A U.S. Perspective on Driver Distraction: Problems, Progress, Priorities

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International Conference on Driver Distraction and Inattention
September 28-29, Gothenburg, Sweden

Topics

- **Why has distraction become such a concern among the public, industry, media, researchers, legislators?**
- **What is known about the safety problem in the U.S.**
- **Progress in identifying effective and acceptable countermeasures**
- **Future priorities**

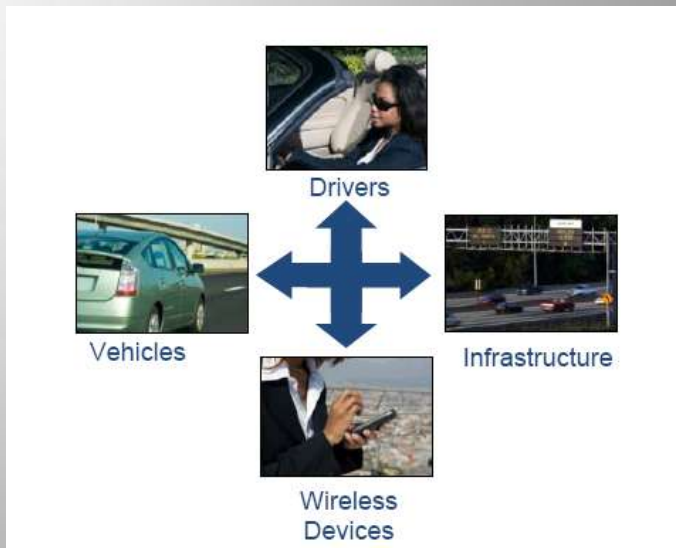
Technology Trend

Built-in Devices

Future Wireless Technologies

IntelliDrive℠
Safer. Smarter. Greener.

- **Signal and Stop Sign Violation Warning**
- **Curve Speed Warning**
- **Collision Warning**
- **Smart Parking-Up-to-the-minute information about parking availability**
- **Vehicle distress signals (alerts other drivers that help is needed)**
- **Real time re-routing**
- **Road condition alerts**
- **Vehicle service alerts**



Brought-in Devices

Cell Phones


What did it do, grandpa?
ADD TO FAVES
ADD NOTE
BLOG THIS
ALL SIZES
NOKIA
Bell Atlantic Mobile


AT&T
9:42 AM
Text
Calendar
Photos
Camera
YouTube
Stocks
Maps
Weather
Clock
Calculator
Notes
Settings


LG


My First
Mobile Phone
My First
Center

Feds fear high-tech car gear

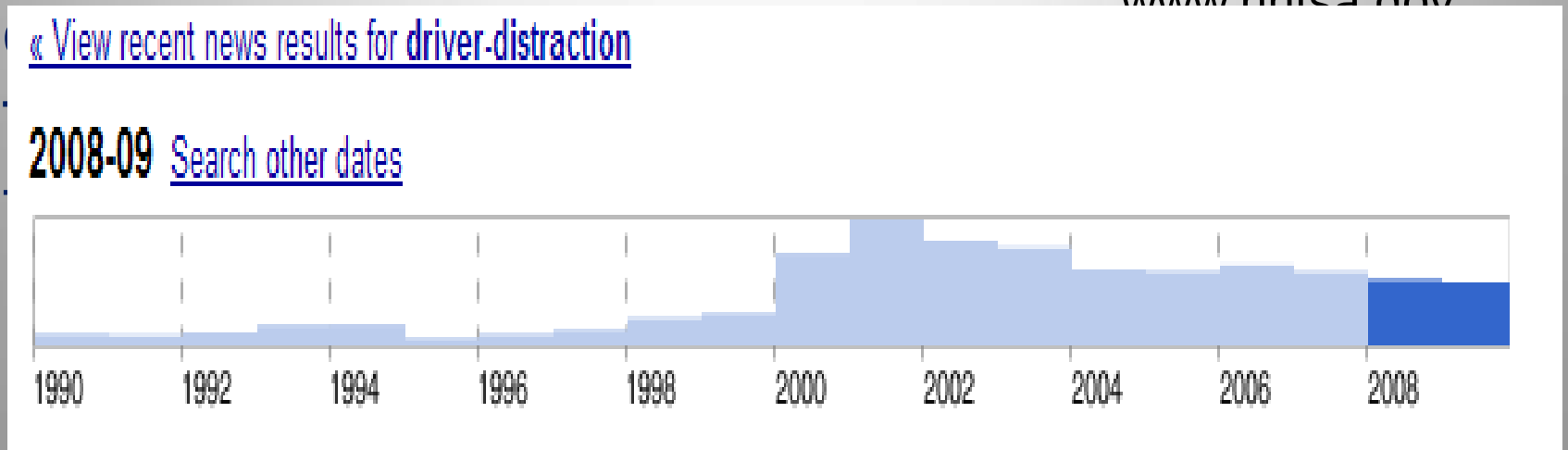
Innovative devices to entertain drivers spur safety concerns

By Dina ElBoghdady / Detroit News Washington Bureau

2000 Public Meeting, Internet Forum, Expert Working Groups Organized by the National Highway Traffic Safety Administration (NHTSA)

- To learn of ongoing initiatives and research needs
- Develop strategies for realizing benefits of in-vehicle technologies without increasing

www.nhtsa.gov



Themes From Working Groups

- Distraction is broader problem than electronic distractions
- Very little is known about the extent of and factors associated with the distraction problem
  - How and when drivers use technology
  - Need naturalistic studies to identify pre-crash circumstances
- Standardized techniques to objectively measure distraction and safety impact; threshold criteria for safety limits are needed
- Need more emphasis on understanding cognitive distractions
- Examine individual differences

NHTSA Distraction Research Program

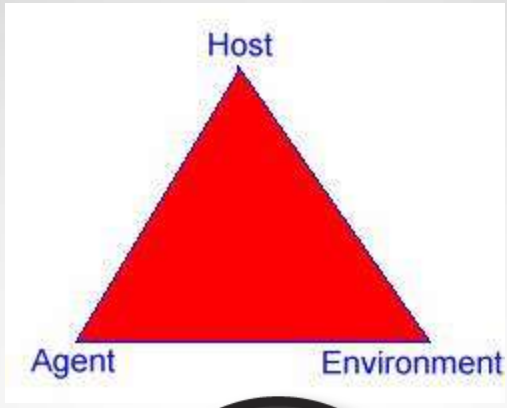
Understand the magnitude and characteristics of the crash risk

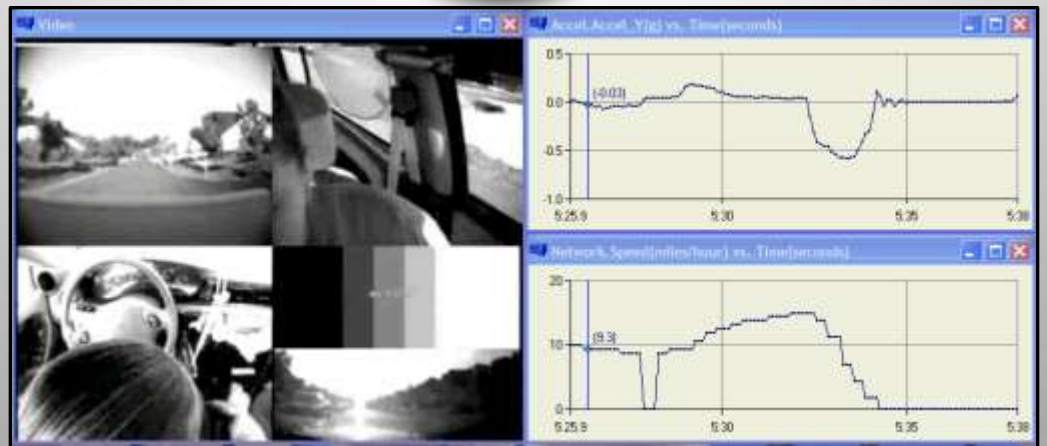
Reduce Device Attentional Demands: Develop metrics & protocols to quantify impacts of interfaces on distraction potential

