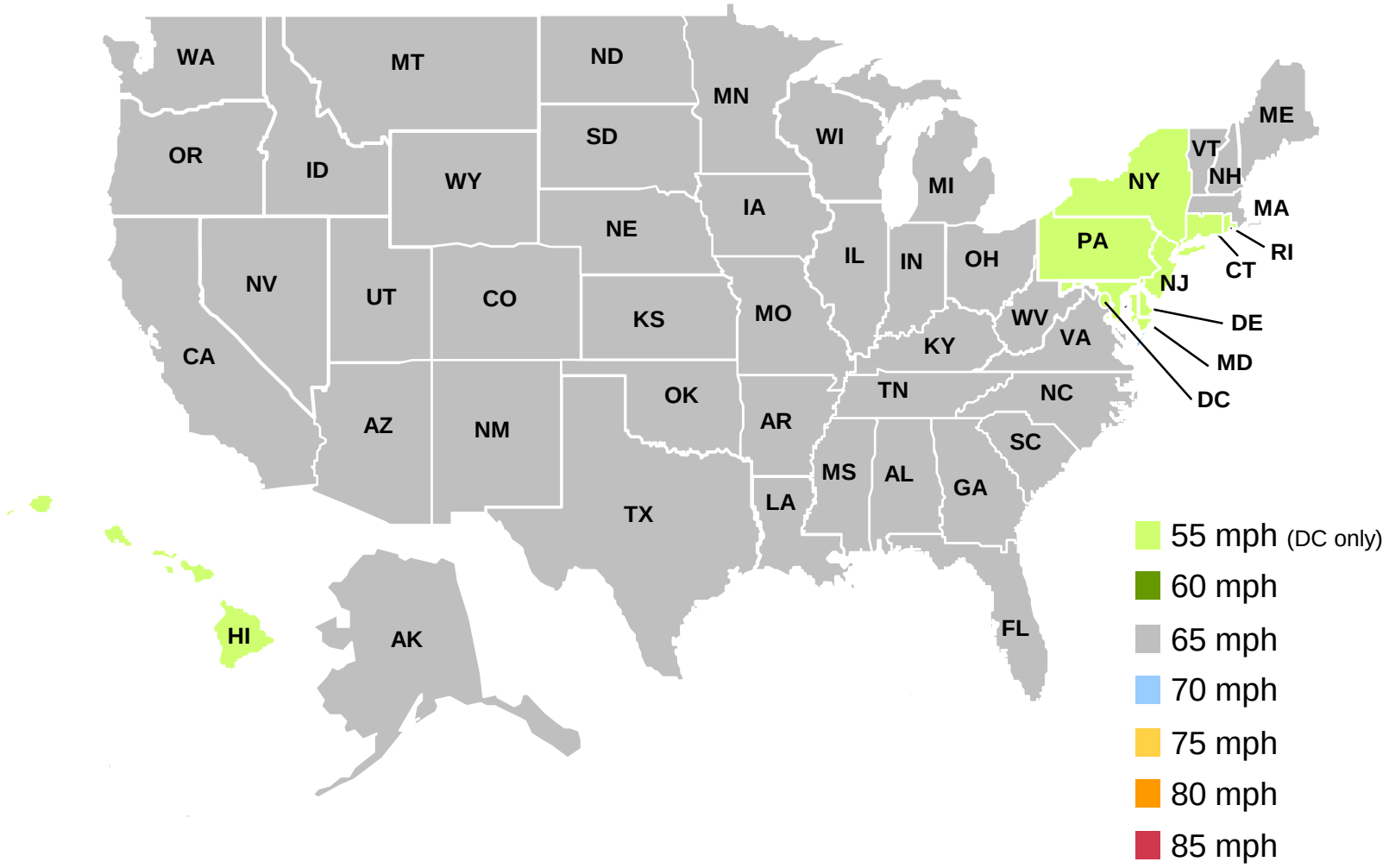


Effects of National Maximum Speed Limit

- 55 mph NMSL
  - 3,000-5,000 fewer deaths in 1974
  - 2,000-4,000 fewer deaths in 1983
- Partial repeal
  - 19 percent increase in deaths on rural interstates
  - 2,000 more deaths during 1987-90
- Full repeal
  - 17 percent increase in fatality rates on interstates
  - 1,000 more deaths during 1996-97
  - 12,545 more deaths during 1995-2005

