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# Drivers and Driver Assistance Systems: How well do they match?

2013 Driving Assessment Conference  
Lake George, NY • June 18, 2013

Adrian Lund, Ph.D., President

## The Insurance Institute for Highway Safety,

founded in 1959, 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.

## The Highway Loss Data Institute,

founded in 1972, shares and supports this mission through scientific studies of insurance data representing the human and economic losses resulting from the ownership and operation of different types of vehicles and by publishing insurance loss results by vehicle make and model.

Both organizations are wholly supported by auto insurers.

# Where are we?

Location of IIHS/HLDI and Vehicle Research Center



# IIHS members write 85% of private passenger market

- ACE Private Risk Services
- Affirmative Insurance
- Agency Insurance Company of Maryland
- Alfa Alliance Insurance Corporation
- Alfa Insurance
- Allstate Insurance Group
- American Family Mutual Insurance
- American National Property and Casualty Company
- Ameriprise Auto & Home
- Amica Mutual Insurance Company
- ARI Insurance Companies
- Auto Club Enterprises
- Auto Club Group
- Bankers Insurance Group
- Bituminous Insurance Companies
- California Casualty Group
- California State Auto Group
- Capital Insurance Group
- Chubb & Son
- Colorado Farm Bureau Mutual Insurance Company
- Concord Group Insurance Companies
- Cotton States Insurance
- COUNTRY Financial
- Direct General Corporation
- Discovery Insurance Company
- Driver's Insurance Group
- Erie Insurance Group
- Esurance
- Farm Bureau Financial Services
- Farm Bureau Insurance of Michigan
- Farm Bureau Mutual Insurance Company of Idaho
- Farmers Insurance Group of Companies
- Farmers Mutual Hail Insurance Company of Iowa
- Farmers Mutual of Nebraska
- Fireman's Fund Insurance Company
- First Acceptance Corporation
- Florida Farm Bureau Insurance Companies
- Frankenmuth Insurance
- Gainsco Insurance
- GEICO Group
- Georgia Farm Bureau Mutual Insurance Company
- GMAC Personal Lines Insurance
- Grange Insurance
- Hallmark Insurance Company
- Hanover Insurance Group
- The Hartford
- Haulers Insurance Company Inc.
- Homeowners of America Insurance Company
- Horace Mann Insurance Companies
- ICW Group
- Imperial Fire & Casualty Insurance Company
- Infinity Property & Casualty
- Kemper Preferred
- Kentucky Farm Bureau Insurance
- Liberty Mutual Insurance Company
- Louisiana Farm Bureau Mutual Insurance Company
- Maryland Automobile Insurance Fund
- Mercury Insurance Group
- MetLife Auto & Home
- MiddleOak
- Mississippi Farm Bureau Casualty Insurance Company
- MMG Insurance
- Mutual of Enumclaw Insurance Company
- Nationwide
- New Jersey Manufacturers Insurance Company
- NLC Insurance Companies Inc.
- Nodak Mutual Insurance Company
- Norfolk & Dedham Group
- North Carolina Farm Bureau Mutual Insurance Company
- Northern Neck Insurance Company
- Old American County Mutual Fire Insurance
- Oregon Mutual Insurance
- Pekin Insurance
- PEMCO Insurance
- Plymouth Rock Assurance
- Progressive Corporation
- The Responsive Auto Insurance Company
- Rockingham Group
- Safeco Insurance
- Samsung Fire & Marine Insurance Company
- SECURA Insurance
- Sentry Insurance
- Shelter Insurance
- Sompo Japan Insurance Company of America
- South Carolina Farm Bureau Mutual Insurance Company
- Southern Farm Bureau Casualty Insurance Company
- State Auto Insurance Companies
- State Farm
- Tennessee Farmers Mutual Insurance Company
- Texas Farm Bureau Insurance Companies
- Tower Group Companies
- The Travelers Companies
- United Educators
- USAA
- Viceroy Insurance Company
- Virginia Farm Bureau Mutual Insurance
- West Bend Mutual Insurance Company
- Young America Insurance Company
- Zurich North America

# Institute activities

We do not lobby, legislate, or litigate

- 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
- IIHS and HLDI rely on aggressive research and communications to empower people and policymakers with objective information

IIHS research and communications cover a wide array of highway safety issues



# 50<sup>th</sup> Anniversary crash test

1959 Bel Air vs. 2009 Malibu

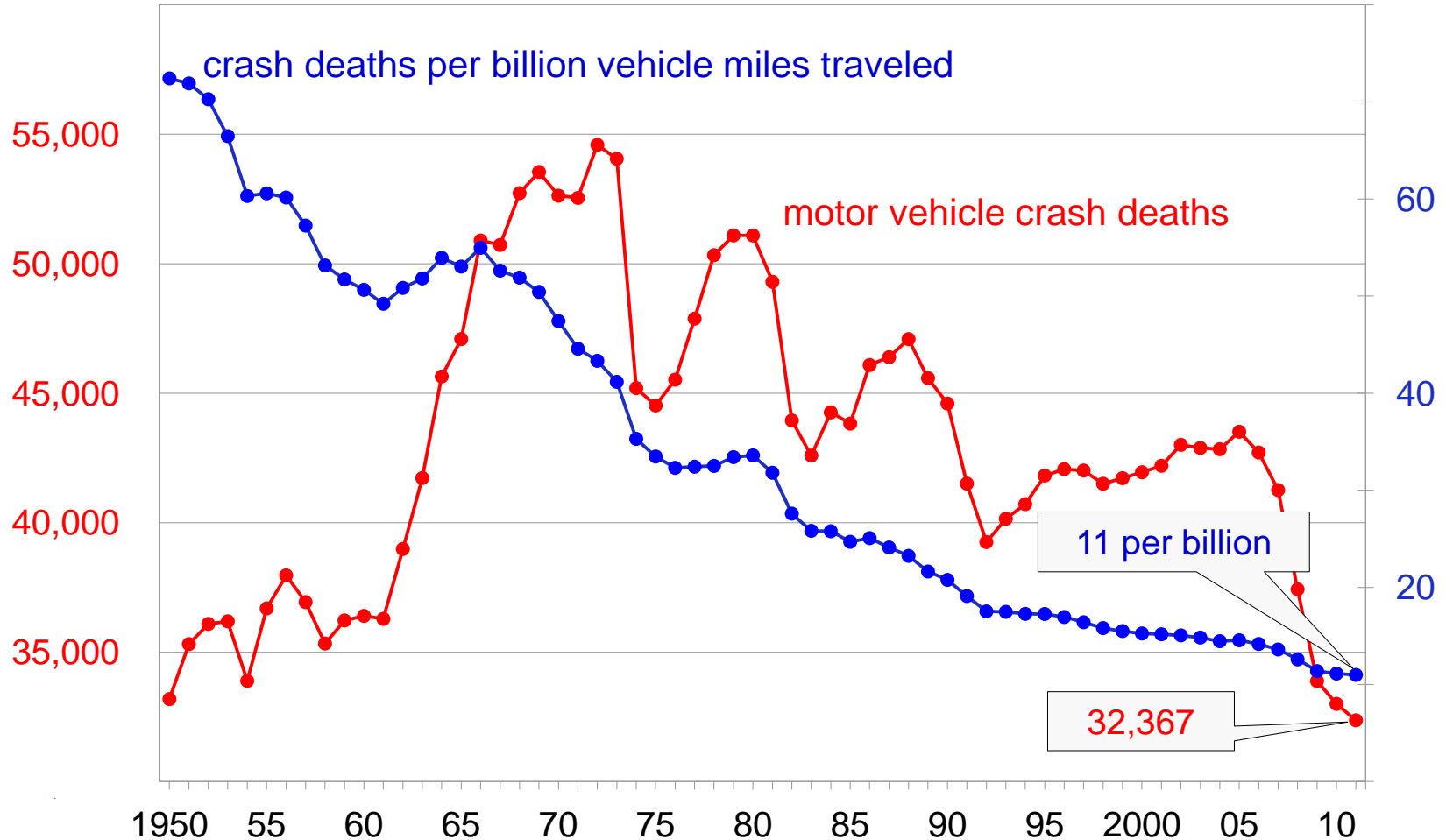
The logo for the Insurance Institute for Highway Safety (IIHS) is centered on a black rectangular background. The words "INSURANCE INSTITUTE" are written in a white, serif, all-caps font. Below this, the words "FOR HIGHWAY SAFETY" are written in the same font but are highlighted by a solid blue rectangular background.

# Overview of presentation

- Some surprising findings about driver behavior and crashes
  - Infotainment technology
  - Advanced driver assistance systems (collision warnings, headlamps, cameras)
- Questions raised about how drivers drive
  - To what extent do drivers consciously control their actions?
  - What is attention?
- Reducing crash risk
  - Advanced technology
  - Old technology



# Fatalities and fatal crash risk per mile traveled have declined steadily since peaking in the 1960s



# Role of driver error has not changed

- 1979 Indiana “Tri-Level Study” estimated driver error as proximate cause of 9 out of 10 crashes
- 2008 National Motor Vehicle Crash Causation Study cited driver error as the critical reason for the crash in 95% of crashes where reason was assigned

Critical reason attributed to driver (top 5):

Inadequate surveillance (19%)

Internal distraction (10%)

Too fast for conditions (8%)

Too fast for curve (5%)

Overcompensation (5%)

In-vehicle technologies:  
New distractions or driver aids?