Reduce Crash Risks: Determine effective and acceptable driver assistance systems

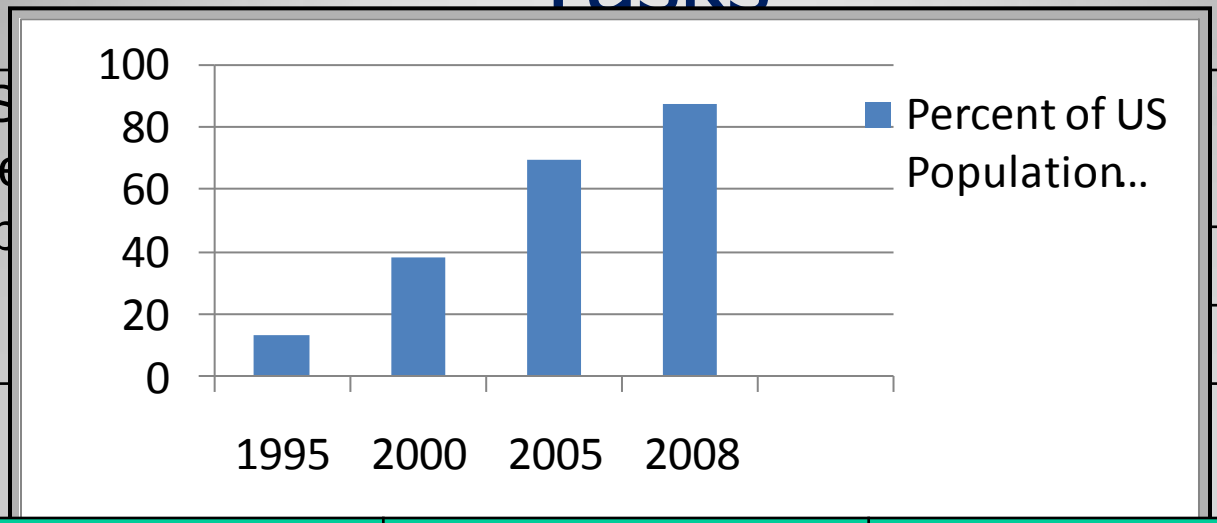
Develop Social Marketing & Behavioral Change Programs

Surrounding the Truth About the Magnitude of the Crash Problem



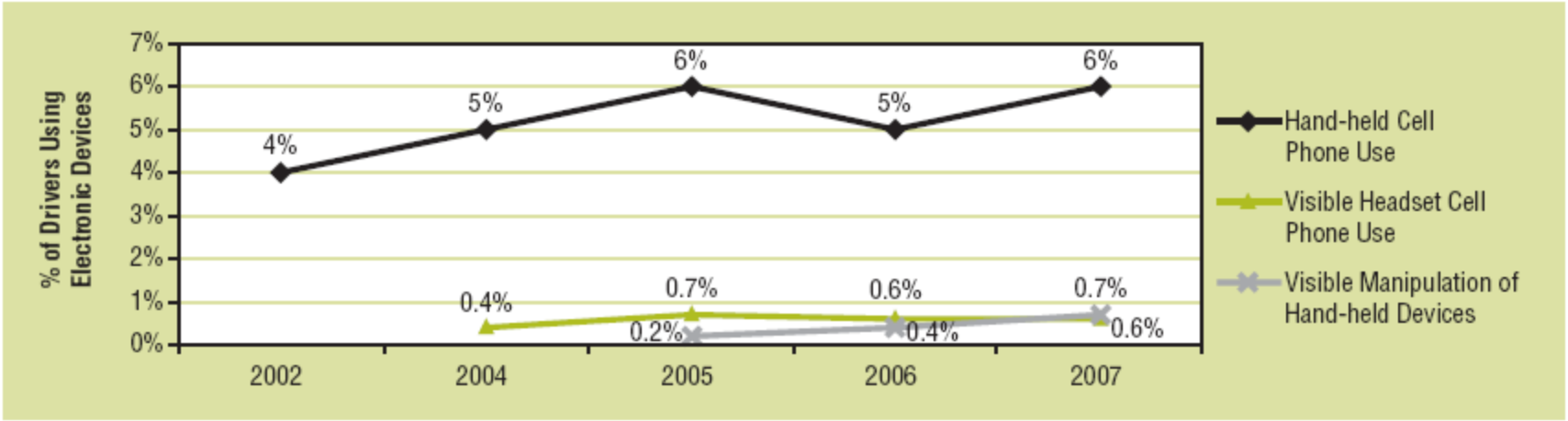


Incidence of Phone Use and Other Tasks



Phone subscribers, CTIA	2008	270 Million
	2000	110 Million

Driver Use of Electronic Devices



Source: National Occupant Protection Use Survey, NCSA/NHTSA, 2006-2007

Data From Police Reports and From 100 Car Data

1995 CDS Goodman et al(1995)	Multitasking related	13% of crashes
	Broadly defined (i.e., all inattention)	25% of crashes
Stutts (2002) NC state police narratives	Cell phone related	.04% of crashes in North Carolina (1996-2000)
2000-2003 CDS Stutts et al (2005)	Distracted	10.5% of drivers in tow away crashes
	Cell phone related	3.6% of distracted drivers in crashes
100 Car data	looking away in 3 sec prior to crash	80% of crashes

VIRGINIA
DRIVER ACTION CONTRIBUTING TO THE CRASH
CALENDAR YEARS 2001 - 2007

Driver Action Contributing To The Crash	Drivers						
	2001	2002	2003	2004	2005	2006	2007
Ran Traffic Control	7,747	7,860	7,837	7,287	7,061	7,258	6,731
Improper Passing	1,707	1,795	1,832	2,018	1,911	1,859	1,727
Left of Center - Not Passing	2,448	2,334	2,538	2,364	2,207	2,129	2,013
Failure To Yield	23,258	22,903	22,892	24,098	23,995	23,100	21,499
Driver Distraction	31,825	28,002	29,554	11,025	7,546	6,826	5,986
Speed Too Fast	14,237	16,152	17,862	11,982	9,978	7,558	7,390
Improper Turn	4,236	4,267	4,283	4,417	4,201	4,174	3,898
Improper Lane Change	2,607	2,996	3,226	6,793	7,186	7,104	6,852
Following Too Close	21,948	24,570	25,352	28,845	29,423	29,737	28,147
Improper Backing	1,613	1,614	1,667	1,900	1,872	1,979	1,855
Illegal or Improper Parking	362	332	348	413	392	484	473
Lights Not On	91	131	95	122	131	122	116
Hit and Run	7,316	7,675	7,817	6,980	7,263	7,773	7,038
Avoiding Pedestrian	179	135	141	154	124	128	107
Avoiding Other Vehicle	3,915	3,942	4,245	3,181	3,071	2,549	2,385
No Violation	113,878	116,509	120,856	122,192	124,676	128,069	121,973
Other	16,390	17,339	17,409	33,660	38,725	40,154	39,249
Not Stated	8,570	8,821	9,152	10,043	8,938	8,502	8,150
Total	262,327	267,377	277,106	277,474	278,700	279,505	265,589

National Motor Vehicle Crash Causation Study (NMVCCS)

Crashes Where the Critical Reasons Were Attributable to Driver

Category	Sub category	Percent of Crashes
Recognition error (40.6)	Inadequate surveillance	20
	Internal distraction	11
	External distraction	4
	Inattention (daydreaming)	3
	Other/unknown	2.5
Decision error	e.g., too fast	41
Performance error	e.g., overcompensation	34
Non performance error	e.g., asleep	10
Other/unknown		8

NMVCCS Report to Congress, July 2008, DOT HS 811 059

Driver-Related, Crash Associated Factors: Interior Non-Driving Activities (NMVCCS)

Activity	% of crash involved drivers (multiple choices/driver)
Conversing with passenger	9.87
Conversing on phone	1.73
Retrieving objects	1.6
Looking at other occupants	1.3
Adjusting vehicle controls	0.9
Dialing/hanging up phone	0.2

NMVCCS Report to Congress, July 2008, DOT HS 811 059

Naturalistic Driving Data: Crash/Near Crash Risk Estimates

odds ratio for crashes/near crashes (Virginia Tech, 100 Car Naturalistic Study, 2006)	Looking at external object	3.8*
	Dialing hand-held phone	2.8*
	Inserting/retrieving CD	2.3
	Eating	1.6
	Talking/listening on phone	1.3
	Passenger , front seat	.5*
	Cumulative eyes off forward roadway>2 sec in 5 sec prior and 1 sec after event	2.37*

* Statistically significant

How is problem explained by news media?