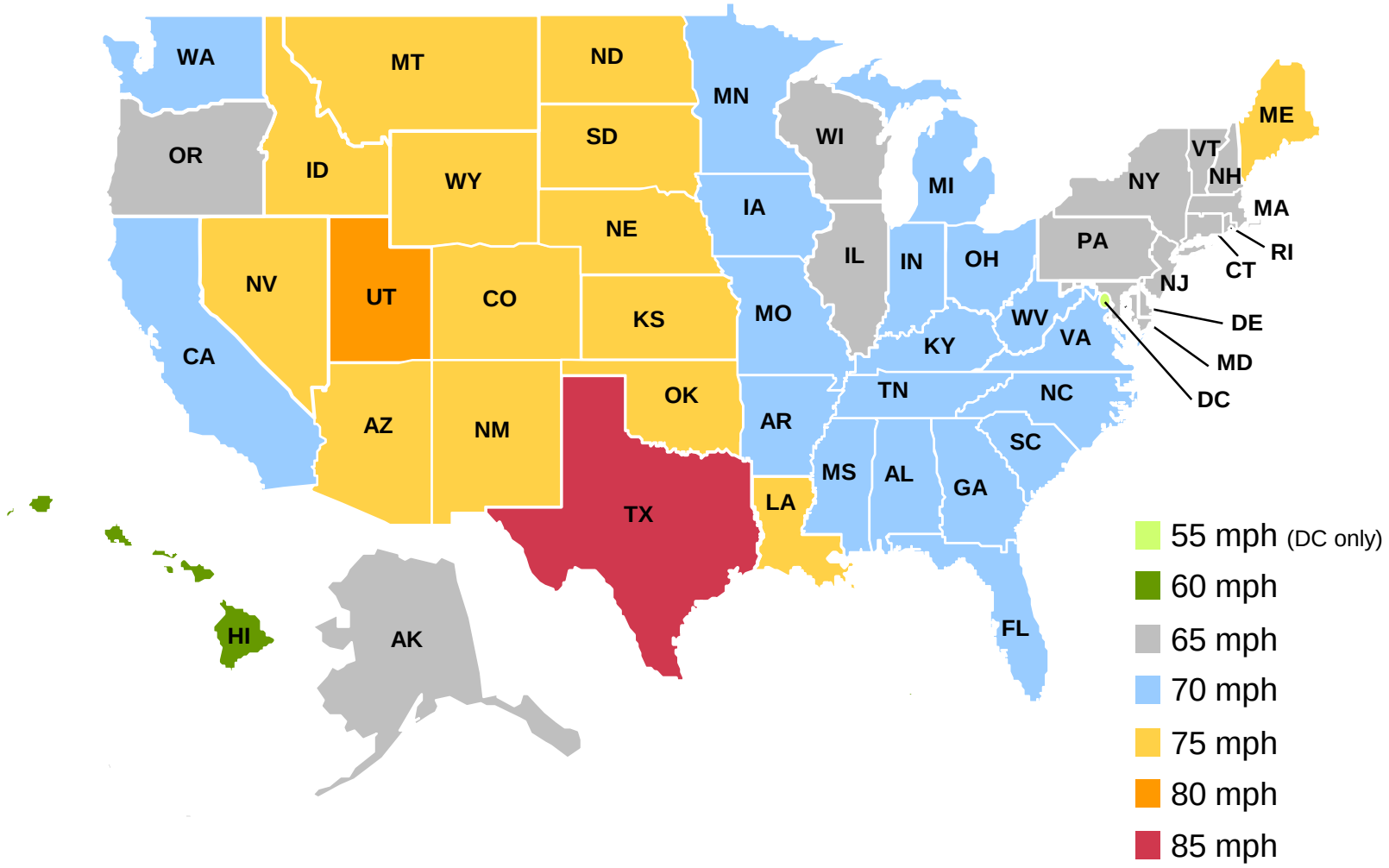
Maximum speed limits

January 1993



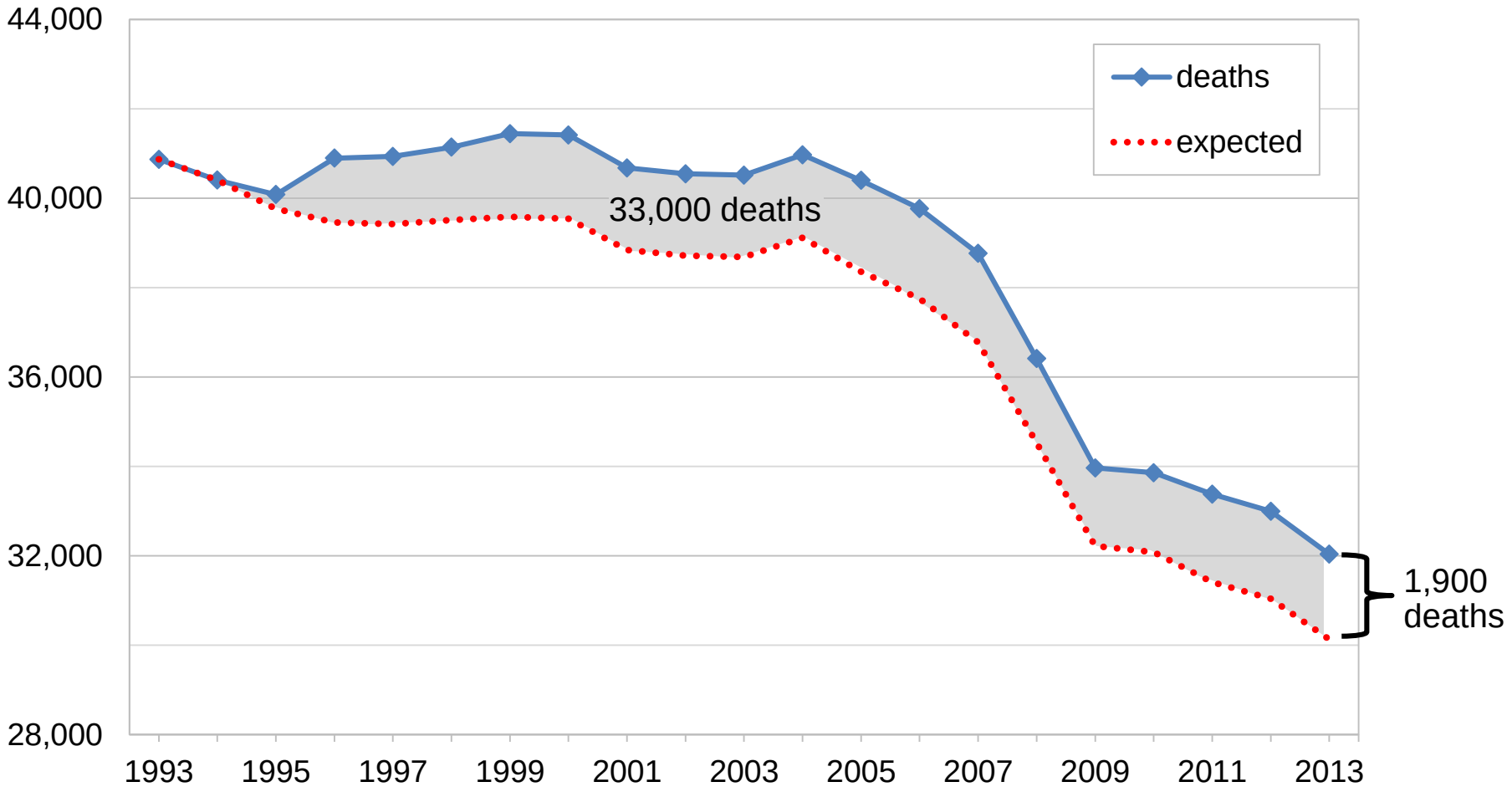
Maximum speed limits

January 2013



Deaths and expected deaths if maximum speed limits had not increased

1993-2013

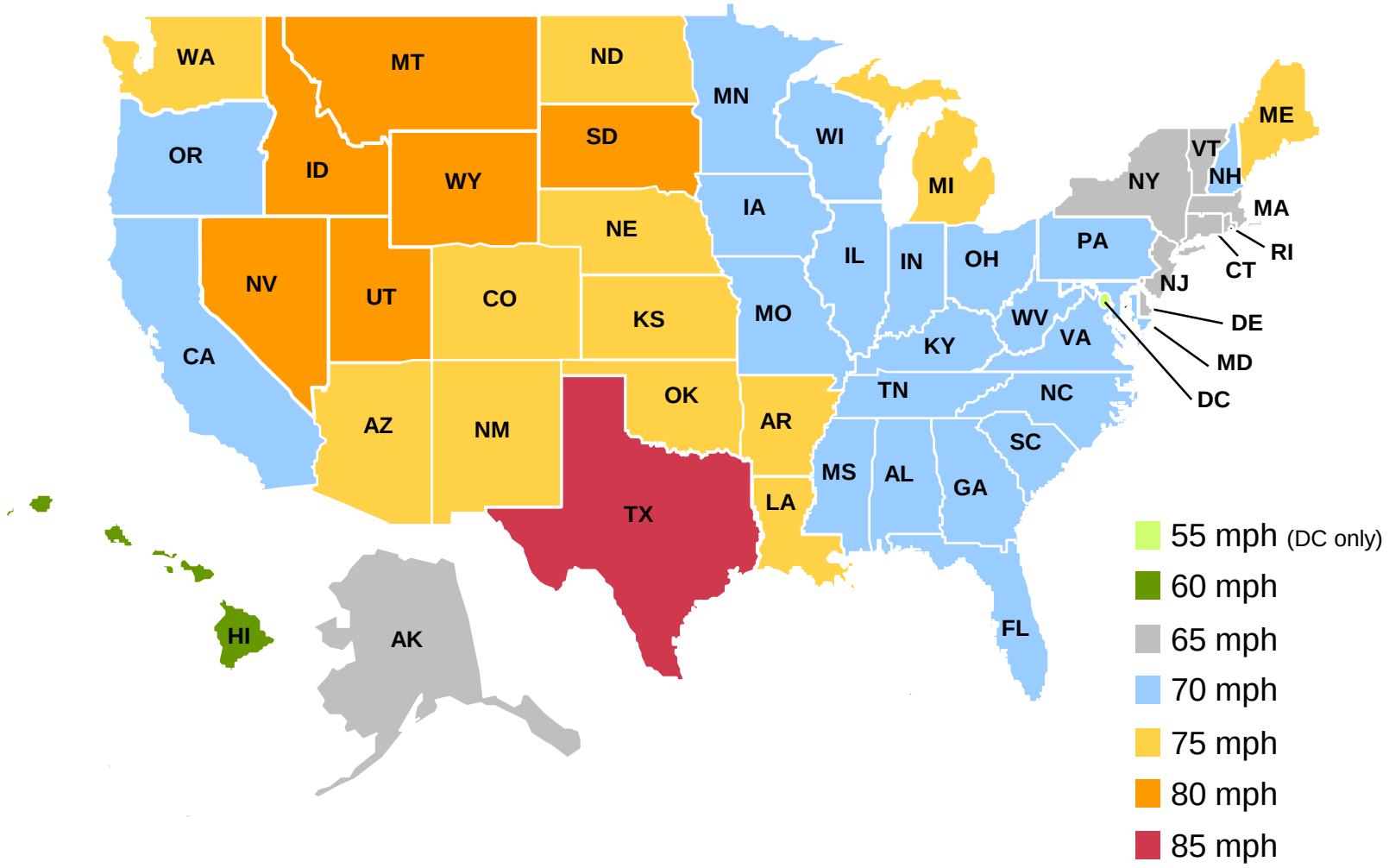


Summary

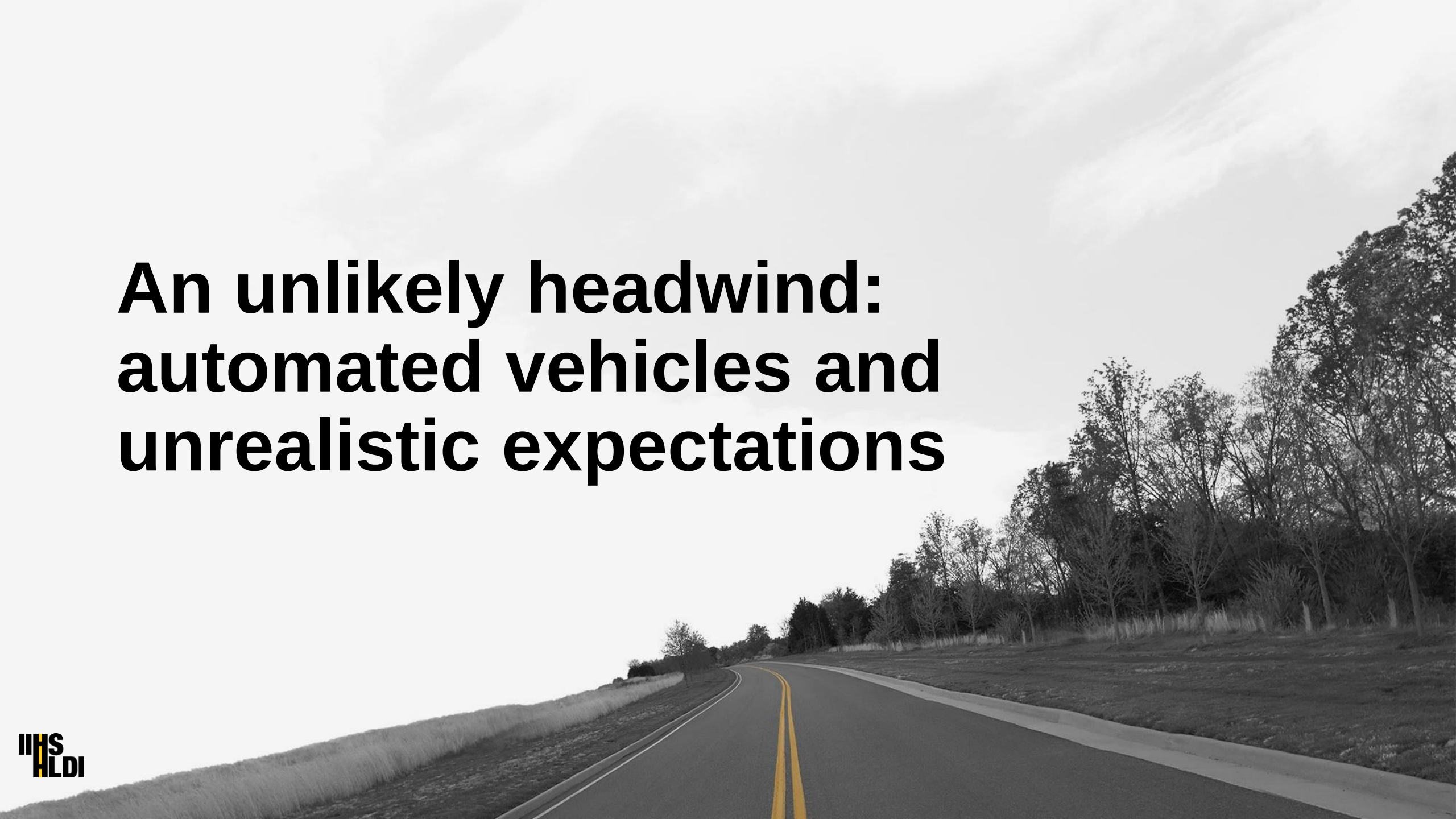
- Speed limits continue to go up
- 8 percent increase in traffic fatality rate on interstates and freeways for every 5 mph increase in maximum speed limits
  - 500 additional deaths in 2013
- 4 percent increase on other types of roads
  - 1,400 additional deaths in 2013
- Approximately 33,000 lives lost due to post-NMSL speed limit increases
  - Three quarters of the 43,000 lives saved by frontal airbags

Maximum speed limits

September 2017



An unlikely headwind: automated vehicles and unrealistic expectations



Front crash prevention systems are reducing police-reported rear-end strikes

Compared with vehicles without any front crash prevention…

…vehicles with **forward collision warning only** are **27% less likely** to rear-end another vehicle.

…vehicles with **forward collision warning AND autobrake** are **50% less likely** to rear-end another vehicle.

If every vehicle on the road had forward collision warning with autobrake in 2014, there would have been an estimated

1,000,000 fewer police-reported crashes

400,000 fewer police-reported injuries

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

99+% of U.S. market

Two auto suppliers join for self-driving cars by 2019

-USA Today, August 23, 2016

BMW Group, Intel and Mobileye team up to bring fully autonomous driving to streets by 2021

-Reuters, July 1, 2016

Lyft predicts mostly self-driving cars by 2021

-New York Post, September 19, 2016

Kia plans fully driverless cars by 2030

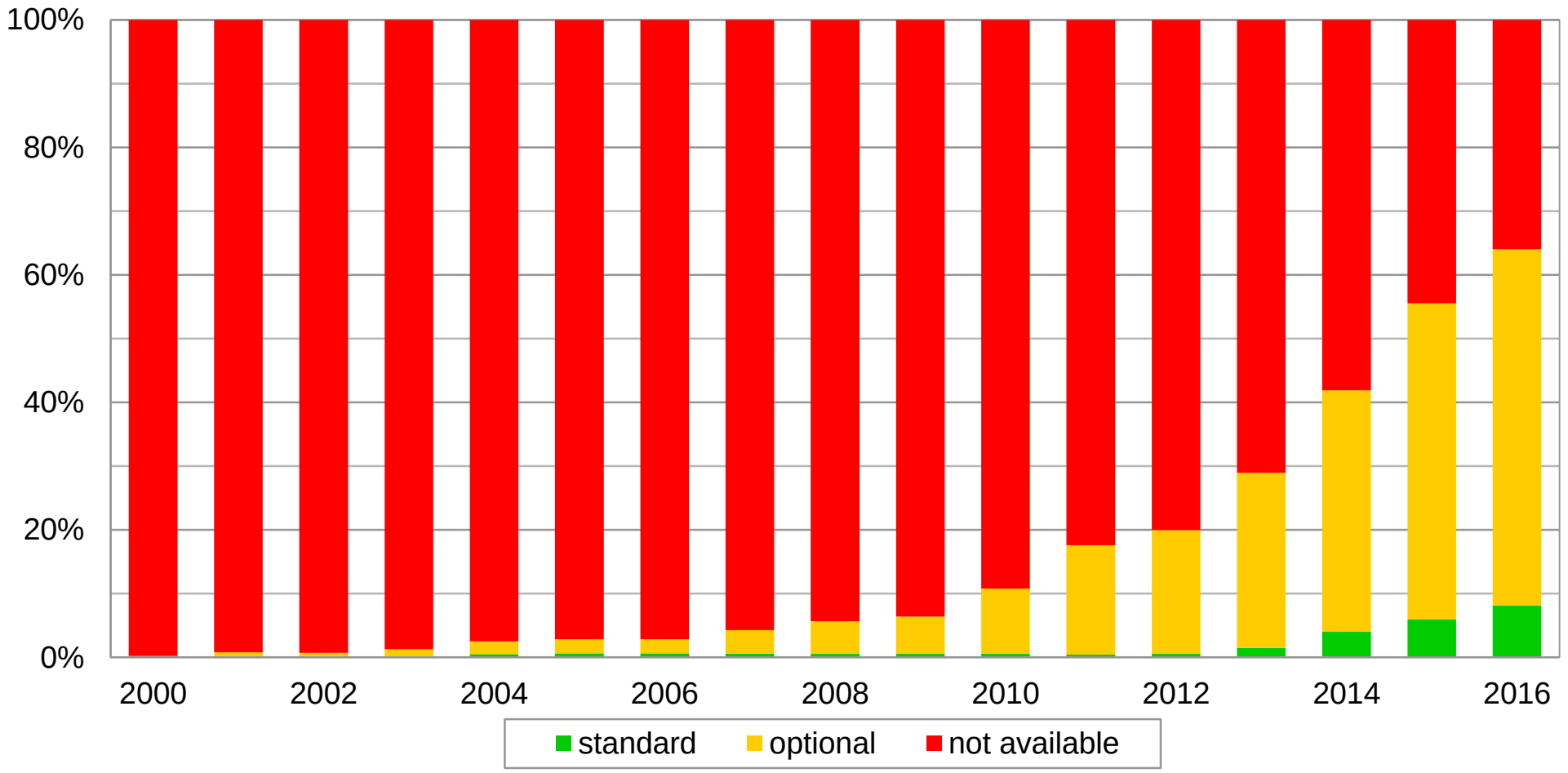
-The Detroit News, January 4, 2016

Ford targets fully autonomous vehicle for ride sharing in 2021; invests in new tech companies, doubles Silicon Valley team