# Infotainment features

- Cellphones
- iPods
- Navigation systems
  - Mobile
  - Built-in
- Radios becoming more complex
  - Multiple bands
  - Built-in controls for iPods
  - CD/DVD players
  - Music streaming

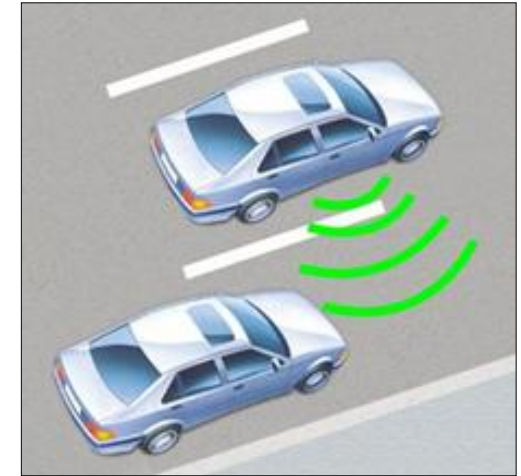
# Advanced information technology for safety



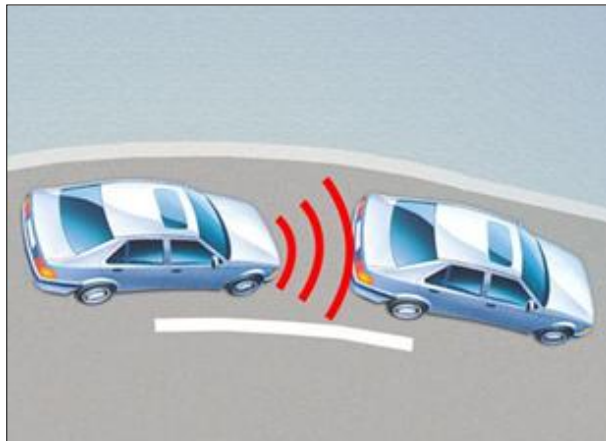
lane departure prevention



crash notification



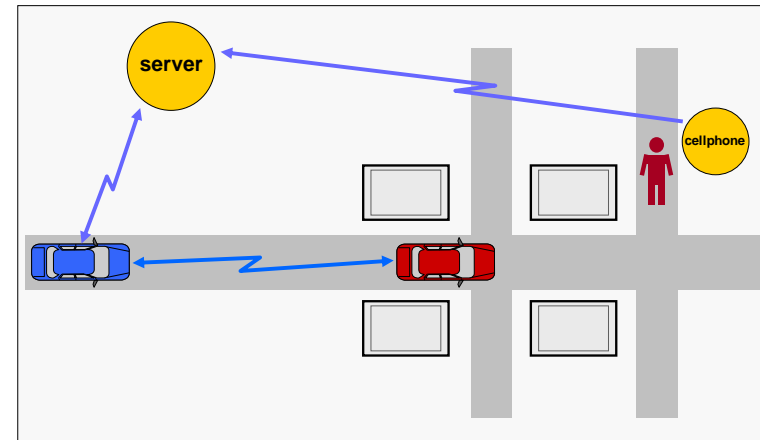
blind spot detection



forward collision warning  
and auto braking



adaptive headlights



vehicle-to-vehicle communication

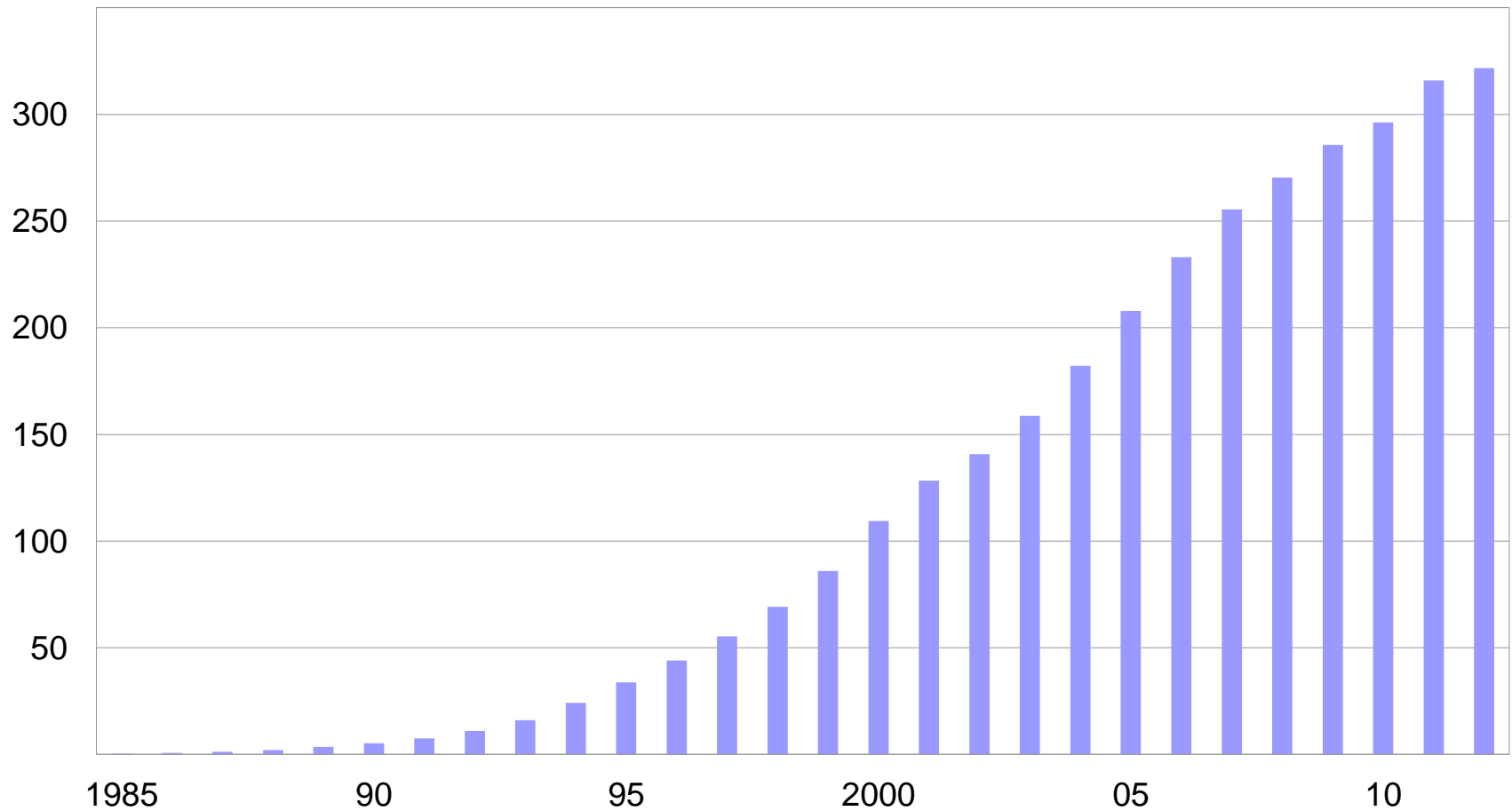


Infotainment usage by drivers  
increased greatly in the early  
2000s

What is the effect on crashes?  
The case of cellphones

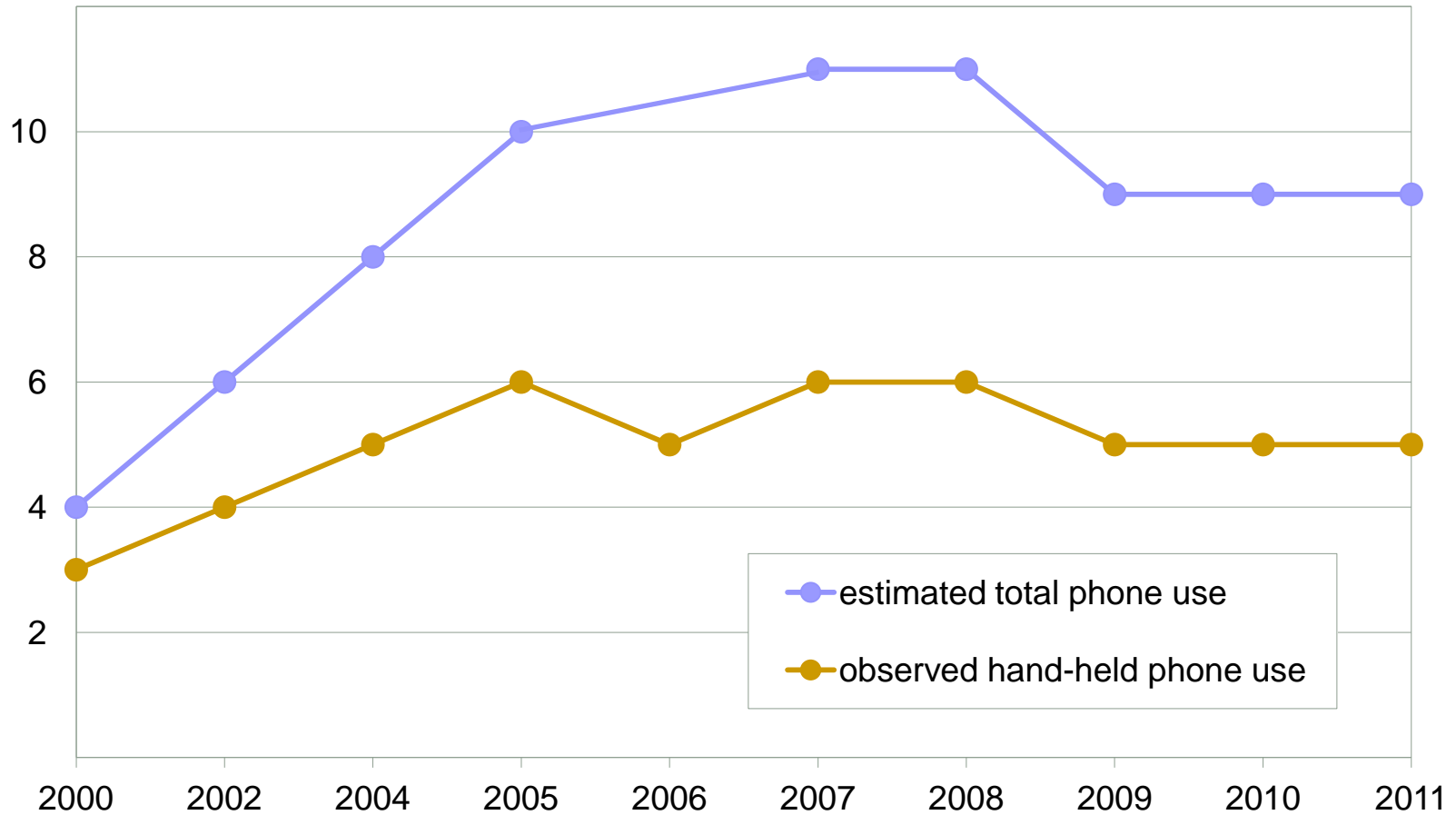
# Cellphone subscribers

In millions, 1985-2012



# Percent of drivers talking on phones

National observational surveys, NHTSA, 2000-11



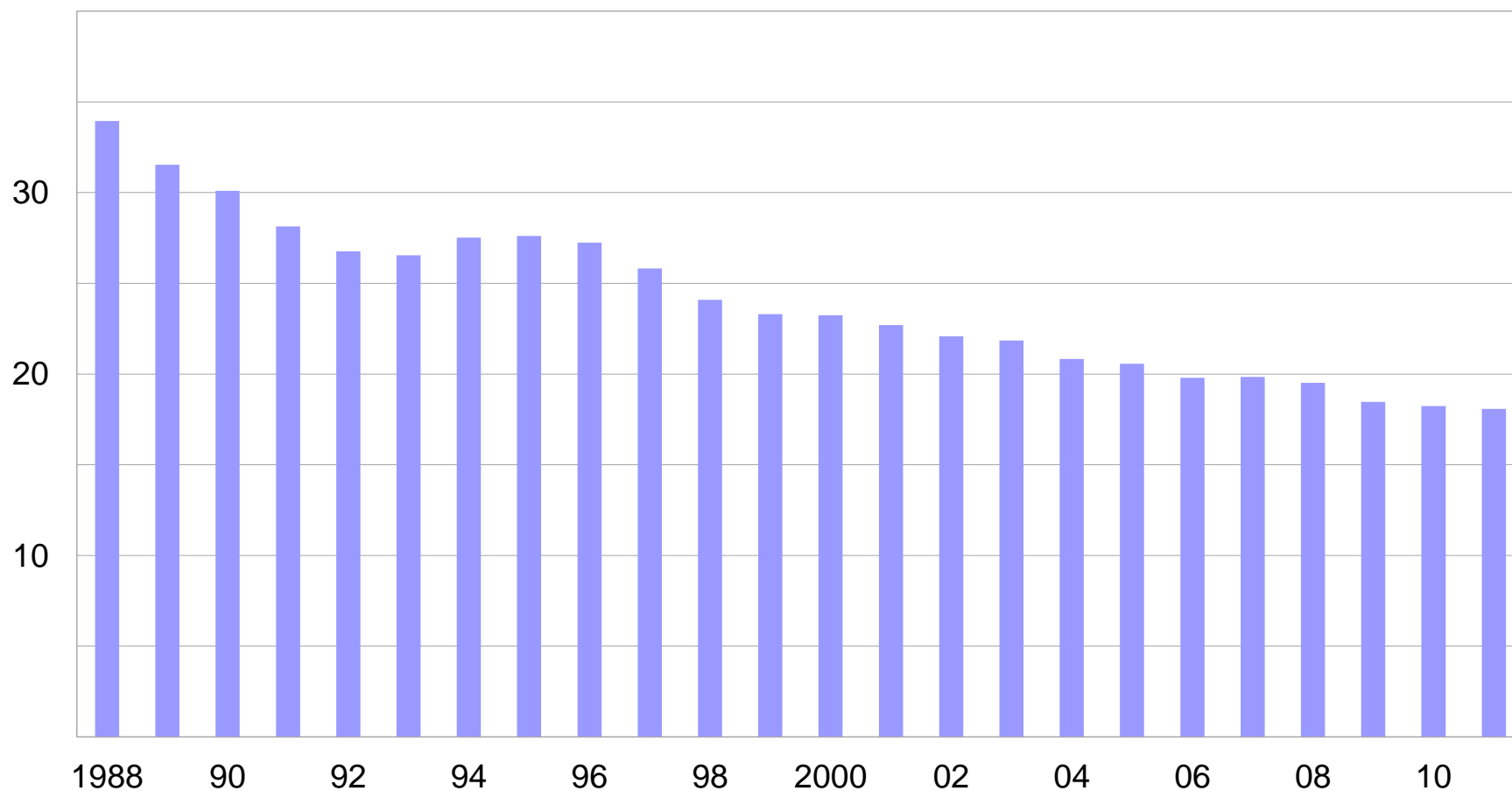


# Cellphones and crash risk

- Multiple laboratory studies demonstrate that cellphone dialing and talking are distracting (i.e., reduce performance on simultaneous task)
- Case-crossover epidemiologic studies in Canada and Australia indicate four-fold crash risk when drivers are talking on their phones
- Virginia Tech naturalistic driving study (2013) suggests a smaller increase in crash risk
  - 1.39 times the risk of a safety critical event during hand-held phone use
    - No increased risk while talking
  - 1.73 times the risk of safety critical event during text messaging or browsing on cellphone

# All police-reported crashes per billion miles traveled

By calendar year



# Summary thoughts on infotainment and crashes

- Infotainment usage distracts
  - In some cases greatly
  - Even voice-activated systems
- Crashes have occurred because drivers were distracted by cellphones and other devices
- No dose response relationship between population cellphone use (and other electronics) and crashes

This poses a scientific conundrum:

Specifically, how can highly distracting activities that are increasing in frequency in the population not be associated with an increase in crashes for the population?

Is there a psychological issue here – another factor needed in our intuitive model of driver attention?