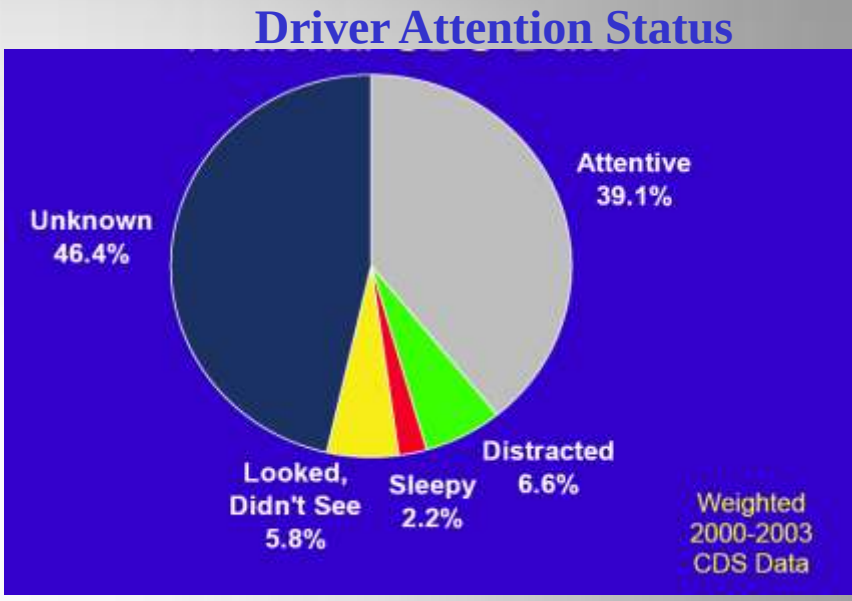
- Notable individual crash reports involving distraction

How is problem explained by news media?

- *Between 20 and 30 percent of all motor vehicle crashes in the United States are caused in part by driver distraction according to the National Highway Traffic Safety Administration (NHTSA).* msnbc.msn.com (8/06)
- *Driver distraction accounts for 80 percent of all vehicle crashes and 65 percent of near-crashes, says the National Highway Traffic Safety Administration.—Bangor Daily News (8/09)*
- *The reality is that driver distraction is the number one cause of crashes— motortrend.com (8/09)*
- *The likelihood that they (drivers using phones) will crash is equal to that of someone with a .08 percent blood alcohol level, the point at which drivers are generally considered intoxicated. –New York Times (8/09)*

Challenges of Characterizing the Distraction Crash Problem

- Crash Data not complete regarding driver distraction
  - driver honesty; misperceptions
  - 40% of cases unknown
- Problems from new "electronic distractors" may not show up in crash data for years
- In the U.S., police reporting varies from state to state
  - Definition of distraction varies
  - In 2003, only 7 states had cell phone fatalities
  - 206 out of 285 fatals were in CA



Understanding the Problem: Progress and Priorities

- Distraction from cell phones and other sources is a safety problem
- The true magnitude of the problem still not known
- Many studies have shown how this increased risk might occur due to the degradation in driving performance during multitasking, including slower reaction time and narrow visual scanning.
  - *Experimental data do not directly translate into estimates of crash risks*
- Future naturalistic studies should help to provide better risk estimates and insights regarding the role of distraction in crash causation.

Core elements of distraction crash risk

- *Attentional demands* : The amount of resources required to perform the distraction task
- *Exposure*: How often and when drivers engage in the task . Driver strategies (if any) to compensate for distraction.

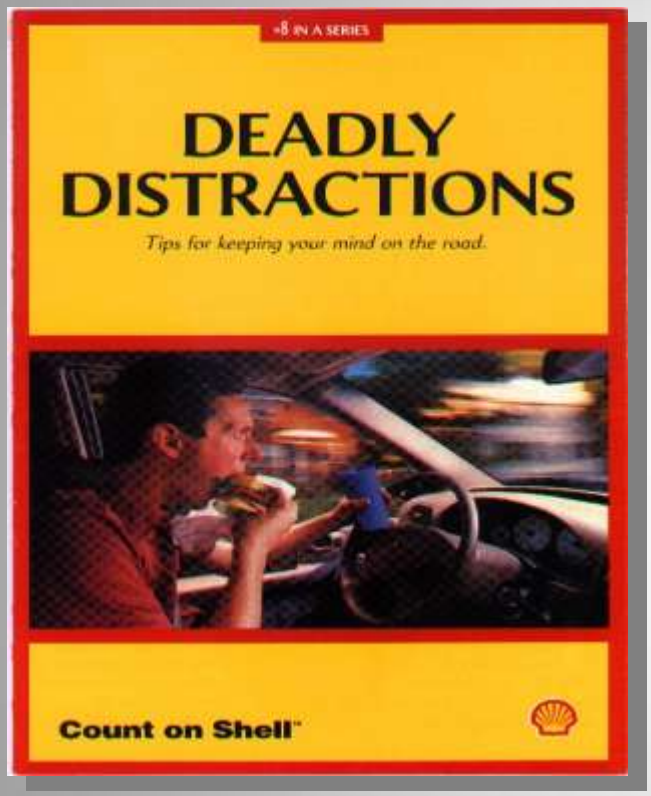
Options to Minimize Distraction Crash Risk

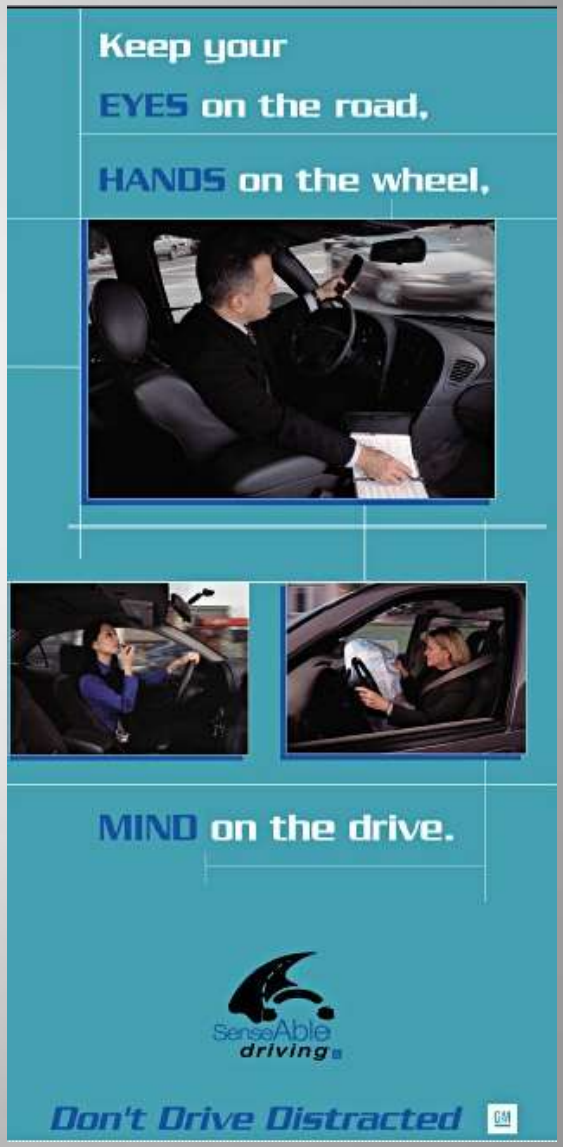
- Change Driver Behavior
  - Laws to prohibit unsafe device use
  - Educate drivers about dangers of driving while distracted
- Improve Device Designs
  - Human engineer equipment designs to minimize demands on drivers
  - Workload managers to automatically limit information to driver
- Warn Distracted Drivers
  - Deploy effective and acceptable advanced driver assistance systems
  - Provide drivers with real time feedback about their risky behaviors

Behavior Change Activities

- Education
- Information Campaigns
- Warning labels
- Laws

Information Campaigns





Typical Phone Safety Tips

- Get to know your wireless phone and its features
- Position your wireless phone within easy reach
- Let the person you are speaking with know you are driving
- Suspend calls in adverse weather and heavy traffic

Wireless Phone Information

Important Safety Precautions

Read these simple guidelines. Breaking the rules may be dangerous or illegal. Further detailed information is given in this user guide.

⚠Warning

Violation of the instructions may cause serious injury or death.

- Never use an unapproved battery since this could damage the phone and/or battery and could cause the battery to explode.

- Never place your phone in a microwave oven as it will cause the battery to explode.
- Never store your phone in temperatures less than -4°F or greater than 122°F.
- Do not dispose of your battery near fire or with hazardous or flammable materials.

- When riding in a car, do not leave your phone or set up the hands-free kit near the air bag. If wireless equipment is improperly installed and the air bag is deployed, you may be seriously injured.