-Ford media center, August 16, 2016

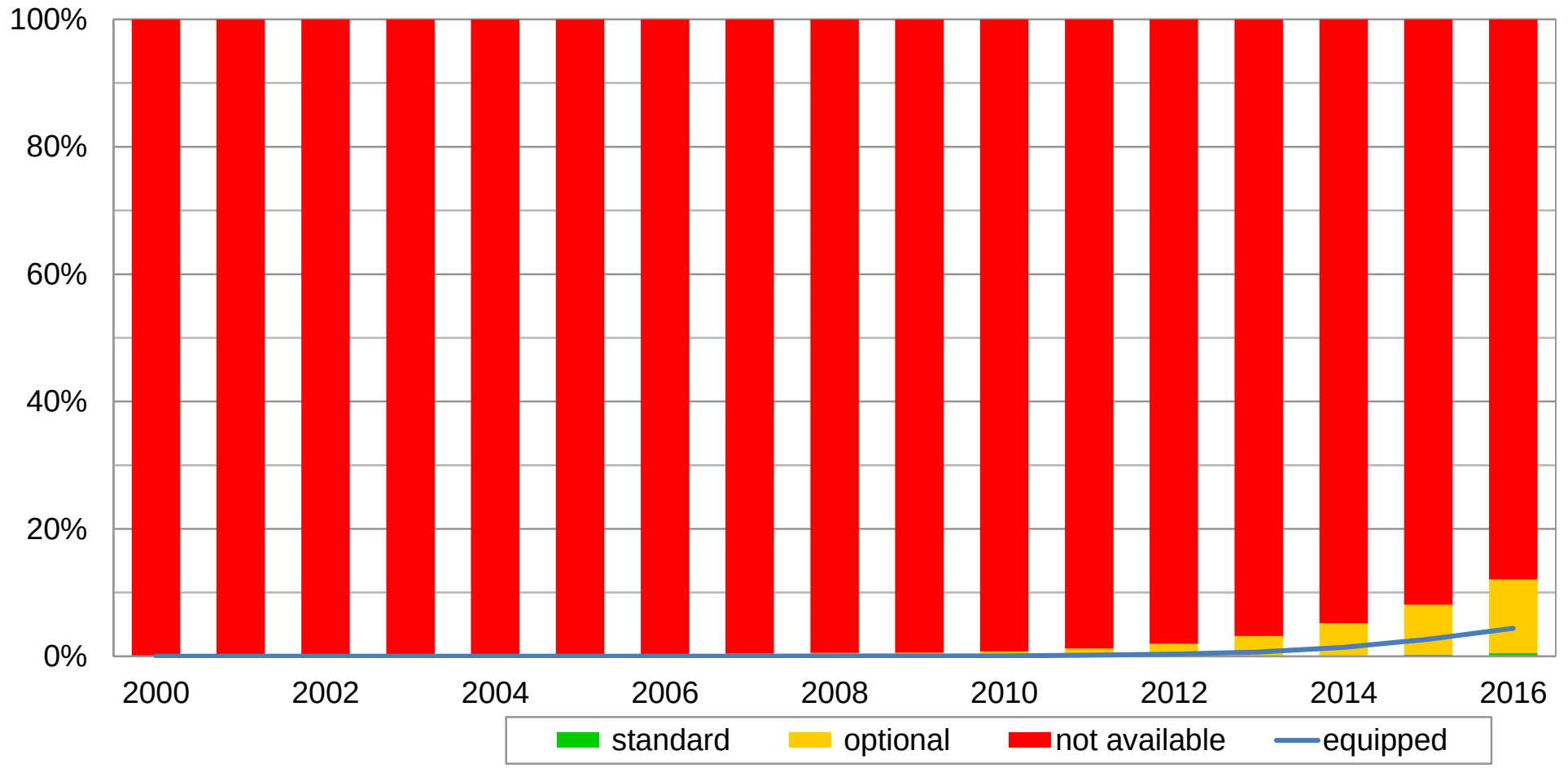
New vehicle series with forward collision warning

By model year



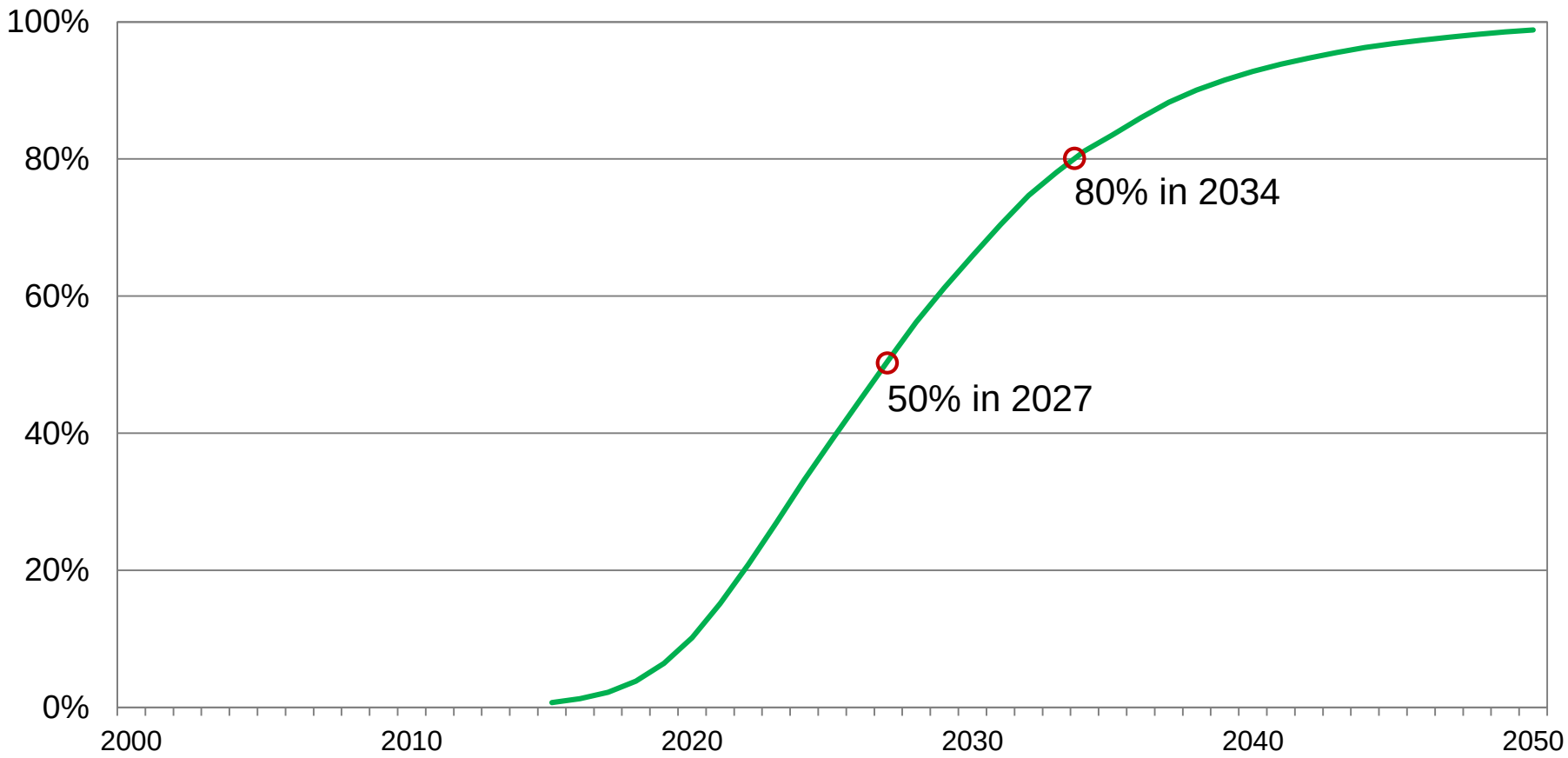
Registered vehicles with forward collision warning

By calendar year



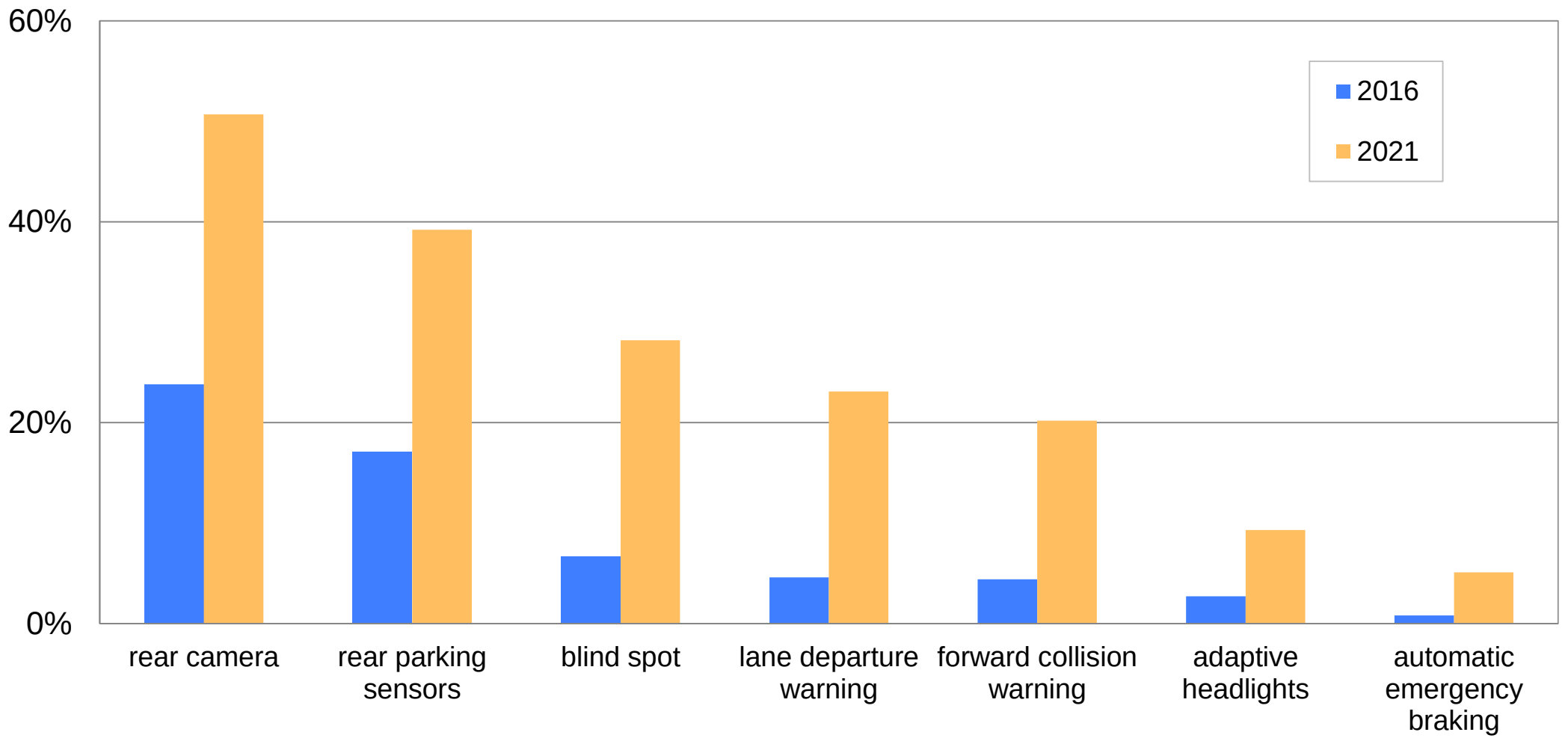
Predicted counts of registered vehicles equipped with front crash prevention