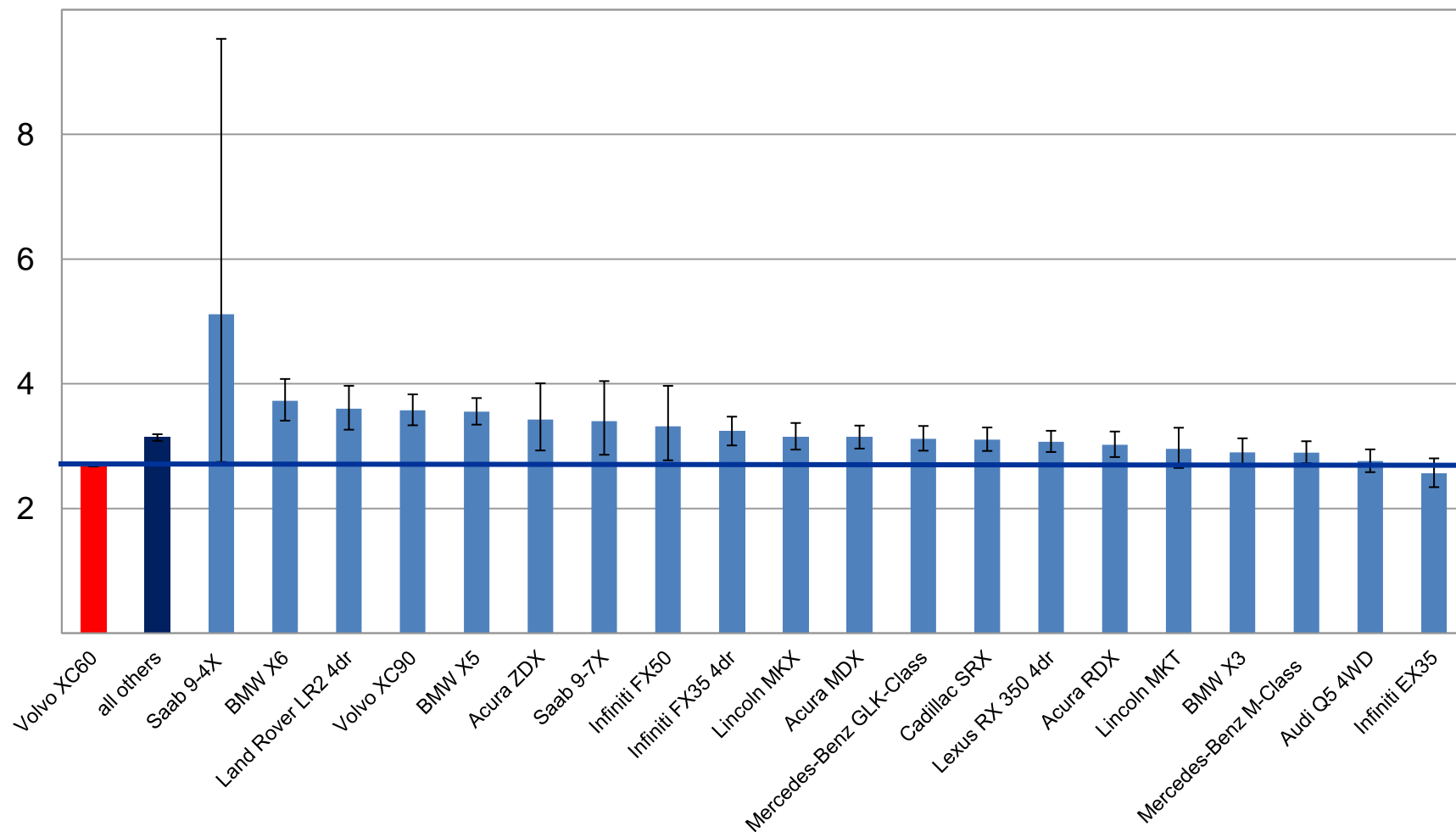


How are advanced driver assistance systems working?

Forward collision warning, with and without automatic braking, is working as expected

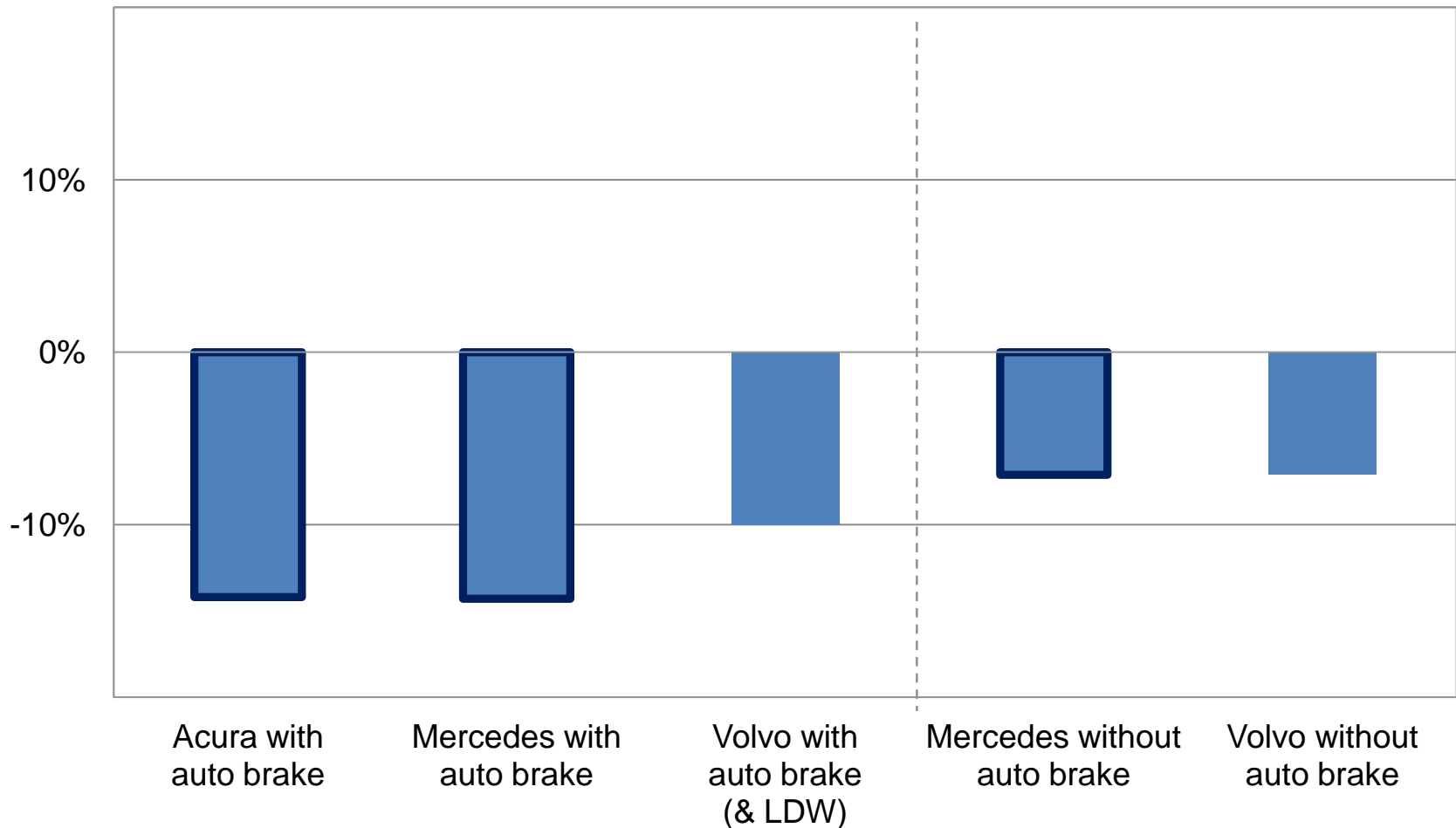
# Volvo XC60 with City Safety (low speed autobrake) vs. other 2009-12 midsize luxury SUVs