- Do not use a hand-held phone while driving.
- Do not use the phone in areas where its use is prohibited. (For example: aircraft)

Consumer Information

Drive responsibly

When behind the wheel, safe driving is your responsibility and it should always be your first priority.

Scientific research on the subject of wireless phone use and driving has been conducted worldwide for several years. According to the National Highway Traffic Safety Administration (NHTSA), the available research indicates that using a wireless phone while driving degrades a driver's performance, whether it is a hands-free or hand-held wireless phone. NHTSA advises that the "safest course of action is to refrain from using a cell phone while driving." NHTSA's policy on "Cell Phone Use While Driving," as well as Frequently Asked Questions on the subject, are available at **www.nhtsa.gov** (click on "Traffic Safety" then on "Drowsy and Distracted Driving").

For your well being and the well being of those around you, you should consider turning your phone off and allowing calls to go to Voice Mail while you are driving.

If you choose to use your wireless phone while driving, several jurisdictions have adopted "hands-free" and other restrictions on the use of wireless devices while driving. It is your responsibility to know and to comply with the law in your area.

BICYCLE BUYER'S AGREEMENT

OWNER'S NAME	SALE NUMBER
ADDRESS	DATE OF PURCHASE
CITY STATE ZIP	SALESPERSON
DEALER'S NAME, ADDRESS, CITY, STATE and ZIP	BRAND
	YEAR
	MODEL
	SERIAL NUMBER

BUYER'S CHECKLIST

As members of the cycling industry, our staff and management would like to thank you for purchasing your bicycle from us.

As in many recreational activities, accidents can and do occasionally occur. It is for this reason, that we specifically bring the following points to your attention. We ask that you read each point carefully and ask questions of our staff if you do not clearly understand any particular point addressed.

1. I have received the owner's manual and agree to read it, especially the safety warnings, before using the bicycle. **I understand that all riders (adults and children) should wear a bicycle helmet whenever riding the bicycle.** Please initial _____
2. I understand that this bicycle is subject to all the laws of the road, and that many states and localities have additional laws which specifically apply to bicycles. Please initial _____
3. I have been instructed in the use of brakes and gear shifting mechanisms, and in the use of all quick release mechanisms (wheels, seatpost, and brakes) as well as any wheel retention devices on this bicycle. Please initial _____
4. I have been advised of the proper size bicycle for me, but the final selection of this bicycle has been my own decision. Please initial _____
5. I understand that regular maintenance is required to keep this bicycle operating properly and that failure to maintain may void the manufacturer's warranty and may make the bicycle unsafe. Regular maintenance includes frequent inspection of all quick release mechanisms and wheel retention devices. I also understand that maintaining appropriate tire pressure at all times is essential for the safe use of this bicycle. The recommended tire pressure is marked on the tire. Please initial _____
6. I have been informed that cables stretch and bolts loosen which affect performance and safety and I should bring the bicycle back within 60 days for a free inspection. Please initial _____
7. I have been informed that the bicycle may be physically capable of handling terrain which is too dangerous for my riding style, ability and experience and I should only ride in areas which are safe, without regard to statements in advertising materials. Please initial _____
8. I understand I have an obligation to read the warranties and return the warranty card to the manufacturer. Please initial _____

By initialing each item on the above checklist, I have indicated my complete understanding of these points, and I acknowledge my responsibilities regarding the contents. I also agree to explain the points on this checklist to anyone besides myself who will be using the bicycle now and in the future.

X _____ _____ _____

Buyer's Signature Date Buyer's Name (Print)

(If Buyer is under 18 years of age, the buyer's guardian must sign.)

- **I have received the owners manual and agree to read it**
- **I understand that all riders should wear helmets**
- **I understand that this bicycle is subject to all the laws of the road**
- **I have been instructed in the proper use of brakes and gear shifting mechanisms**

2009 Survey by AAA Foundation for Traffic Safety*

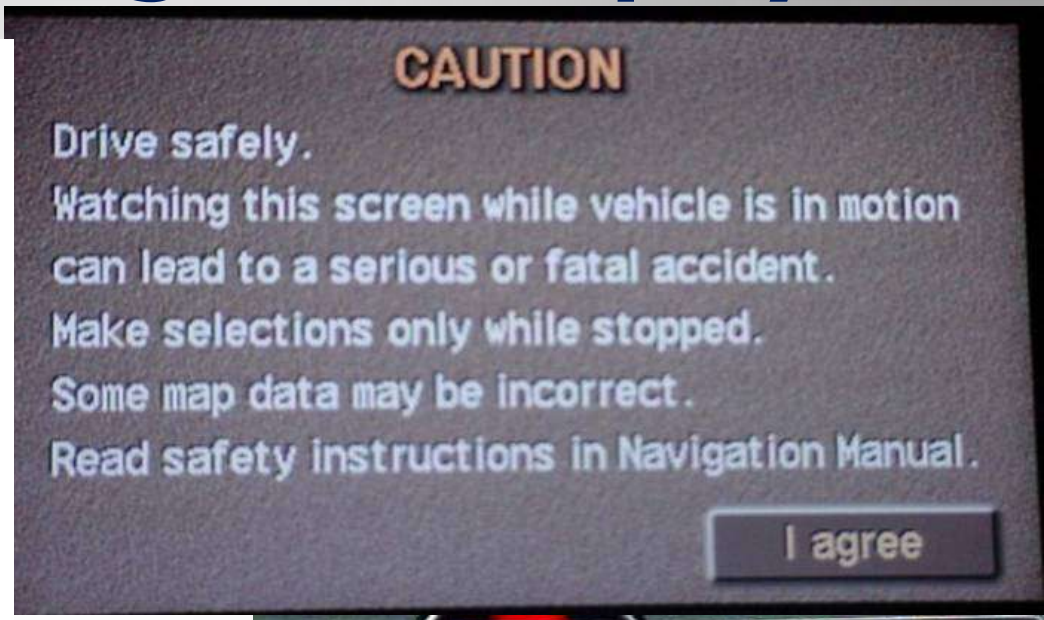
- 95% of drivers said that text messaging while driving was completely or somewhat unacceptable;
  - 18% of those same drivers admitted having read or sent a text message or email while driving in the past month.
- 71% rated talking on a handheld cell phone while driving as unacceptable
  - 30% of those same drivers reported doing this
- 95% rated driving 15 mph over the speed limit on a residential street as unacceptable
  - 21% of those same drivers admitted having done this.

*Random sample telephone survey of 2,501 U.S. residents 16 years of age and older, http://www.aaafoundation.org

Automobile Information in Owners Manuals and Navigation Displays

⚠ CAUTION:

This system provides you with a far greater access to audio stations and song listings. Giving extended attention to entertainment tasks while driving can cause a crash and you or others can be injured or killed. Always keep your eyes on the road and your mind on the drive — avoid engaging in extended searching while driving.