With 2022 voluntary commitment



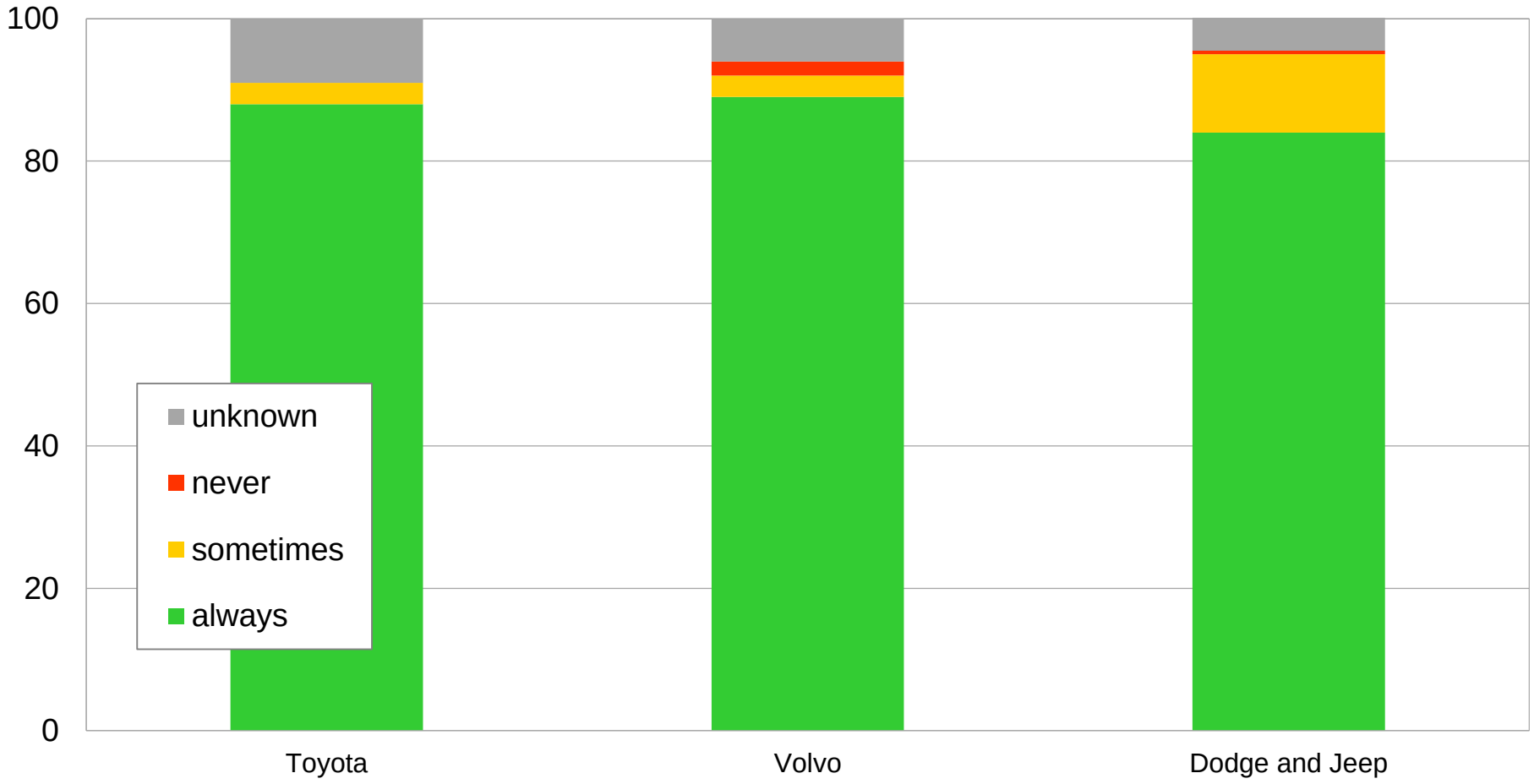
Estimated registered vehicles by feature

Calendar years 2016 and 2021



Driver acceptance and safe use of automated systems

Percent of vehicle owners who reported driving with forward collision warning turned on

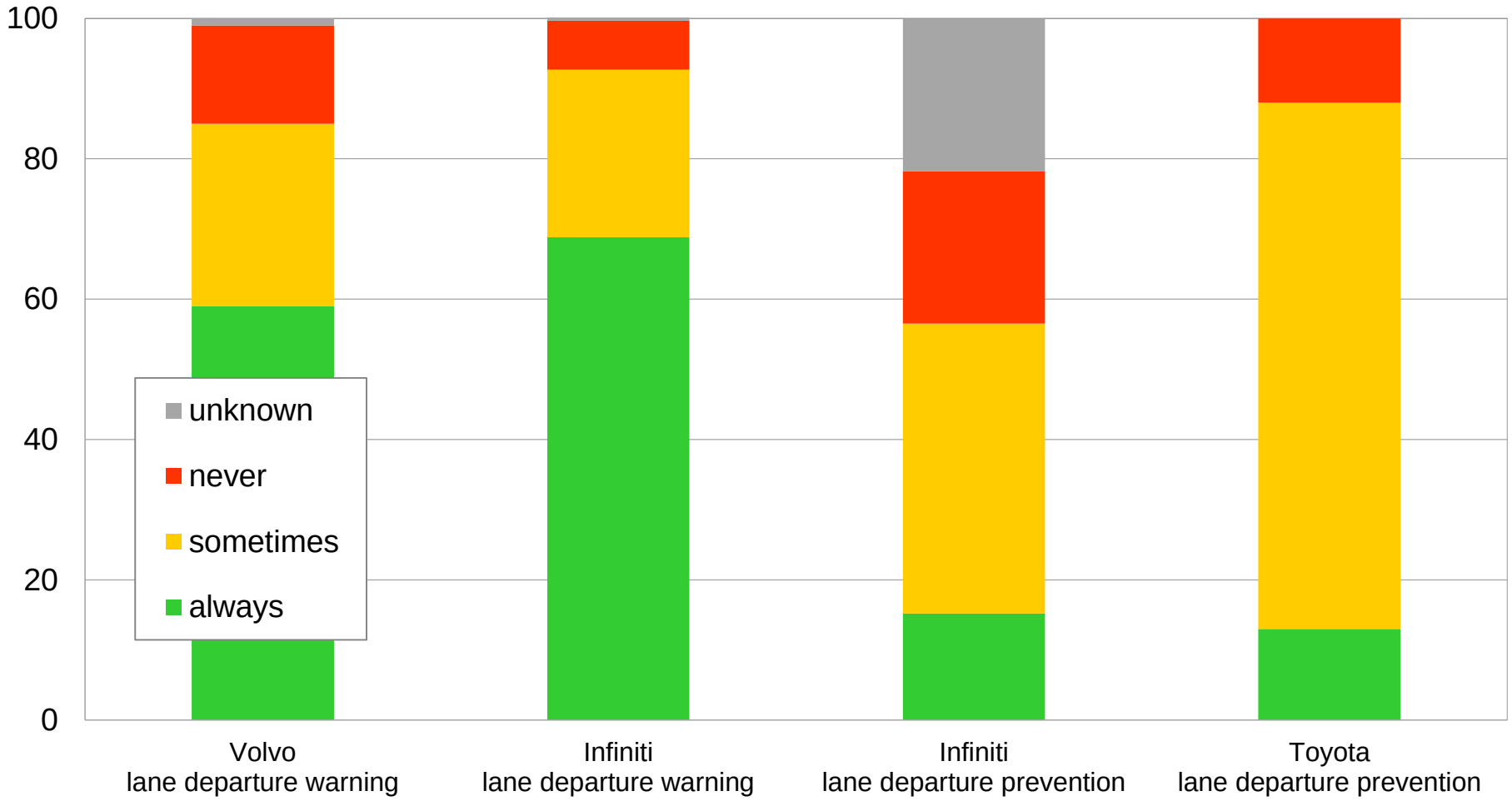


On-off status of front crash prevention systems

By manufacturer

	percent with system on	number observed
Cadillac	92	206
Chevrolet	87	142
Honda	98	239
Lexus	50	8
Mazda	95	20
Volvo	94	52
total	93	667

Percent of vehicle owners who reported driving with lane-maintenance systems turned on



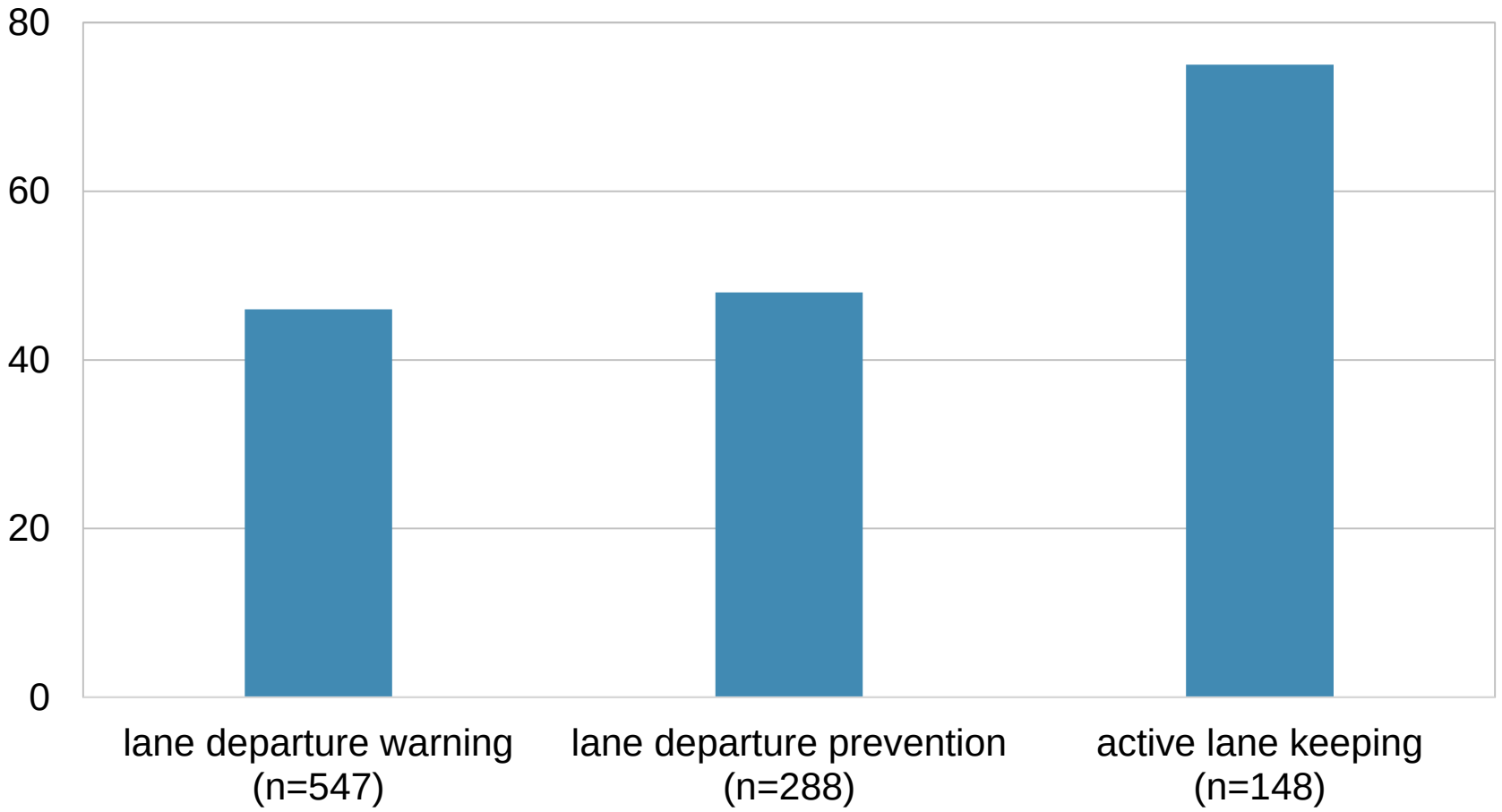
On-off status of lane-maintenance systems