Property damage liability claims per 100 vehicle years, 2009-12



# High speed forward collision warning, with and without autonomous braking

Property damage liability claim frequency by manufacturer

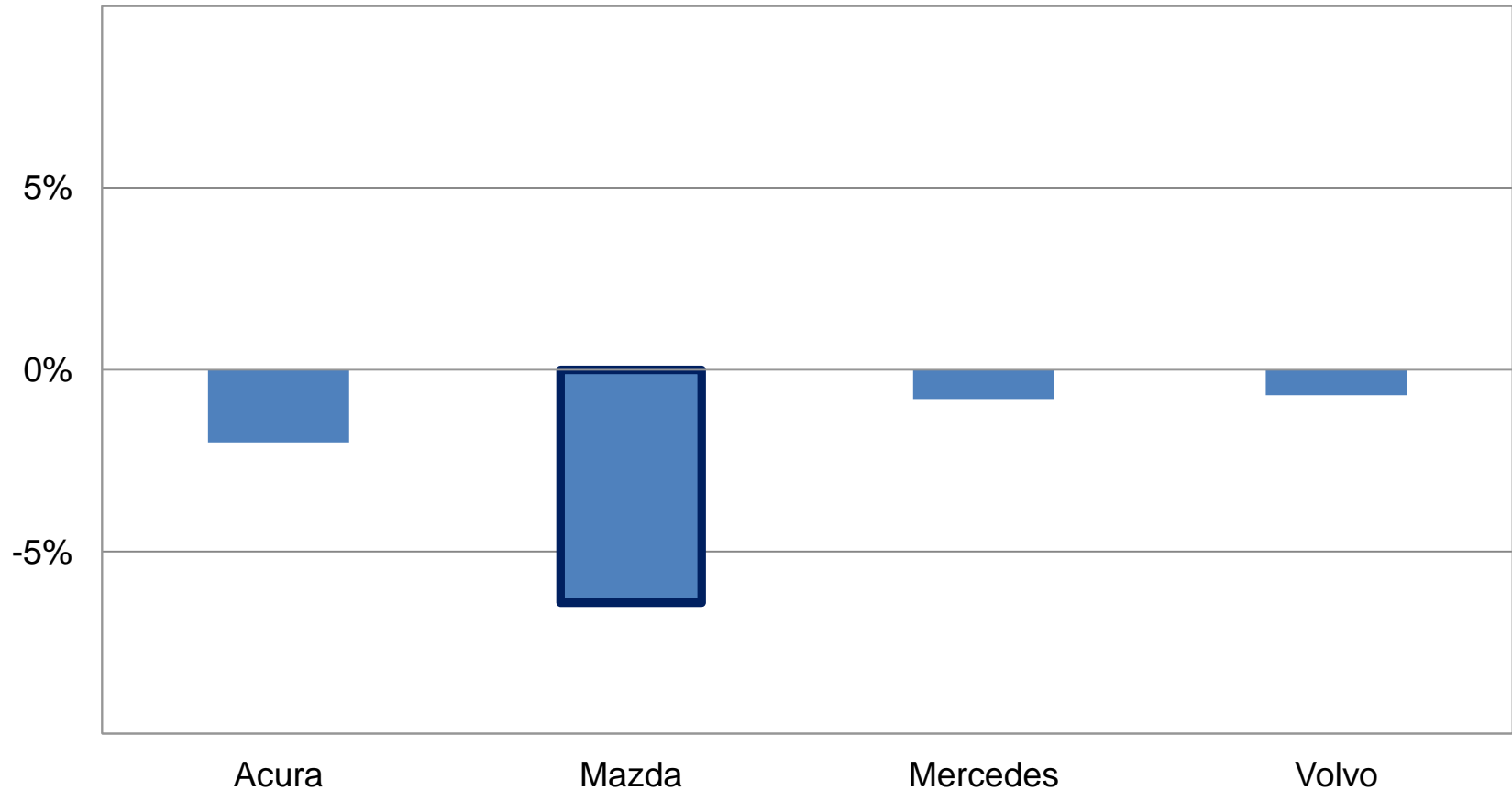


Adaptive headlights (steering responsive lamps) are working but not on single vehicle run-off-road crashes as expected

Adaptive headlights seem not to be reducing insurance collision claims, the kind of claim that would result from a single-vehicle crash (possible exception of Mazda)

# Adaptive headlights

Percent change in collision claims per insured vehicle year

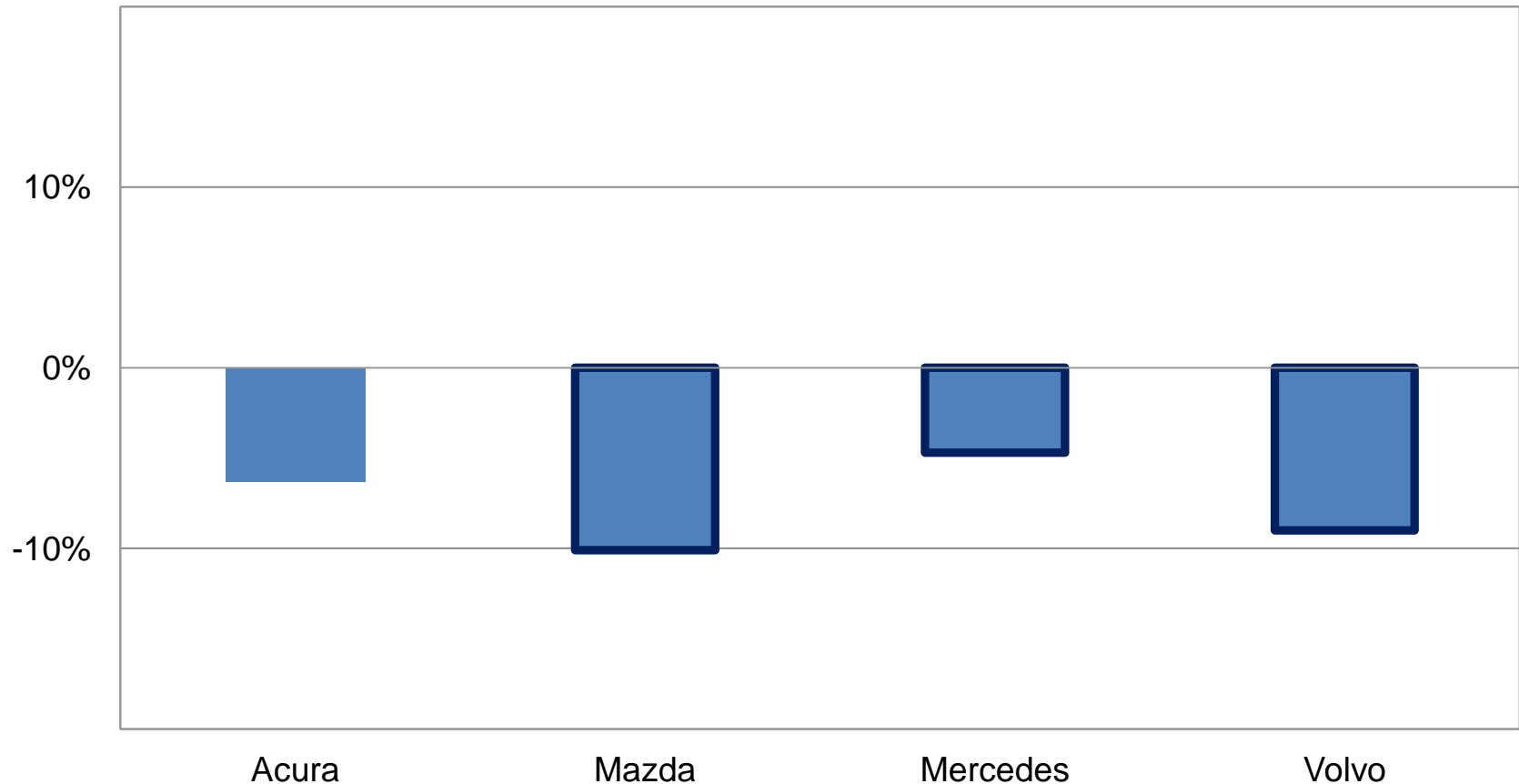




However, vehicles with adaptive headlights are involved in fewer crashes with other vehicles for which that vehicle is responsible, as indicated by a reduction in property damage liability claims and in claims for injuries in other vehicles