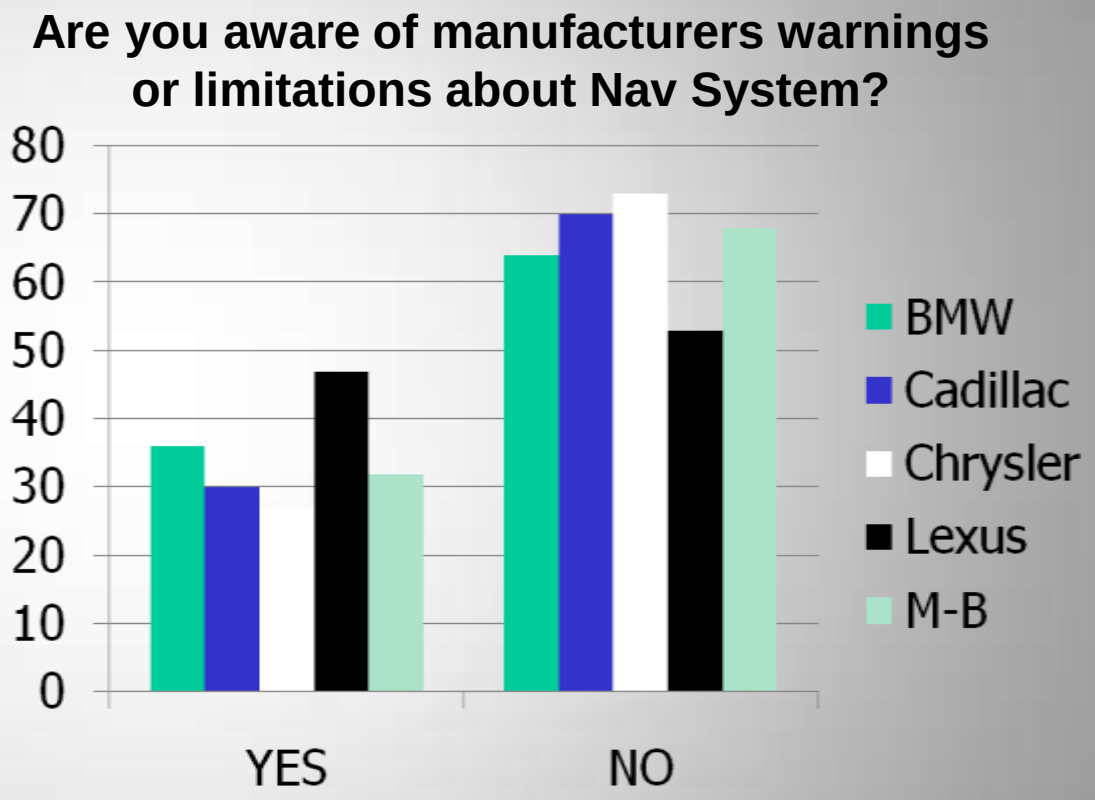


SAFETY INFORMATION

Driving while distracted can result in loss of vehicle control, accident and injury. Ford strongly recommends that drivers use extreme caution when using any device that may take their focus off the road. The driver's primary responsibility is the safe operation of their vehicle. Only use cell phones and other devices not essential to the driving task when it is safe to do so.

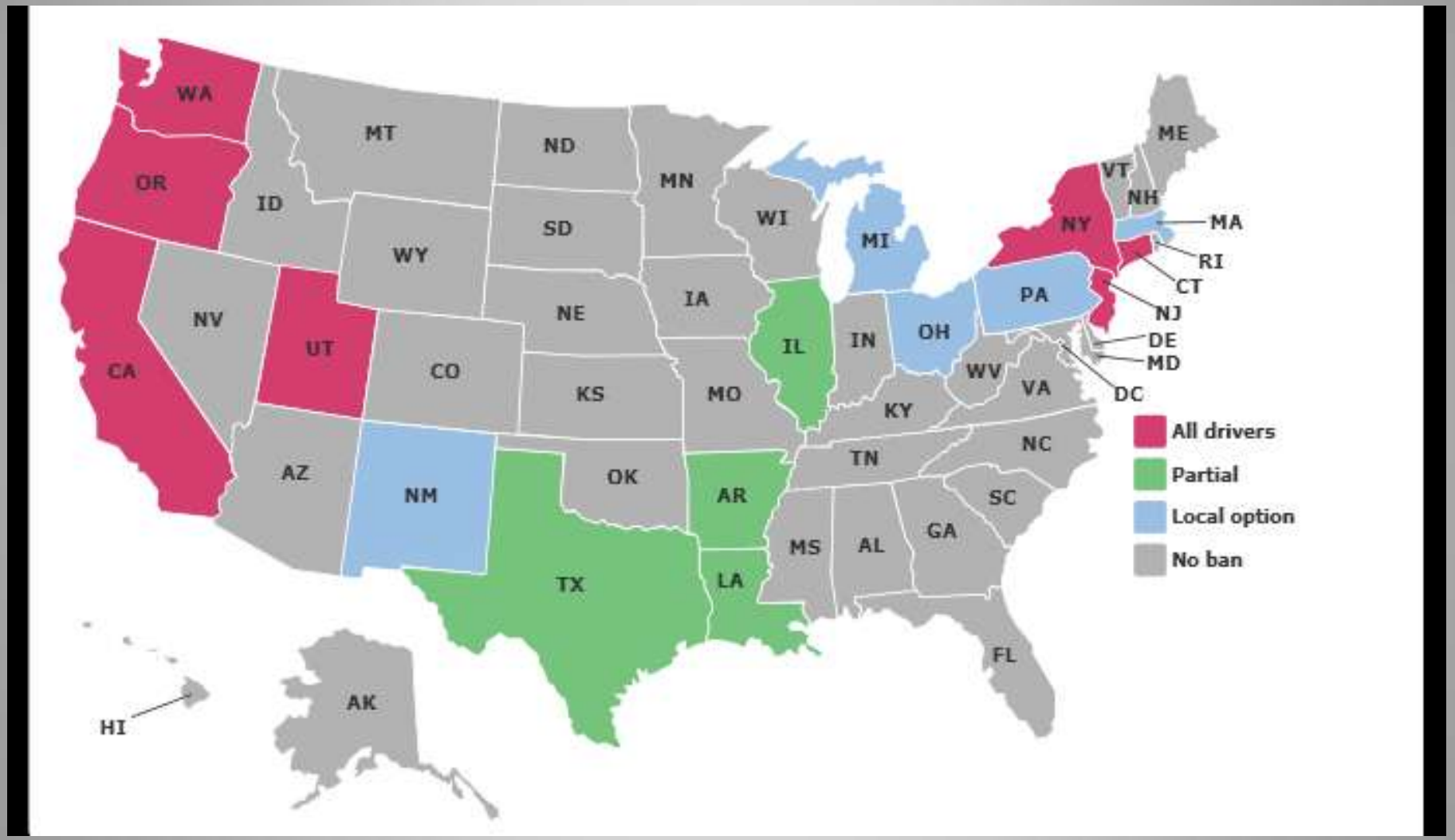
Survey of Early Adopters: OEM Navigation Systems

- Questionnaire responses from 1500 drivers who purchased cars with navigation systems
- 63% not aware of any manufacturer's warnings



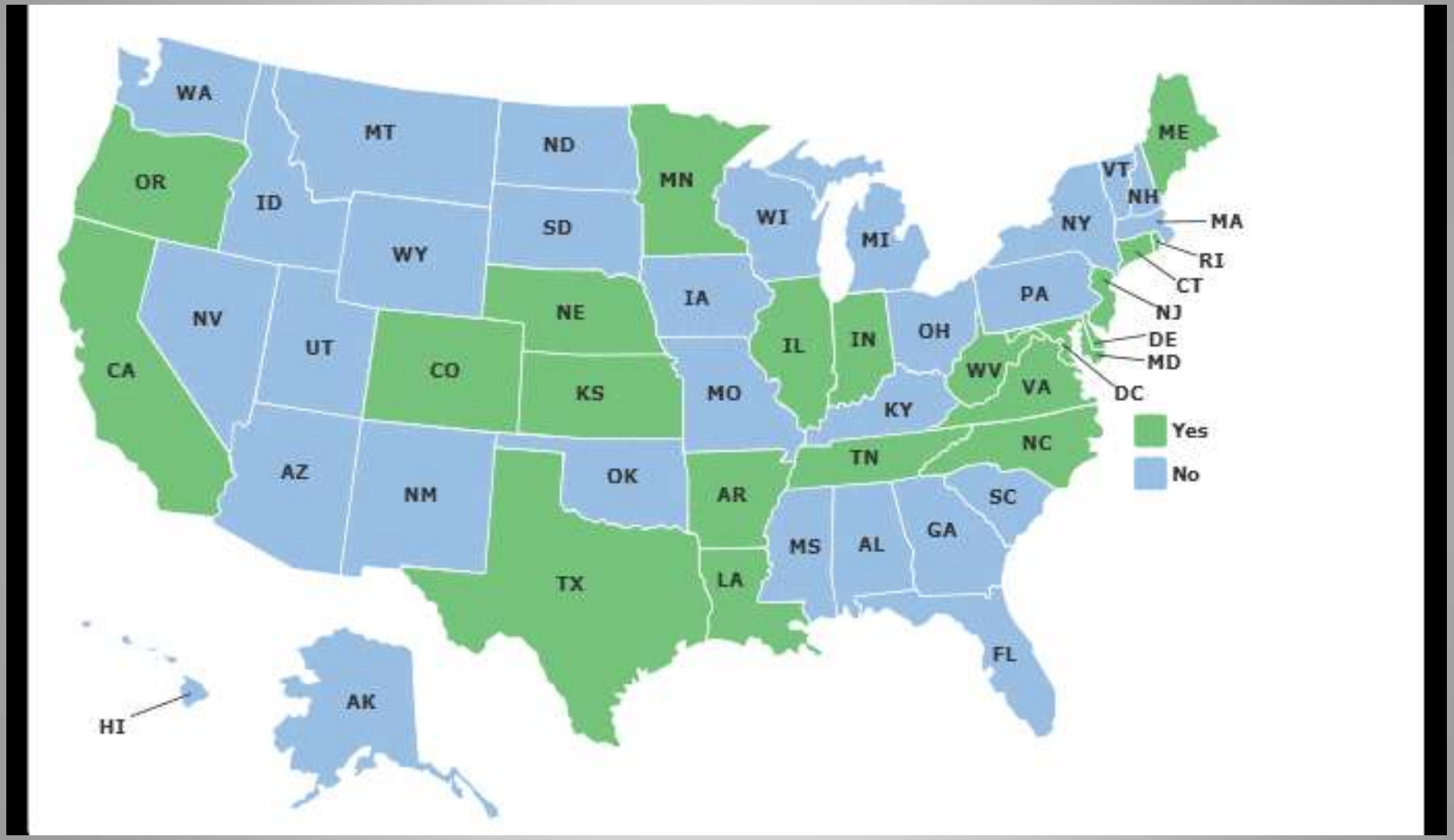
2008 NHTSA Report with AAA Foundation for Traffic Safety, DOT-HS 810 927