By manufacturer

	percent with system on	number observed
Cadillac	57	207
Chevrolet	50	147
Ford/Lincoln	21	115
Honda	36	239
Lexus/Toyota	68	147
Mazda	77	26
Volvo	75	105
total	51	986

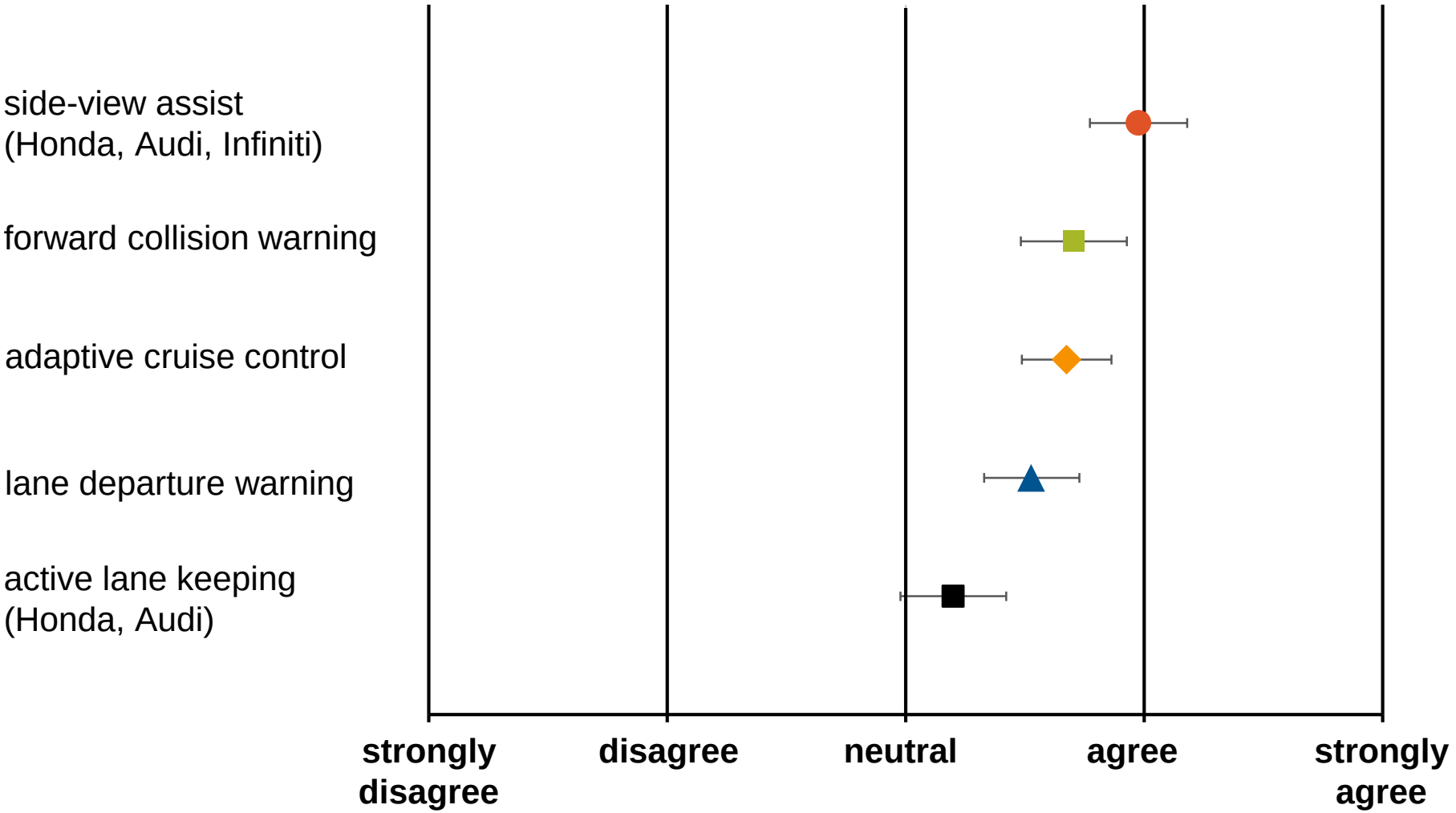
On-off status by maximum observable lane-maintenance intervention level

Percent with system on



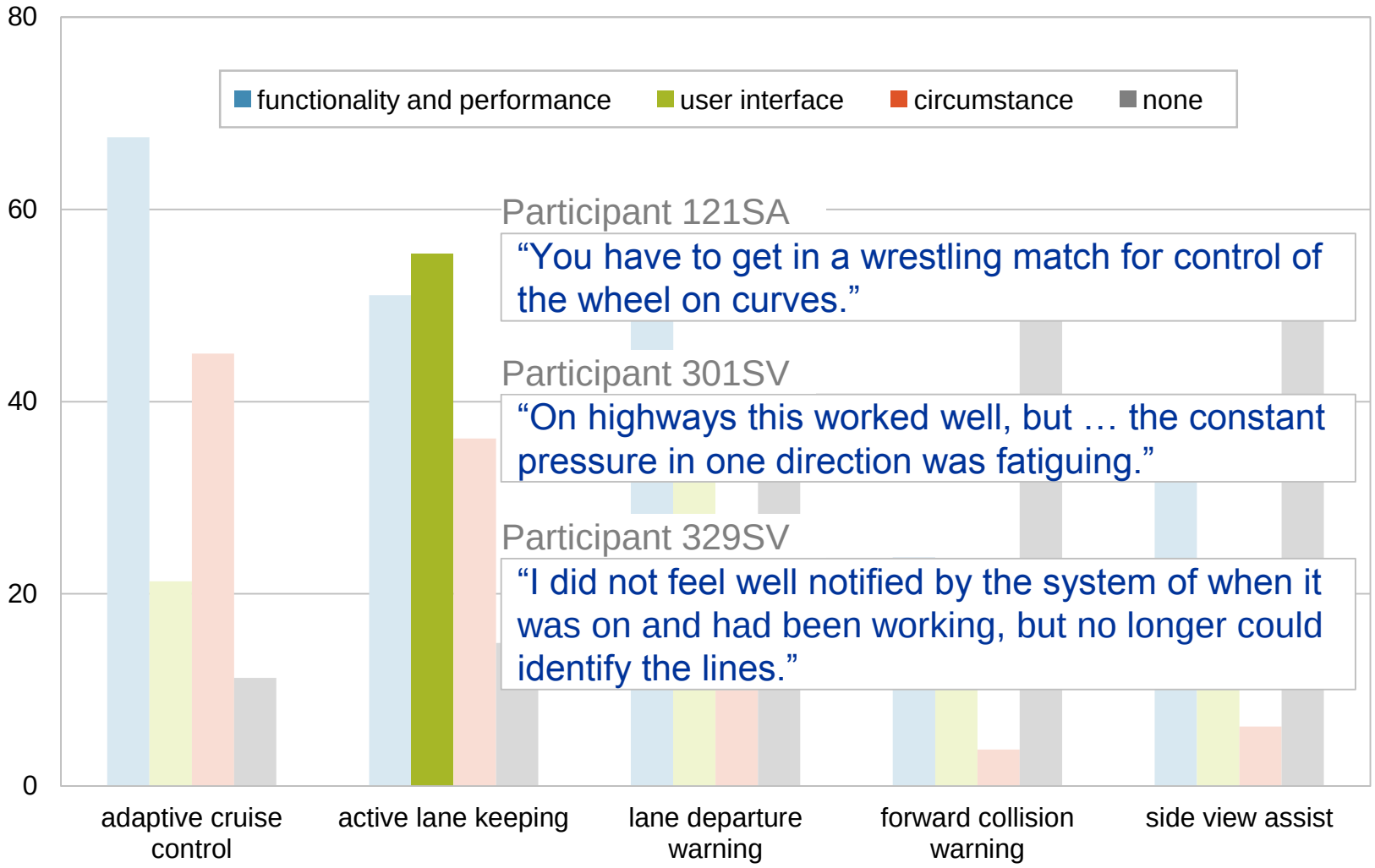
Active lane keeping ranked least in trust

Average rating and 95% confidence interval by system



Technologies had different problem areas

Percentage of drivers by complaint type



Participant 121SA

"You have to get in a wrestling match for control of the wheel on curves."

Participant 301SV

"On highways this worked well, but … the constant pressure in one direction was fatiguing."

Participant 329SV

"I did not feel well notified by the system of when it was on and had been working, but no longer could identify the lines."