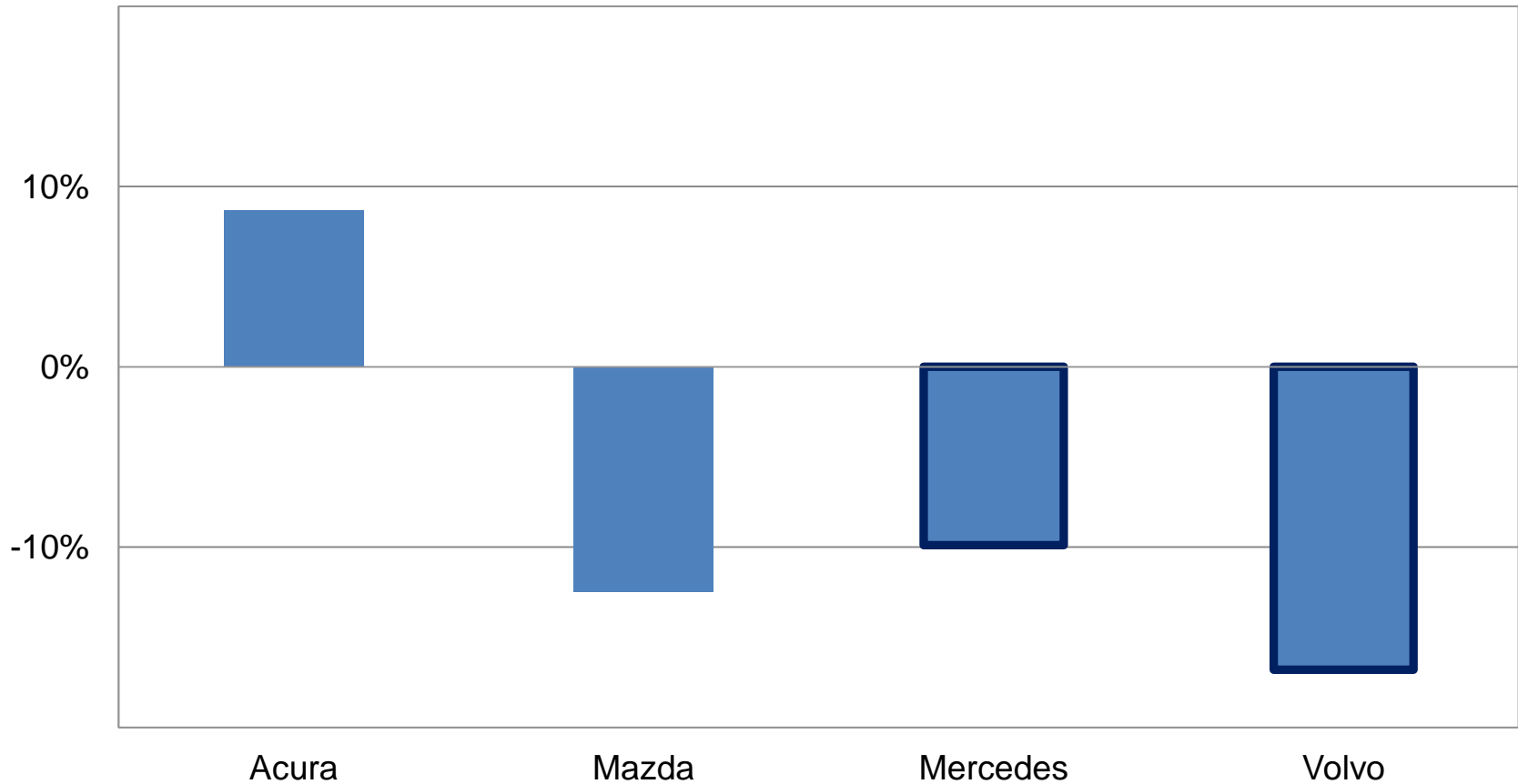
# Adaptive headlights

Percent change in property damage liability claims per insured vehicle year



# Adaptive headlights

Percent change in bodily injury claims per insured vehicle year

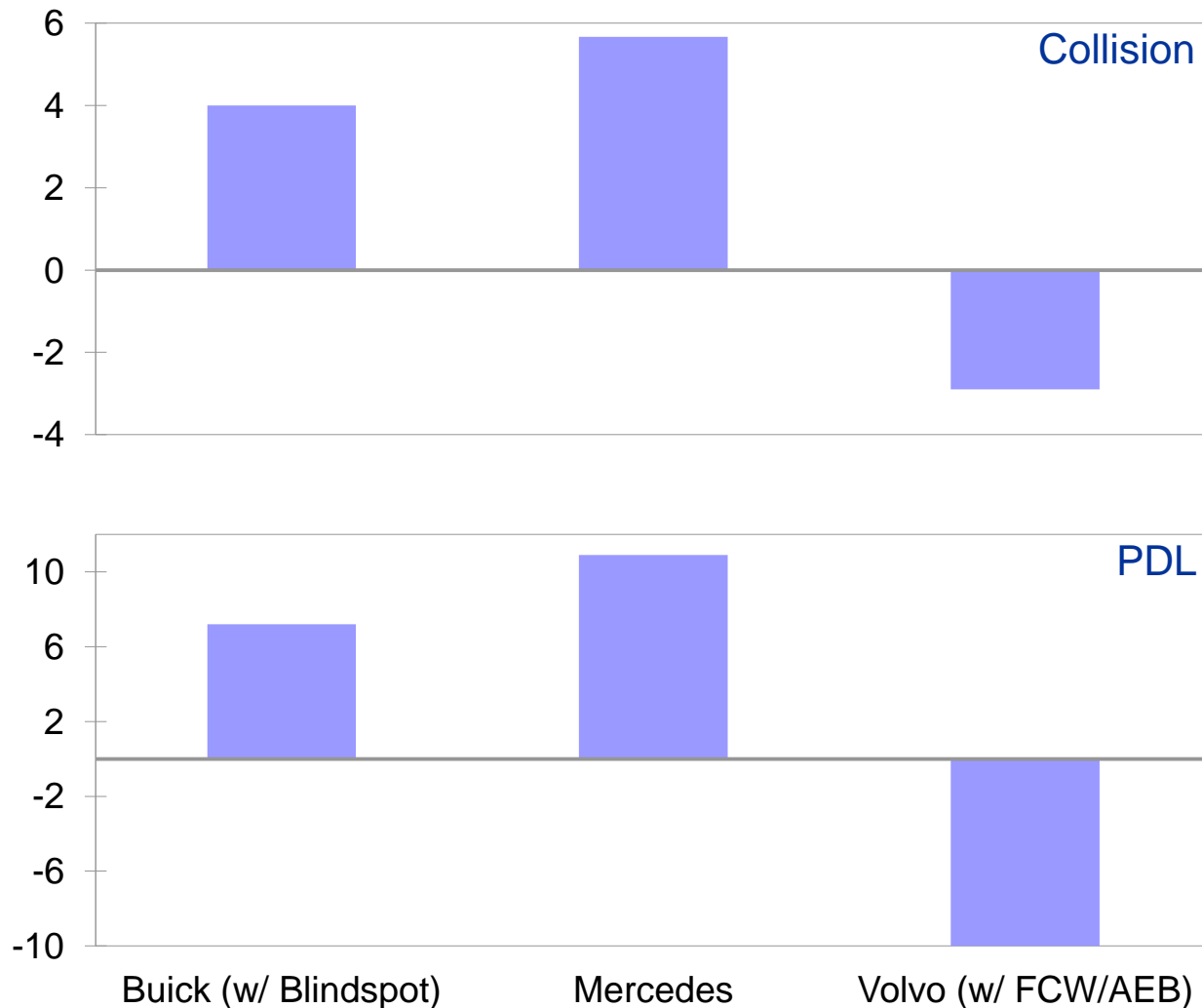


Some crash avoidance systems  
are showing no effectiveness

Lane departure warning  
(LDW, without active lane  
keep assistance) may be increasing  
crashes claimed with insurers

# LDW is not reducing crash incidence

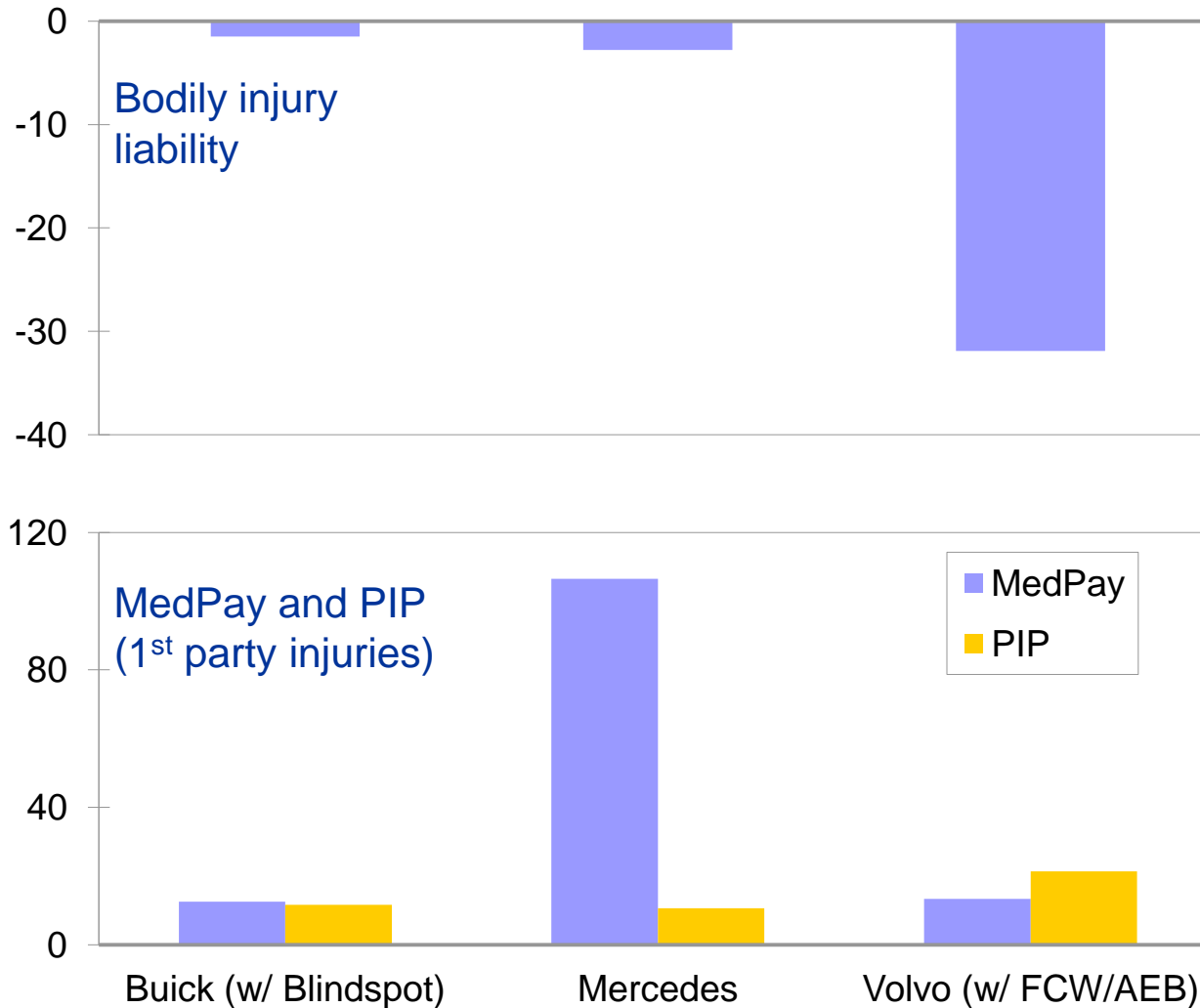
Percent change in vehicle damage claims per insured vehicle year