Hand Held Phone Bans



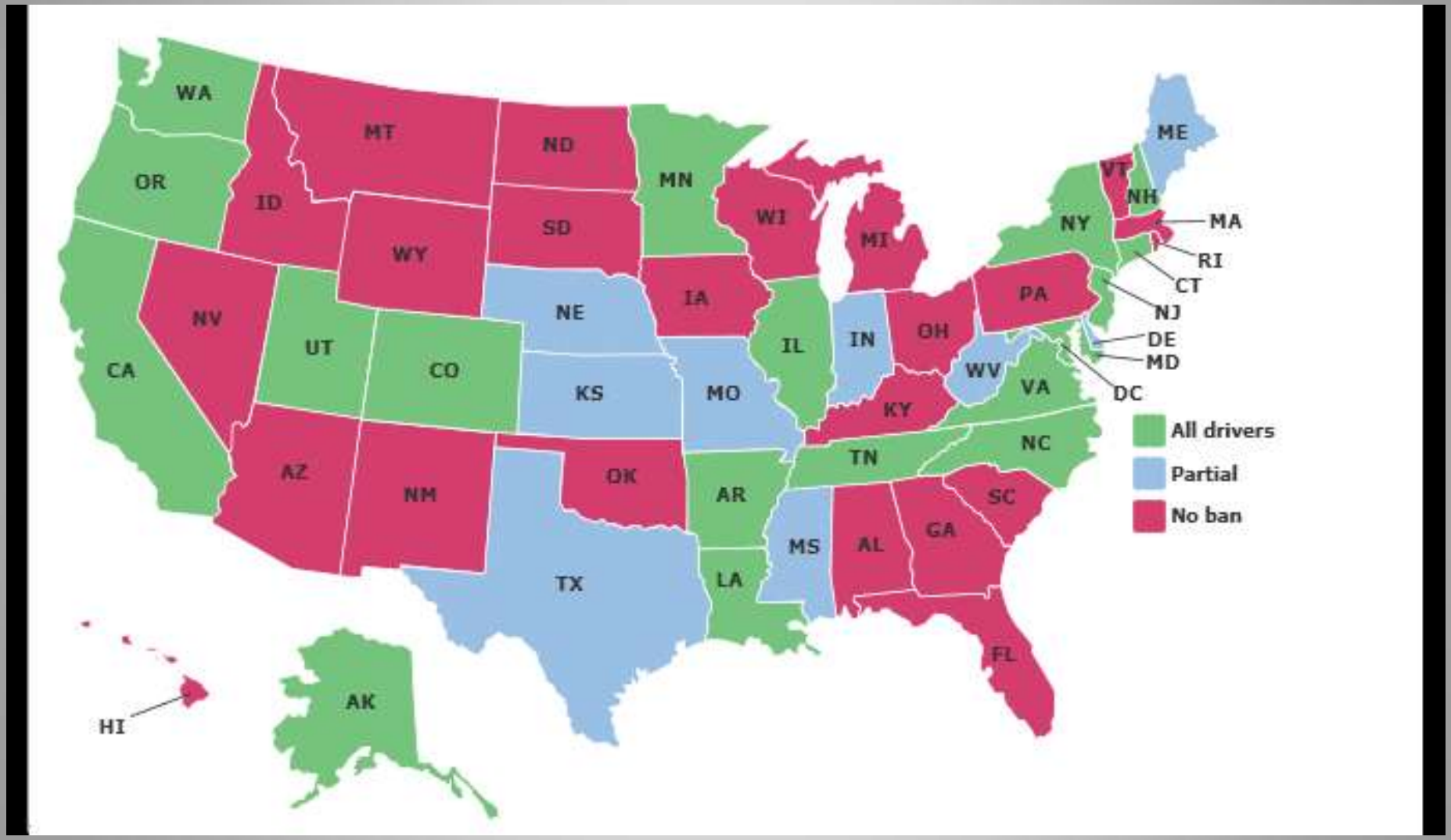
Insurance Institute for Highway Safety: www.iihs.org

Young Driver Cell Phone Bans



Insurance Institute for Highway Safety: www.iihs.org

Texting Bans



Insurance Institute for Highway Safety: www.iihs.org

Proposed Ban on All Phone Use

National Safety Council **NEWS**

Communications and Public Affairs • 1121 Spring Lake Dr • Itasca, IL 60143 • (630) 775-2307 • media@nsc.org

For Immediate Release
Jan. 12, 2009

Contact: Meredith Morris
(630) 775-2307

National Safety Council Calls for
Nationwide Ban on Cell Phone Use While Driving
Bold Plan Seeks to Involve Law Makers, Businesses and Public

Itasca, Ill. – The National Safety Council today is calling on motorists to stop using cell phones and messaging devices while driving, and is urging businesses to enact policies prohibiting it and governors and legislators in all 50 states and the District of Columbia to pass laws banning the behavior.

Federal Actions Focused on Behavior Change

- NHTSA policy: "The safest course of action is to refrain from using a cell phone while driving."
- NHTSA recommends that States adopt teen Graduated License provision prohibiting use of portable communications and entertainment devices
- A bill was introduced in U.S. Senate in July to reduce federal funding to States that do not enact an anti-texting law.
- In 2008, the Federal Railroad Administration ordered a ban on all personal electronic devices for employees while operating trains
- This week U.S. Department of Transportation holding distraction Summit

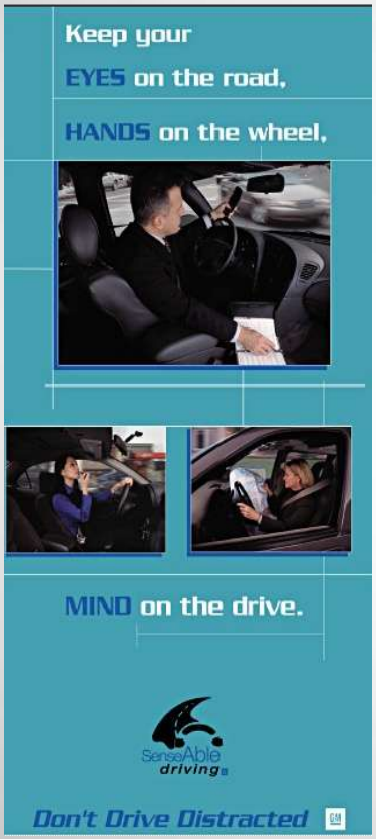
What works?

COUNTERMEASURE	EFFECTIVENESS	USE	COST	TIME
GDL for teens	★★★★★	High	Low	Medium
Cell phone laws	★★	Low	Varies	Short
Reckless driving laws	★	High	Varies	Short
Communication and outreach	★	?	Medium	Medium
Others	?	?	?	?