Level 2 automated driving experience - issues

Lost lane lines

On-road testing of Tesla “Autopilot” 7.1 (hardware version 1)

Stopped lead vehicle

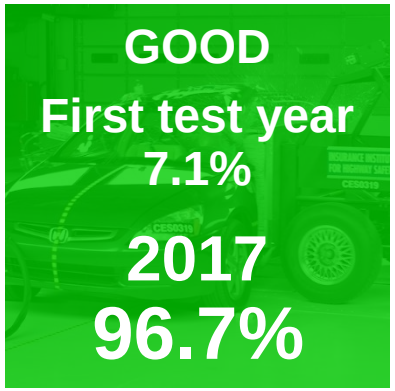
On-road testing – 2017 Mercedes-Benz E-Class

Much of the improved highway safety picture in the USA in recent decades is due to improved crashworthiness

IIHS testing programs

1995
Front moderate overlap

2003
Side impact



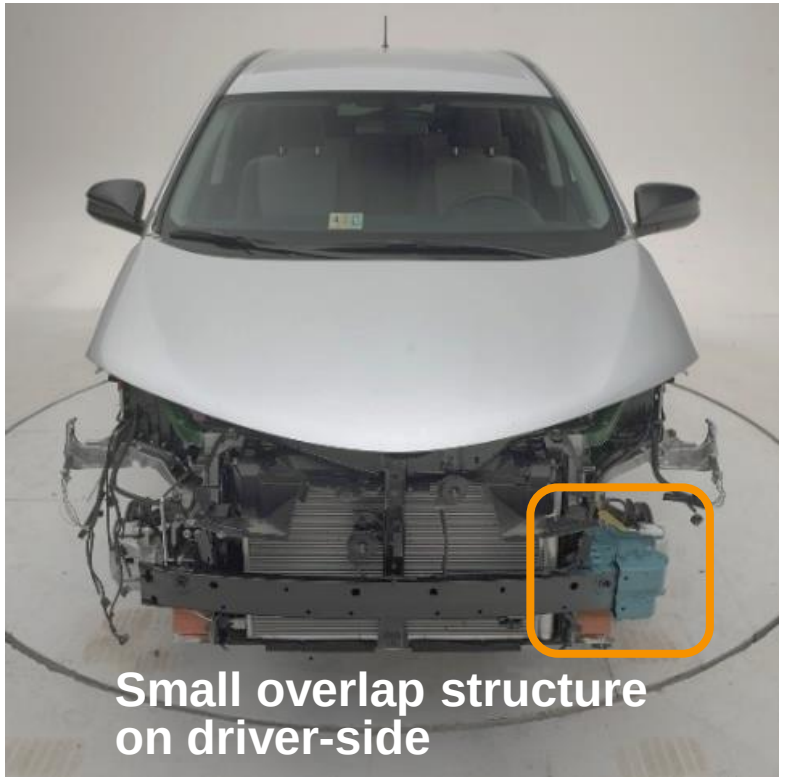
2004
Rear
(whiplash mitigation)

2009
Roof strength

2012
Front small overlap

Passenger-side small overlap tests

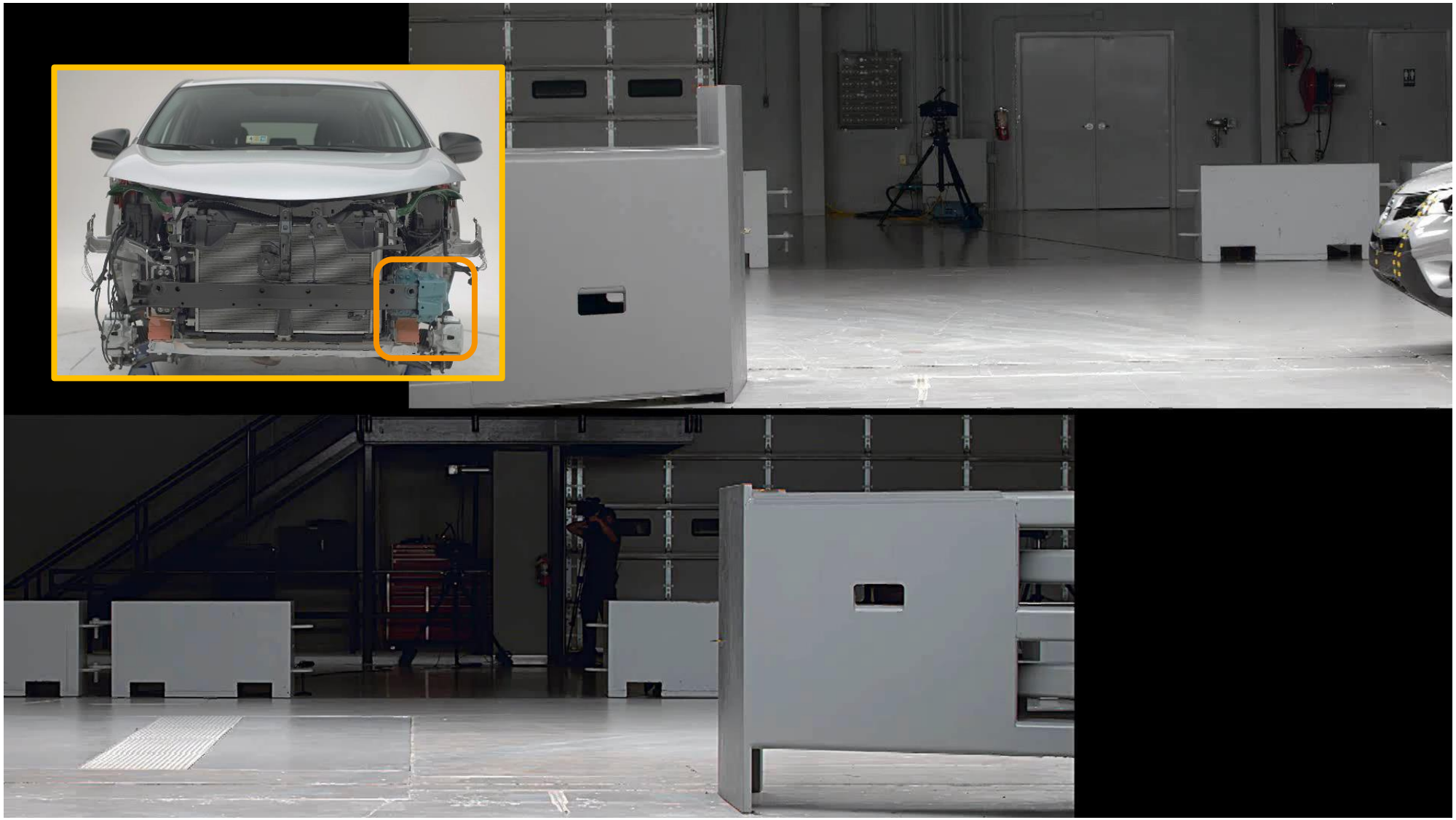
Small overlap countermeasures are not always applied to the passenger-side



Passenger-side moderate overlap tests of two vehicles

- Moderate overlap tests indicate good protection for the passenger and performance is not affected by small overlap countermeasures
- Many vehicles sold and tested as right-hand drive in other markets

Toyota RAV-4 has driver-side only countermeasures



Driver/passenger small overlap crash ratings

	driver-side impact	passenger-side impact	visible design application
2016 Hyundai Tucson	G	G	symmetric
2015 Buick Encore	G	A	symmetric
2015 Honda CRV	G	A	symmetric
2015 Mazda CX-5	G	A	symmetric
2014 Subaru Forester	G	M	symmetric
2015 Nissan Rogue	G	M	driver-side
2015 Toyota RAV4	G	P	driver-side

	driver-side impact	passenger-side impact
2016 Hyundai Tucson	G	G
2015 Buick Encore	G	A
2015 Honda CRV	G	A
2015 Mazda CX-5	G	A
2014 Subaru Forester	G	M
2015 Nissan Rogue	G	M
2015 Toyota RAV4	G	P

2017 first official ratings test series: midsize cars

Driver- and passenger-side small overlap ratings

Midsize cars

	driver-side impact	passenger-side impact
2018 Subaru Outback/Legacy	G	G
2017 Ford Fusion	G	G
2017 Honda Accord	G	G
2017 Nissan Altima	G	G
2017 Hyundai Sonata/Kia Optima	G	G
2018 Toyota Camry	G	G
2017 Nissan Maxima	G	G
2017 Mazda 6	G	G
2017 Volkswagen Jetta	G	A
2017 Volkswagen Passat	G	M
2017 Chevrolet Malibu	G	M

Range of structural performance

GOOD

2017 Ford Fusion

ACCEPTABLE

2017 Mazda 6

Dummy observations

2017 midsize cars

- All driver dummies indicated low risk of injury
- Range of injury protection for passenger dummies
  - Insufficient airbag protection for passengers

    In 3 vehicles, passenger dummy's head contacted dash and sensors measured high risk of injury

    In 2 vehicles, dummy's head moved into a gap in airbag protection
  - 2 dummies measured high risk of leg injury from contact with the lower dash/glove box

Range of passenger restraint system performance

GOOD

2017 Nissan Maxima

MARGINAL

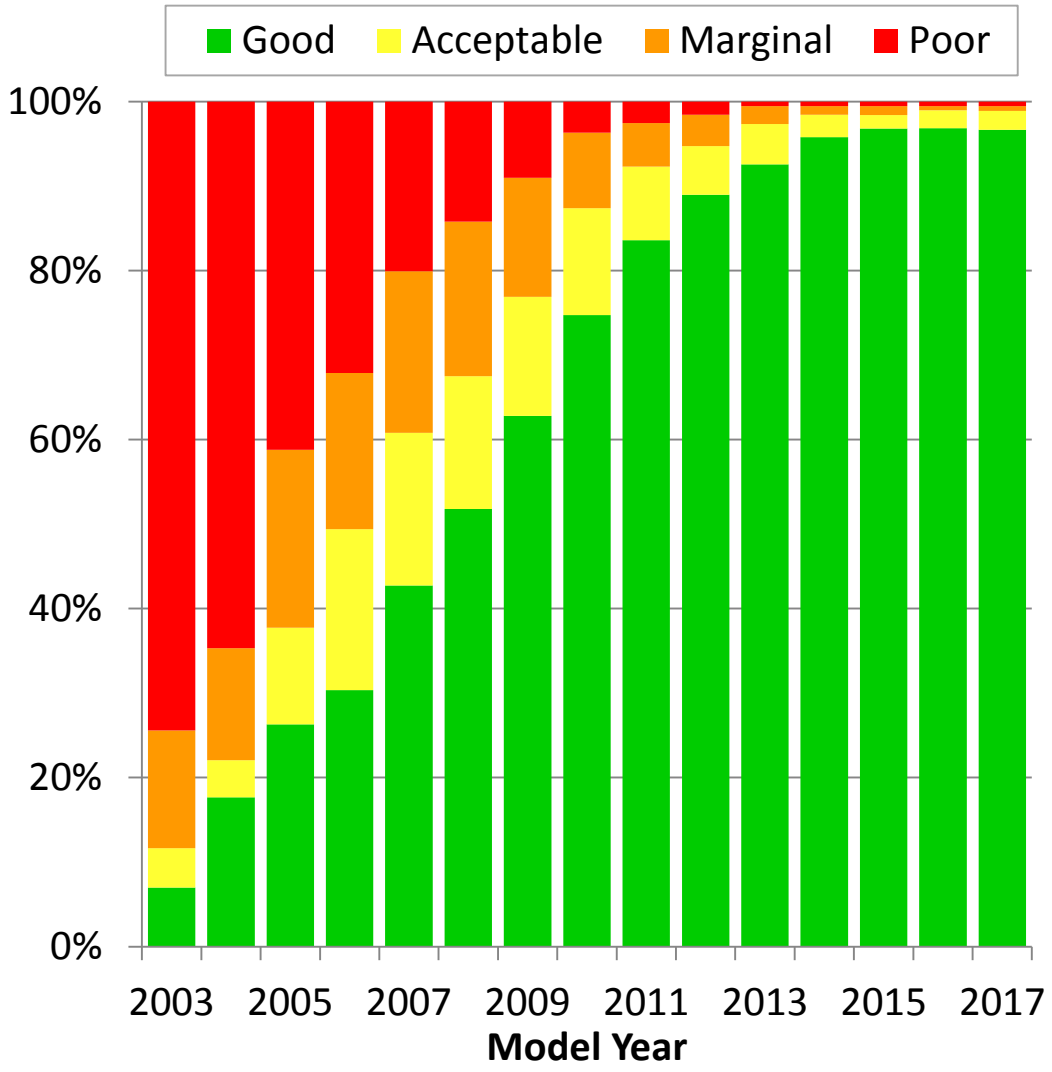
2017 Chevrolet Malibu

Summary of passenger-side small overlap testing

- More vehicles integrating small overlap countermeasures to both driver and passenger sides
  - Countermeasures are improving structural performance
    - In 2015 small SUV series, 3 vehicles received poor structural ratings
    - In current midsize car series, the worst structural rating was acceptable
  - Remaining deficiencies related to restraint system performance
    - 5 models demonstrated insufficient head protection from the frontal airbag
- Results will be published in October 2017
- Good or acceptable passenger-side small overlap performance a requirement for 2018 *TOP SAFETY PICK+*

Side crashworthiness research

Side impact crashworthiness: what's next?