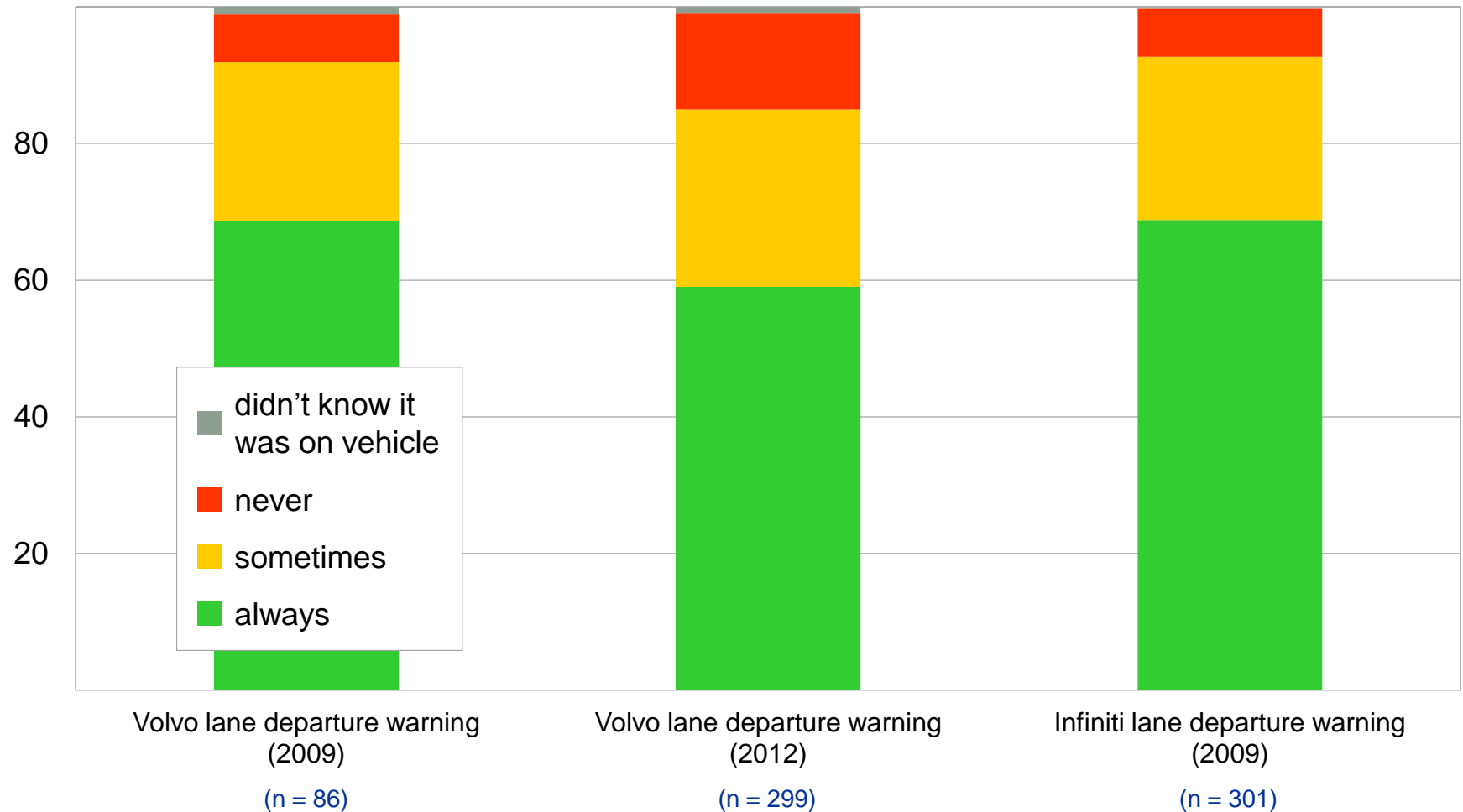
Only Volvo LDW systems are associated with decreases in claim frequency, and that is likely due to the forward collision warning with autonomous braking system, which always is paired with LDW

# LDW is not reducing injury incidence

Percent change in claims per insured vehicle year



# Percent of owners who drive with lane departure warning turned on







Questions raised about how  
drivers drive:

How much of driving is  
consciously controlled?

# Intuitive model of driver behavior

Oversimplified but useful for this discussion

- Drivers set out to get from point A to point B without crashing
  - With rare exceptions of suicide and homicide
- Drivers (safe ones) constantly scan the road ahead and behind for risk
  - Drivers are cognitively engaged with the task unless attention is diverted to unrelated activity (distraction)
- Infotainment devices bring additional cues for behavior unrelated to the task of driving
  - These cues increase distraction from primary vehicle control task
- Crash avoidance features cue drivers when their distractions have led to danger
  - These cues return drivers' attention to primary vehicle control task

# Is cognitive engagement the default driver state?

Mind wandering is common

- “We developed a smartphone technology to sample people’s ongoing thoughts, feelings, and actions and found (i) that people are thinking about what is not happening almost as often as they are thinking about what is and (ii) found that doing so typically makes them unhappy.”
  - Killingsworth, M.A. and Gilbert, D.T. 2010. A wandering mind is an unhappy mind. *Science*, 330, 932.
- “... people adjust their effort to the immediate and prospective demands of tasks that are put before them.”
  - Hancock, P.A. 2013. In search of vigilance: The problem of iatrogenically created psychological phenomena. *American Psychologist*, 68(2), 97-109.

# How great are the situational demands for cognitive control of driving ?

- Driving for most of us is an overlearned behavior
- Overlearned behaviors may have limited conscious control; for example
  - Throwing a baseball does not involve calculation of parabolic trajectories but rather the exercise of brain-muscle connections developed with practice
  - Maintaining lane position and driving around curves is easier if one looks ahead to where the vehicle is going rather than nearby, trying to control distance to road edge lines precisely
- Sometimes we arrive at our destinations with little memory of how we got there
  - Do you remember your drive to the airport to come here?

# What does it mean to pay attention to driving?

- Conscious attention to paying attention is not attention to the driving task
  - That's like being proud of humility
- If most driving is habitual, then driving effectiveness depends on
  - The adequacy of overlearned driving habits (hence the importance of graduated licensing)
  - The degree to which the road environment engages the driver's attention when necessary (road geometry and rules of the road)
  - Recapturing attention when unusual circumstances arise (special signing – flashing lights, crash avoidance features)

# Implications for advanced driver assistance systems


- Forward collision prevention
  - Systems appear to work
  - Cues are effective
    - But not always, because autonomous braking improves effectiveness
  - One surprising finding is equivalence of different alert strategies as indicated in equivalent findings across automakers
- Adaptive (steering responsive) headlamps
  - Benefits consistent with the addition of information that fits drivers' habits
  - Although data are preliminary, other lighting improvements also seem to reduce insurance crash claims

# Implications for advanced driver assistance systems

- Lane departure warning
  - Cues are ineffective
  - If the negative effect is real, is it possible that exposure to non-meaningful warnings may be making drivers less sensitive to all cues?
- Implication for V2V and V2I communications
  - These can greatly increase information coming to drivers
  - What problems may occur if too much of the information has limited implications for immediate behavior?

Providing these cues hypothesizes that what the car thinks drivers should focus on is more important than what the driver is focused on

Is information that has no immediate behavioral value distracting from the driving task?

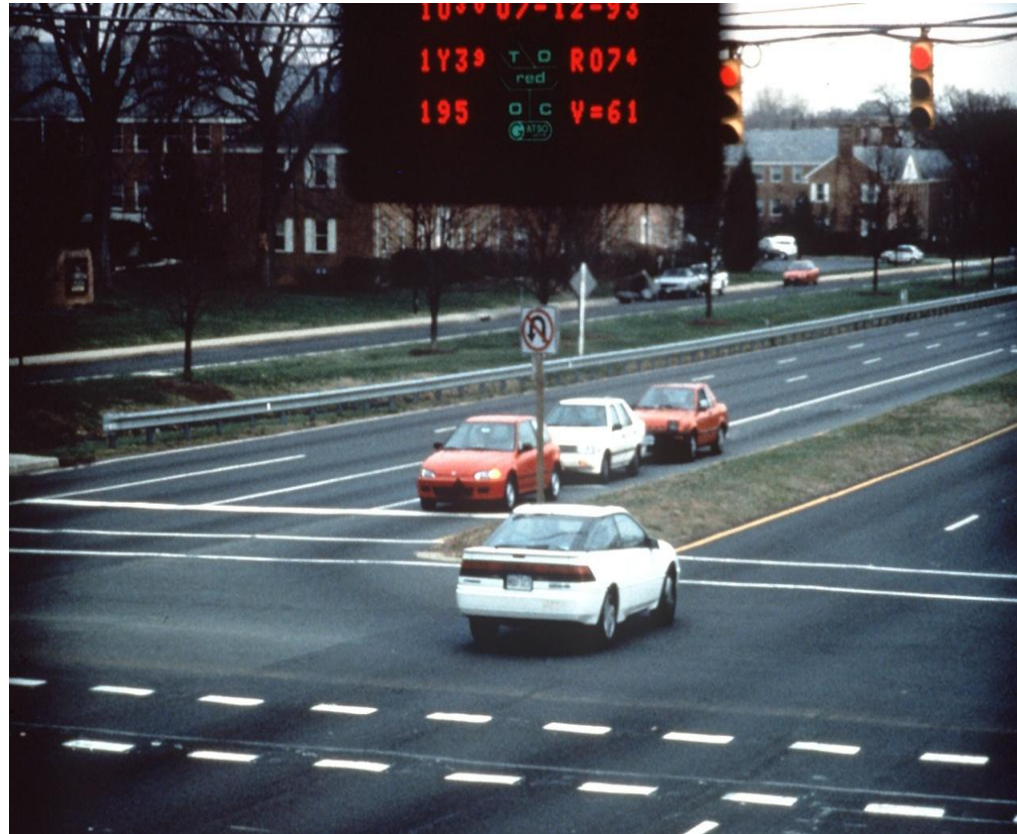


Improvements in driver  
attention and performance may  
not require new technology