Demonstrated to be effective
Demonstrated to be effective in certain situations
Likely to be effective
Effectiveness still undetermined
Limited or no high-quality evaluation evidence

Countermeasures that Work: Guide for State Safety Offices, 2009, www.nhtsa.gov

Behavioral Change Challenges



- Laws are unpopular and difficult to enforce
- Difficult to evaluate effectiveness
- Many drivers know distraction is a problem but do it anyway

Behavioral Change: Progress and Priorities

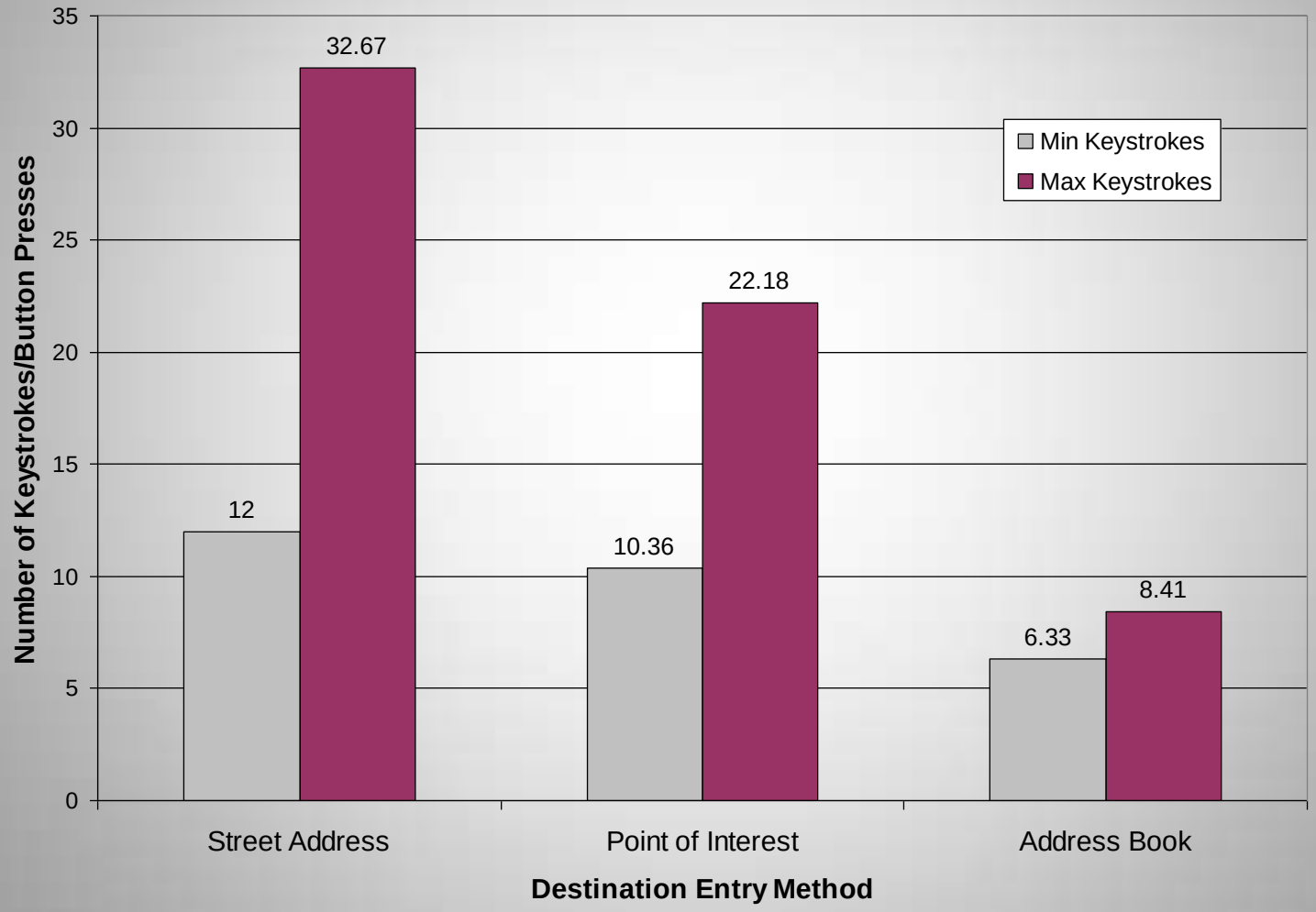
- Many different traditional approaches have been tried
- Very little known about what works or how to make them effective and acceptable
- Explore innovative approaches
- Tailor to individual differences

Improving Device Designs

Center for Auto Safety Petition to NHTSA, 2007

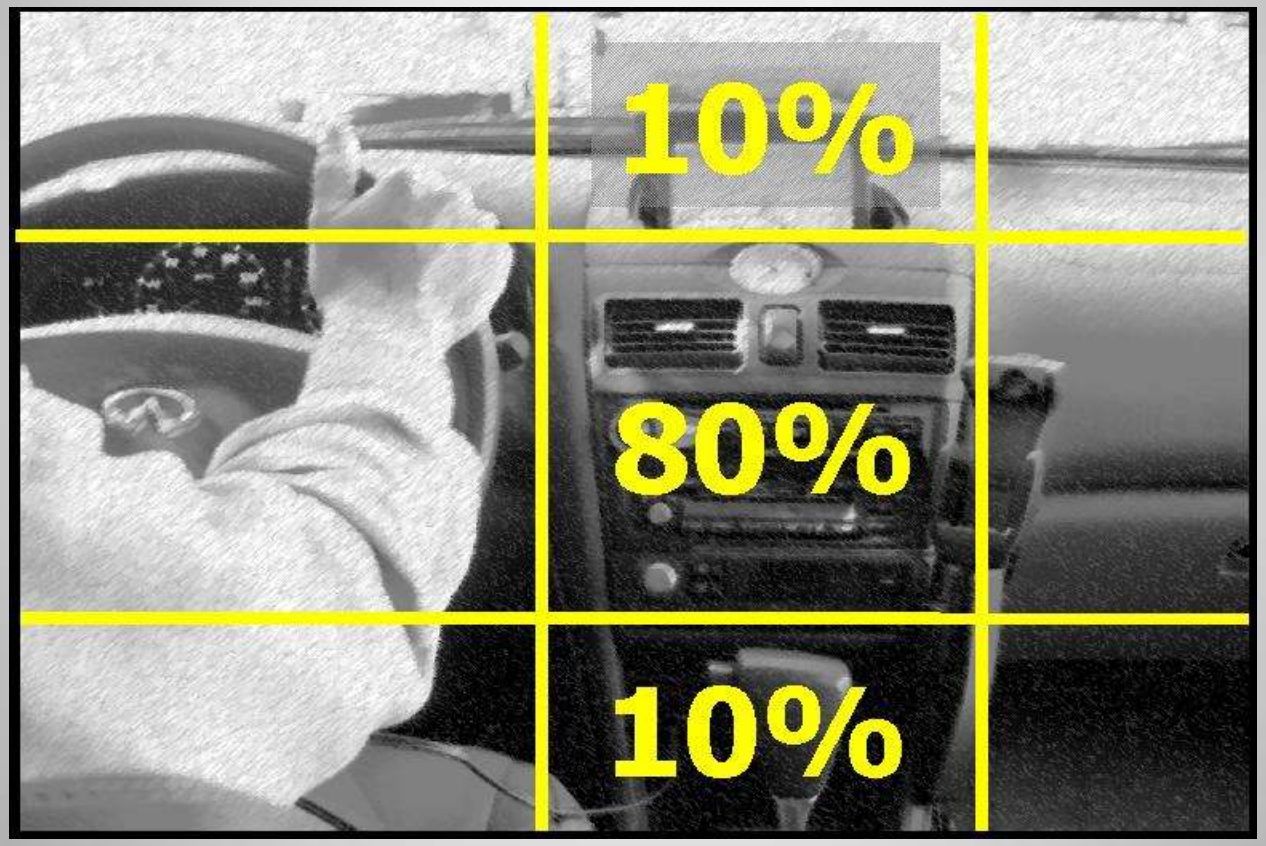
- "Any vehicle integrated personal communication system including cellular telephones and text messaging systems shall be inoperative when the transmission is in a forward or reverse drive condition"
- Also, issue proposed rulemaking to prohibit use while driving of other vehicle integrated telematics systems that significantly increase crash rates
- NHTSA rejected the petition
  - Drivers could instead use portable devices
  - No safety benefits

Destination Entry for Nav Systems: Number of Keystrokes/button presses



Inventory of in-vehicle technology human factors design characteristics, 2002, DOT HS 809 457

Survey of Display Locations



Inventory of in-vehicle technology human factors design characteristics, 2002, DOT HS 809 457

Naturalistic Study of Cell Phone Interfaces at NHTSA

- 10 drivers , regular phone users
- 6 weeks
- 25-55 yrs old

Hand-held (HH)
- manual dialing & answering, HH talking

Headset Hands-free
-manual dialing & answering, hands-free talking with headset

Voice Dialing Speaker Hands-free
-Voice digit dialing, manual answering, hands-free talking with speaker

Interface	*Dialing*	*Talking*
Hand-held	**Manual**	**Hand-held**
Hands-free talking	**Manual**	**Hands-free**
Enhanced hands-free	**Voice***	**Hands-free**