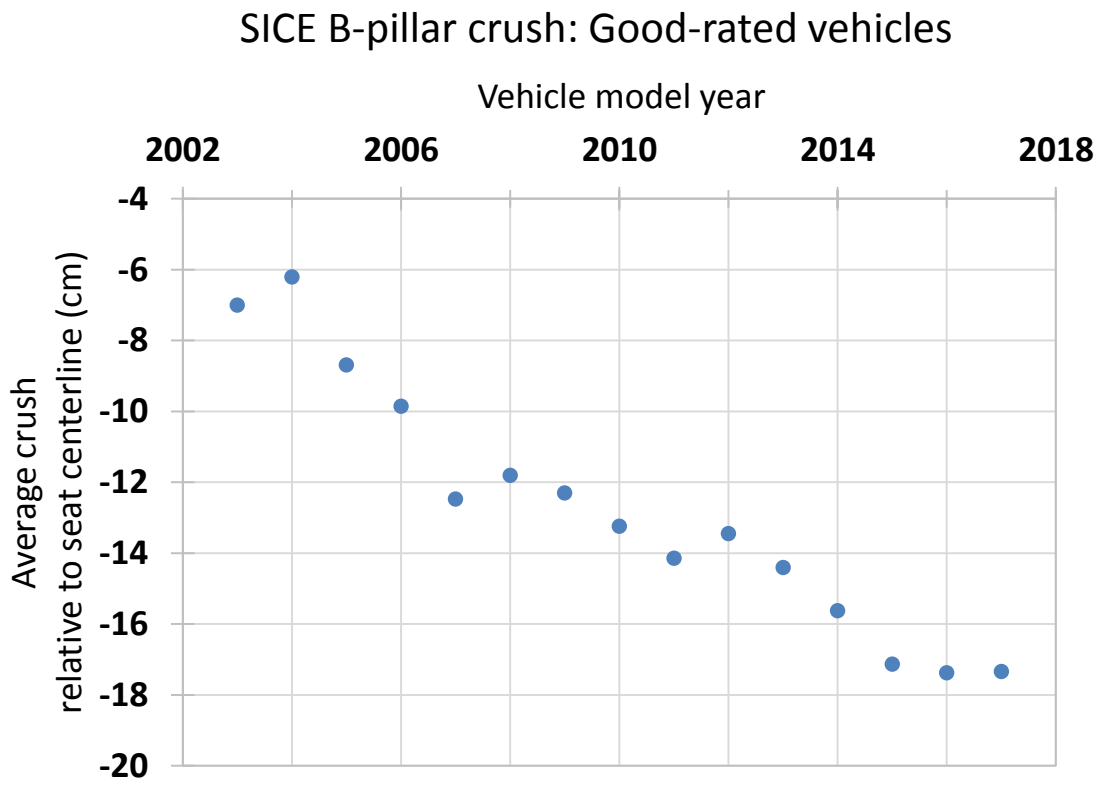
- Driver side impact fatality rates in 1-3 year old vehicles:
  - 2005: 22 per million RVY
  - 2015: 5 per million RVY
- 5,593 passenger vehicle occupant side-impact fatalities in 2015
  - Most not rated by IIHS
  - When rated, 49% were Good

Relevance

109 seriously ir … CIREN

Research questions

- Can modified laboratory test configurations predict real-world injuries that the current IIHS SICE test does not?
  - Forward impacts
  - Higher severity
- If so, do newer Good-rated vehicles already perform better than older Good-rated vehicles?
  - Less than 10% of the NASS/CIREN case vehicles were 2010+ models



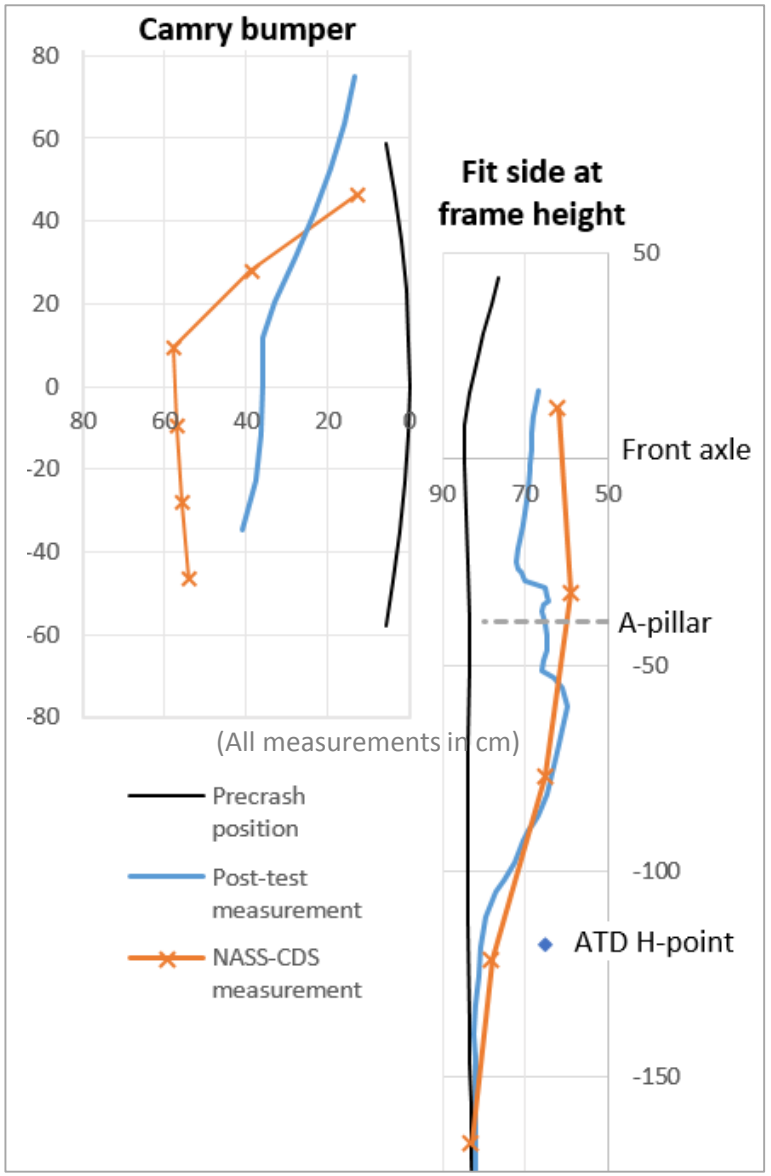
Test matrix

Struck Honda Fit model year	Configuration		
	Fit moving 33 km/h; striking 1999 Camry @ 88 km/h, 19 cm forward of front axle	Standard SICE (MDB @ 50 km/h)	MDB @ 60 km/h
2007	A	B	
2015	C	D	E

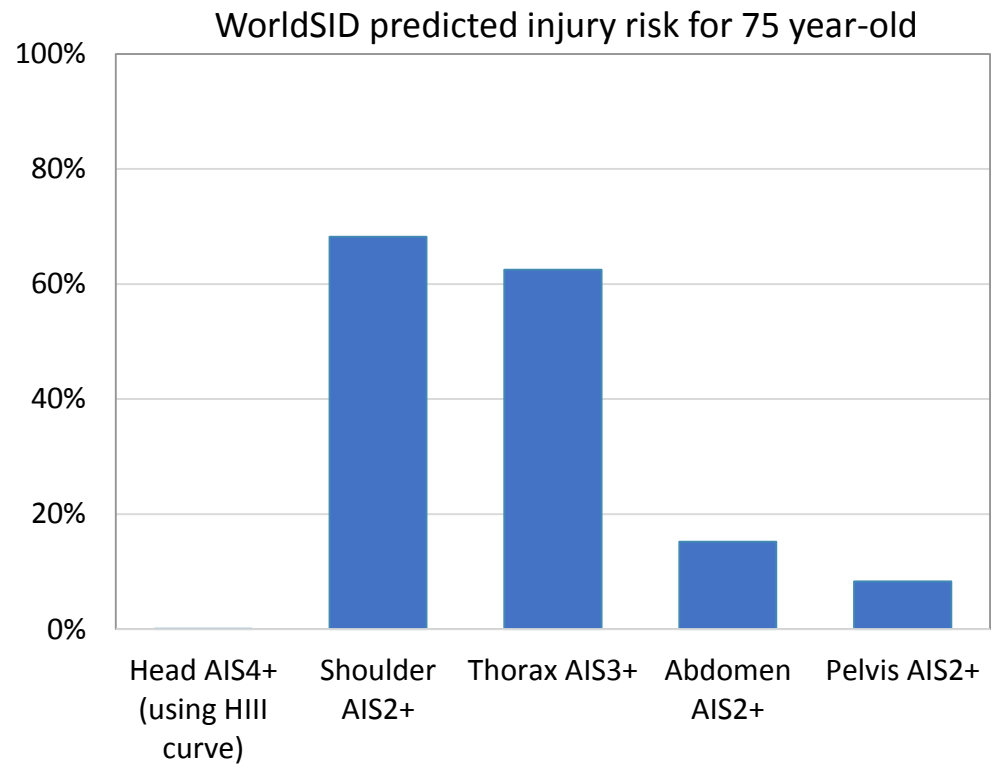
- Camry vs. 2007 Fit chosen to replicate NASS-CDS case
- WorldSID 50-M with RibEye deflection measurement system used in all tests
  - Better representation than SID-IIs of case occupant anthropometry
  - Ribeye allowed comparison of oblique thoracic loading

Impact configuration for tests A & C

Results: real-world case vs. reconstruction test



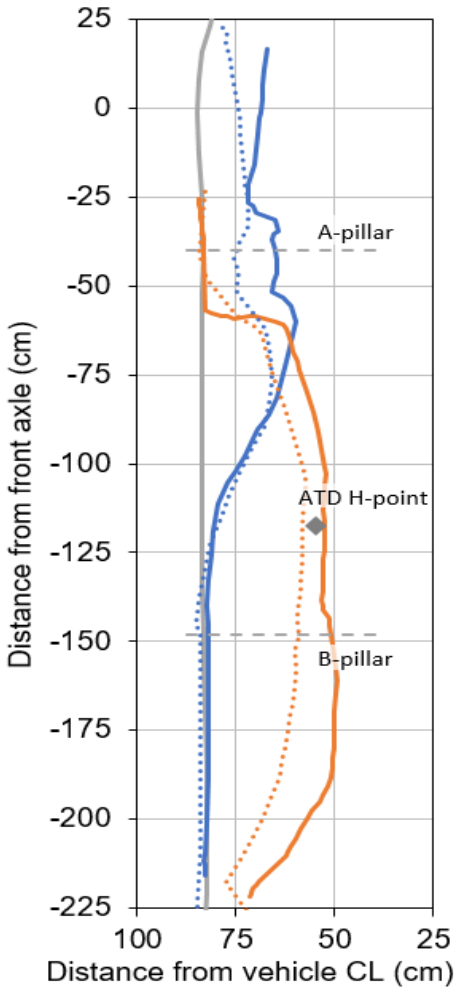
NASS-CDS case occupant	75-year-old male, 185 cm, 104 kg, belted, fatally injured
AIS ≥ 2 injuries	AIS 5 Bilateral flail chest AIS 4 Trachea perforation AIS 3 Pulmonary artery laceration AIS 3 Left lung contusion, laceration, hemothorax AIS 2 Spleen laceration