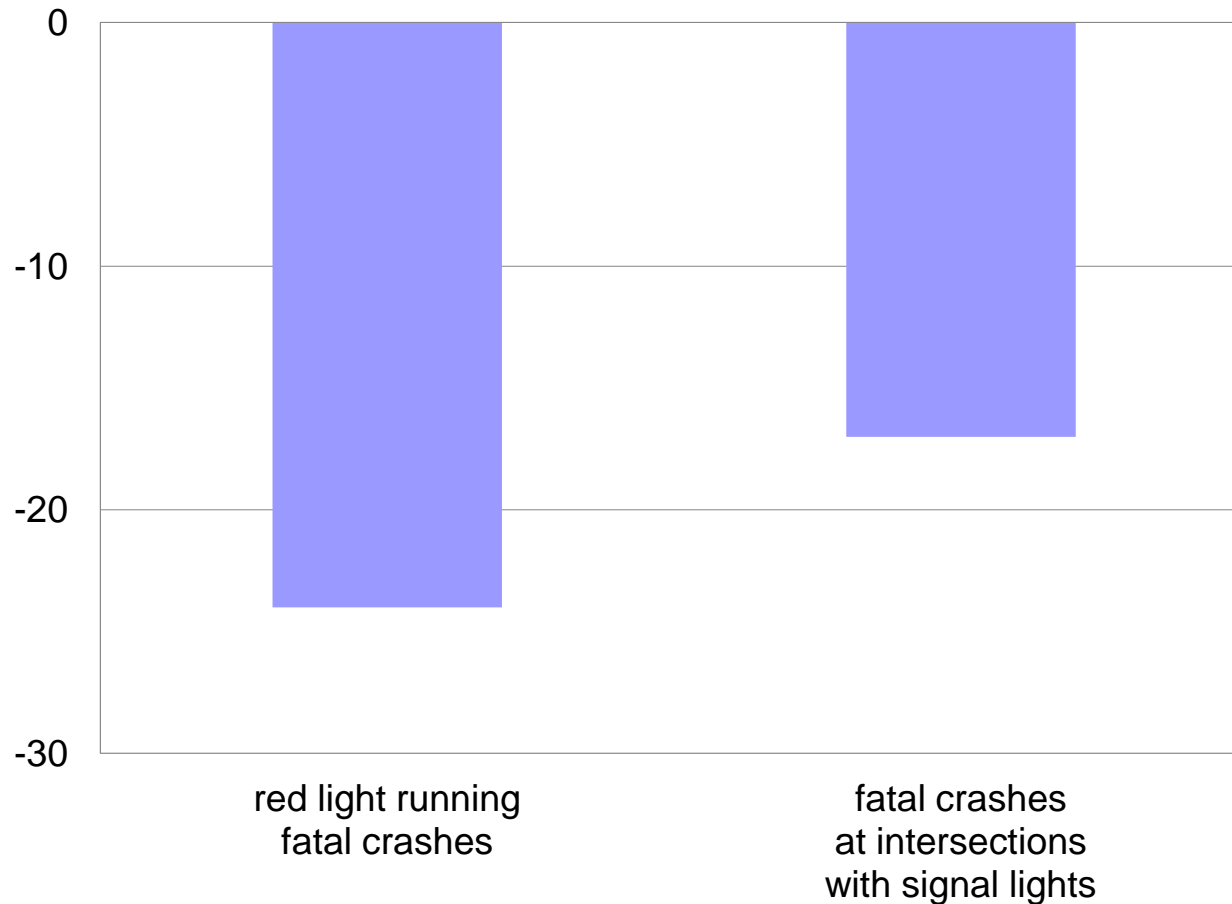
Red light cameras already  
are making drivers pay more  
attention at intersections



In 2011 on US roads,  
about 150,000 red-light-  
running crashes caused  
about 118,000 injuries  
and about 700 deaths.



# Percent difference in actual fatal crash rates during 2004-08 in 14 large cities with red light cameras vs. expected rates without cameras



Red light cameras are sometimes criticized for enforcing right-turn-on red rules. However, stop-before-turning rules are meant to protect pedestrians from drivers who might otherwise be looking left for oncoming traffic when pedestrians enter the road from the right.



Roundabouts also reduce crashes

Is that partly because they make drivers pay attention (as well as slow down)?



# Roundabouts are safer and more efficient



Roundabouts require drivers to:

- slow down,
- look for traffic in the circle,
- negotiate the circle,
- watch for other traffic entering the circle.

# Estimated crash reductions if 10 percent of signalized intersections in US converted to roundabouts

- Approximately 43,000 crashes prevented in 2011 including:
  - 170 fatal crashes
  - 28,000 injury crashes



# Estimated annual economic savings if 10 percent of signalized intersections in US converted to roundabouts

- Vehicle delays reduced by more than 900 million hours
- Fuel consumption reduced by more than 600 million gallons

# Conclusion

- Infotainment and crash avoidance features promise to proliferate in the near term
- Our intuitive model of driver behavior – that the default driver state is cognitive attention to the task – probably misleads us
  - Effective integration of these features into the driving environment requires recognition that
    - Much of our daily lives involves mind wandering
    - Much of driving behavior is habitual, with limited cognitive control
- Key question for all of us: How do we get drivers the information they need and want without distracting them from the driving task as they perform it?



## Postscript

Research planned at  
the Insurance Institute  
for Highway Safety

vehicle to pedestrian



vehicle to stationary vehicle



vehicle to moving vehicle

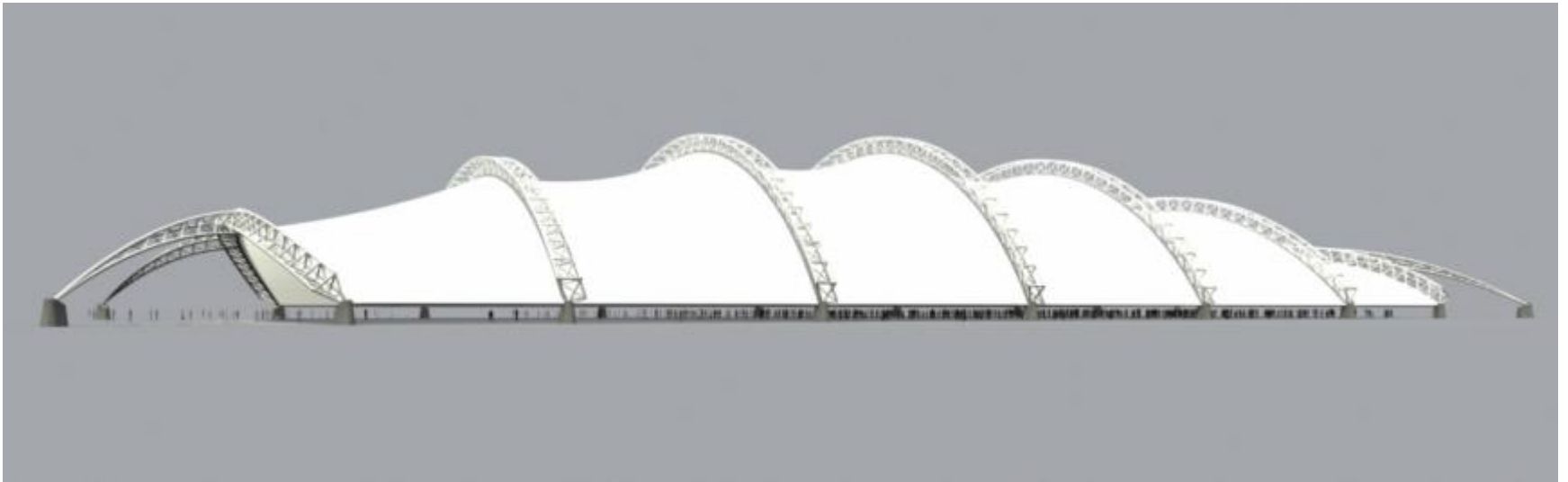
# Planned expansion of test track capability





# Covered test track

Steel and tensile fabric structure



# Form to finish first of 18 support piers





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Dedicated to reducing deaths, injuries,  
and property damage on the highway