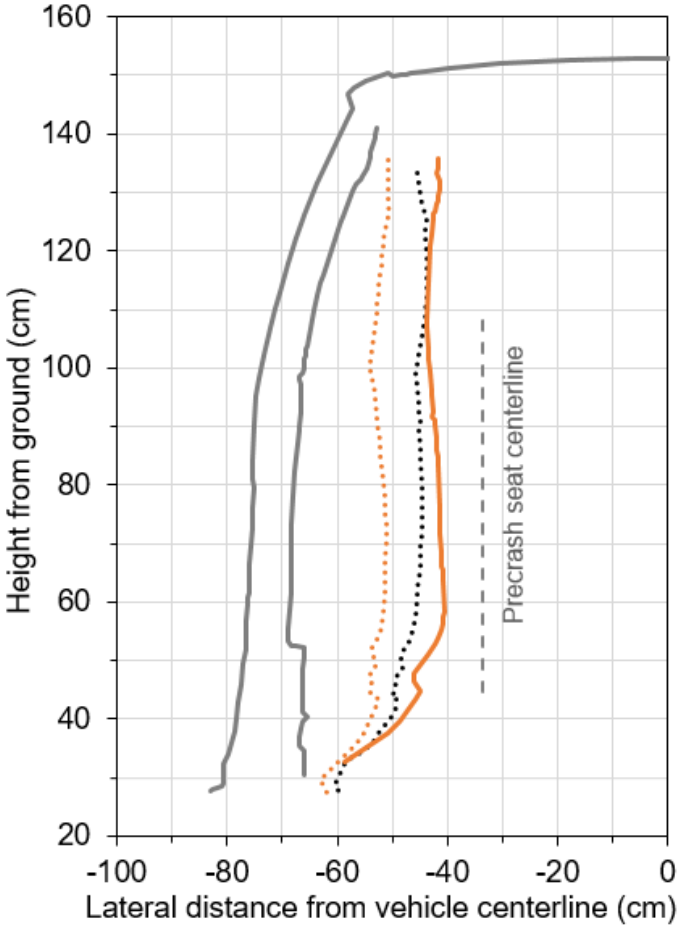
Results: test comparison (structure)

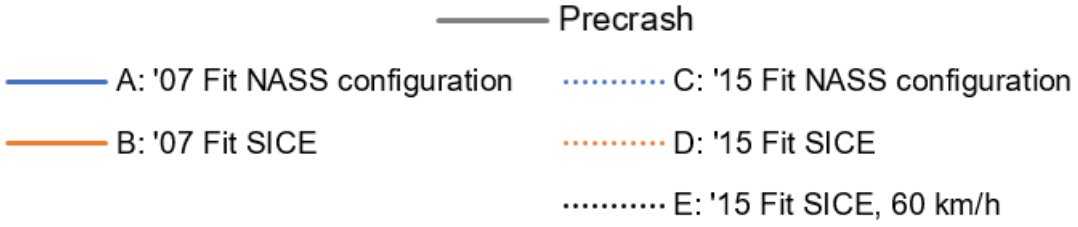
- NASS configuration
  - Most intrusion forward of H-point
  - No B-pillar intrusion
  - 2015 less intrusion than 2007
- SICE tests
  - Peak intrusion centered near H-point and B-pillar
  - 2015 less intrusion than 2007
  - 2015 less B-pillar intrusion at 60 km/h than 2007 at 50 km/h
  - 2015: 5-10 cm more intrusion at 60 km/h than at 50 km/h

Mid-door side contours



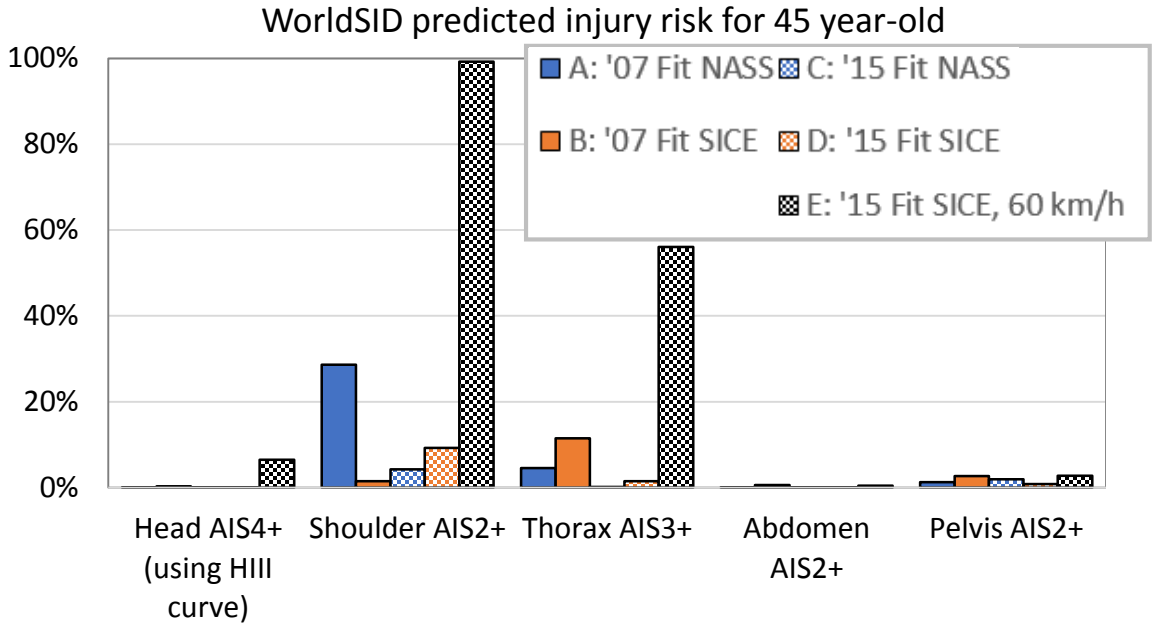
B-pillar profiles (inboard edge)

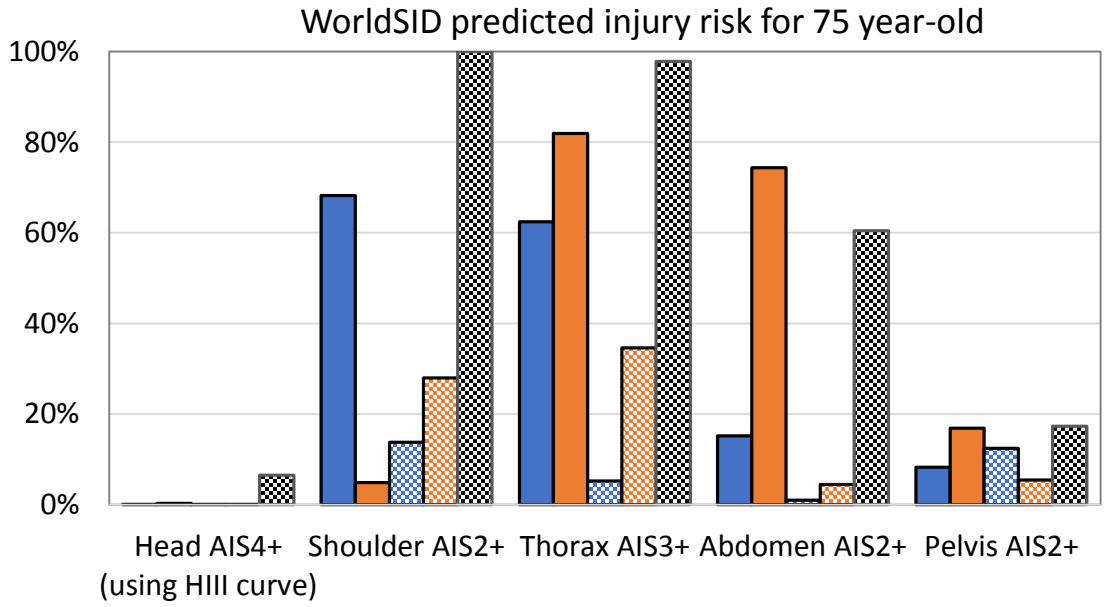




Results: test comparison (injury)

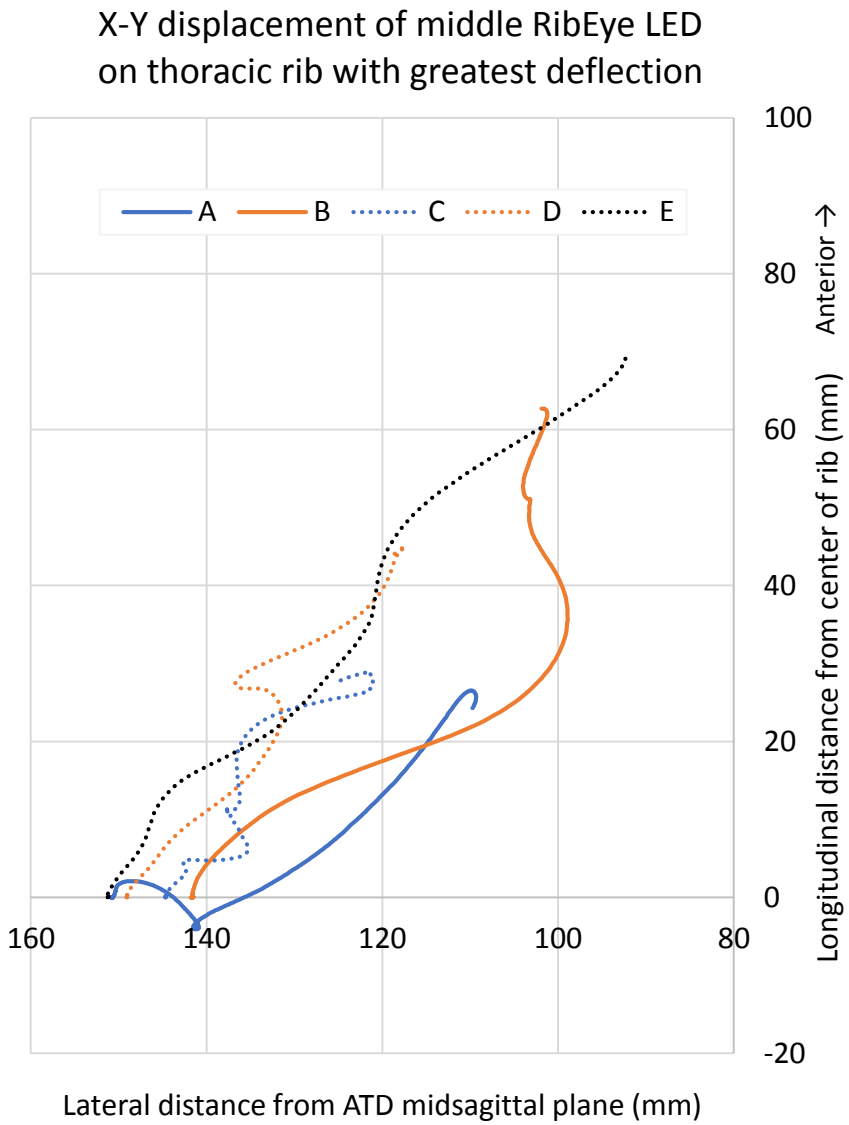
- 60 km/h SICE test produced highest injury risks, except for abdomen
- 50 km/h SICE test produced higher injury risk than NASS configuration, except:
  - ‘07 Fit shoulder
  - ‘15 Fit pelvis
- ‘15 Fit produced lower injury risk than ‘07 Fit, except:
  - SICE shoulder
  - NASS configuration pelvis





Results: RibEye data

- All tests produced overall rib displacement in oblique posterior-to-anterior direction
- NASS configuration tests A & C showed only slight initial displacement in the anterior-to-posterior direction
- Unknown whether loading direction controlled by ATD design or rotation around pre-tensioned belt
- Regardless of cause, ATD did not identify unique injury mechanism in NASS configuration



Conclusions

- While NASS reconstruction showed general agreement with real-world case, the injury risk for most body regions was lower than in the current SICE test
- These tests do not justify an evaluation program with a more forward impact location
  - The higher impact speed would produce greater injury risks at the current impact location
- Vehicle designs continue to improve beyond requirements for Good SICE rating; the distribution of injury-producing crash configurations likely is different for current vehicle designs
- A higher SICE impact speed would likely drive more restraint system changes than structural changes; potential tradeoffs would need to be considered

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