*implemented using AutoPC

Findings for calls from moving car

Interface	% driving hours talking	Avg. talk duration (sec.)	% time both hands on wheel when talking
Hand-held	9.1	204.8	0.1
Hands-free Talking	6.7	136.6	13
Enhanced Hands-free (*includes manual interface)	5.3*	120.8 107.1*	16 (baseline = 13%)

Wireless Phone and AutoPC Related Technology: Driver Distraction and Use Effects on the Road, Dot 809 752, 2004

Driver Workload Metrics Project--
Collision Avoidance Metrics Partnership

- Metrics and procedures to assess visual, manual, and cognitive distraction.
- Toolkit of evaluation methods to help device developers
- Metrics criteria:
  - repeatable, safety relevant, and sensitive to level of attentional demand
  - lab metrics that were predictive of driving measures
  - on road measures that distinguished multitasking from 'just driving'

Driver Workload Metrics Final Report, 2006, DOT HS 810 635

Range of Metrics Tested

Measuring workload in lab

Measuring workload on road

- **Static Task Time**
- **Visual Occlusion**
- **Peripheral Detection Task (PDT)**

Vehicle Control

Object & Event Detection

Visual Scanning

Statement of Principles, Criteria and Verification Procedures on Driver Interactions with Advanced In-Vehicle Information and Communication Systems

- Led by the U.S. Alliance of Automobile Manufacturers
- Based on European Statement of Principles
- Sections
  - Placement
  - Information presentation
  - Interactions with displays & controls
  - System behavior
  - Driver instructions
- Focused on visual-manual interfaces, not voice
- How well are these or other guidelines being followed? Are they helping safety?

Survey of Early Adopters: OEM Navigation Systems

- Questionnaire responses from 1500 drivers who purchased Navigation systems

Is responding to driver voice commands useful?	Percent 'yes'
Lexus	51
Mercedes	72

Did voice directions reduce time looking at screen?	Percent
YES	76
NO	16
DON'T KNOW	8

Preference for Viewed or Spoken Directions?	Percent
View	13
Listen	26
Both	61

2008 NHTSA Report with AAAFoundation for Traffic Safety, DOT-HS 810 927

Examples of Auto Company Approaches

- Keep the driver's eyes on the road and hands on the wheel
- Minimize the number of steps to perform any task
- Create a common interface
- Utilize a lock-out protocol to prohibit especially demanding tasks

- Intense and lengthy discussions can indeed be distracting
- Visual distraction, not cognitive distraction, is the main safety concern in the real world
- Research indicates the superiority of hands-free voice interfaces as compared to hand-held or visual–manual interfaces

Measurement of Device Distraction Potential

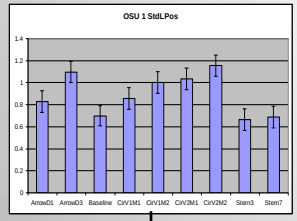
Occlusion Goggles

Peripheral Detection Task

Can Consumer Distraction Ratings Lead to Better Choices?

Relation of Safety to Device Design

Experimental Data



Metrics of Distraction Potential

?

Naturalistic Data

.5 - 1.0	1.1
1.0-1.5	1.1
1.5-2.0	1.4
>2	2.3

Relative Risk for Eyes Off Road; Relative Risk of Tasks

Relating Device Design to Safety

Tasks	Mean # Lane Deviations	Mean # Glances away from road	100 Car data
Adjust Vent	0	1.83	Simple tasks Crash/near crash risk= 1.2
Adjust Fan	1	1.78	
Following Nav system voice directions	0	1.31	
Activate defrost	3	2.51	Complex tasks Crash/near crash risk=> 3.1
Zoom level on Nav system	4	2.91	
Insert Cassette Tape	13	2.06	

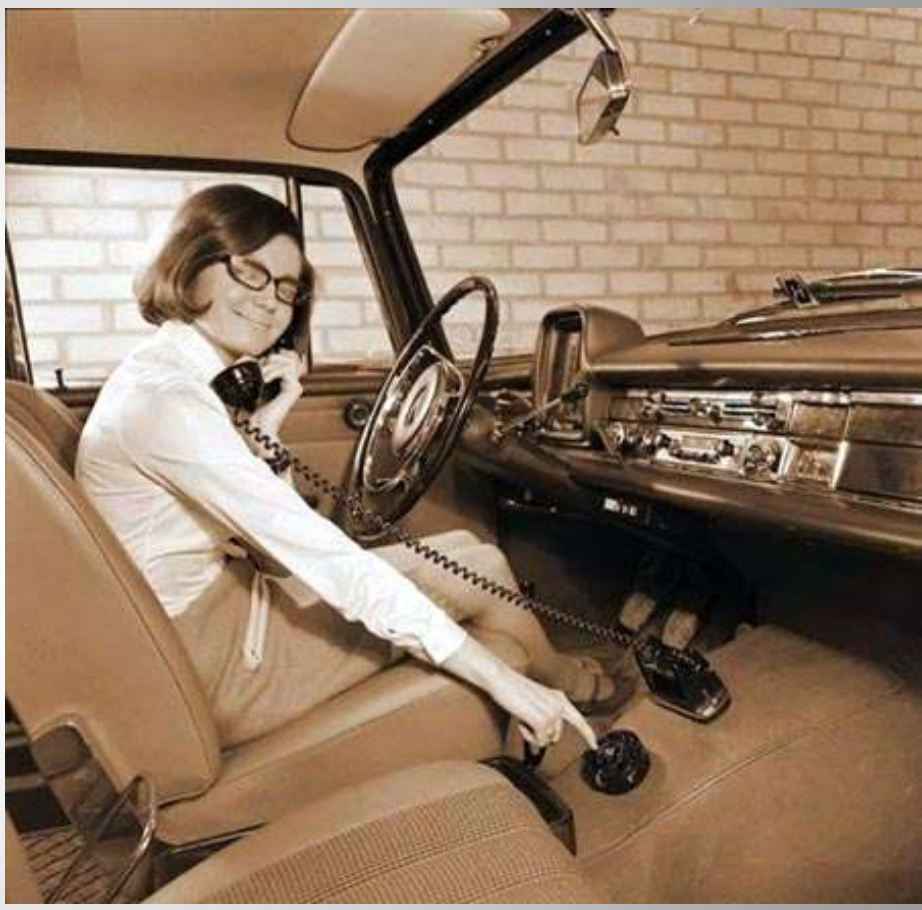
The Relative Risks of Secondary Task Induced Driver Distraction, Dingus and Klauer, SAE 2008-21-0001

Challenges of Improving Device Designs

- **How to achieve desired changes: Performance Standards vs. Design Standards vs. Guidelines**
  - PS based on driver performance are difficult to implement objectively (e.g., glance times less than 2 seconds)
  - DS are too restrictive and limit innovations
  - Hard to apply to multiple devices with additive demands on driver
  - Little incentive to follow guidelines
- **Difficult to relate to crash reduction**

A Few Cell Phone Challenges

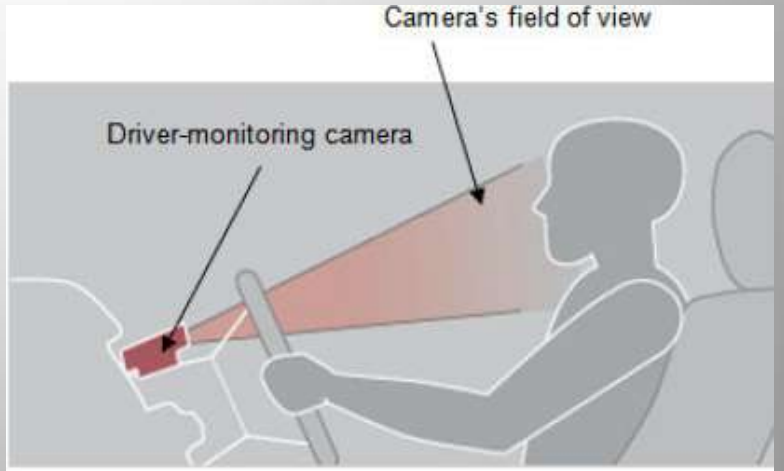
- Not all phone interfaces are the same
  - Hand held; hands free mean ?
- How to put risk of phone conversations in perspective
  - Like drunk driving?
- How to make the connection between experimental study findings and real world driving and crashes
  - Example: Rear signaling research



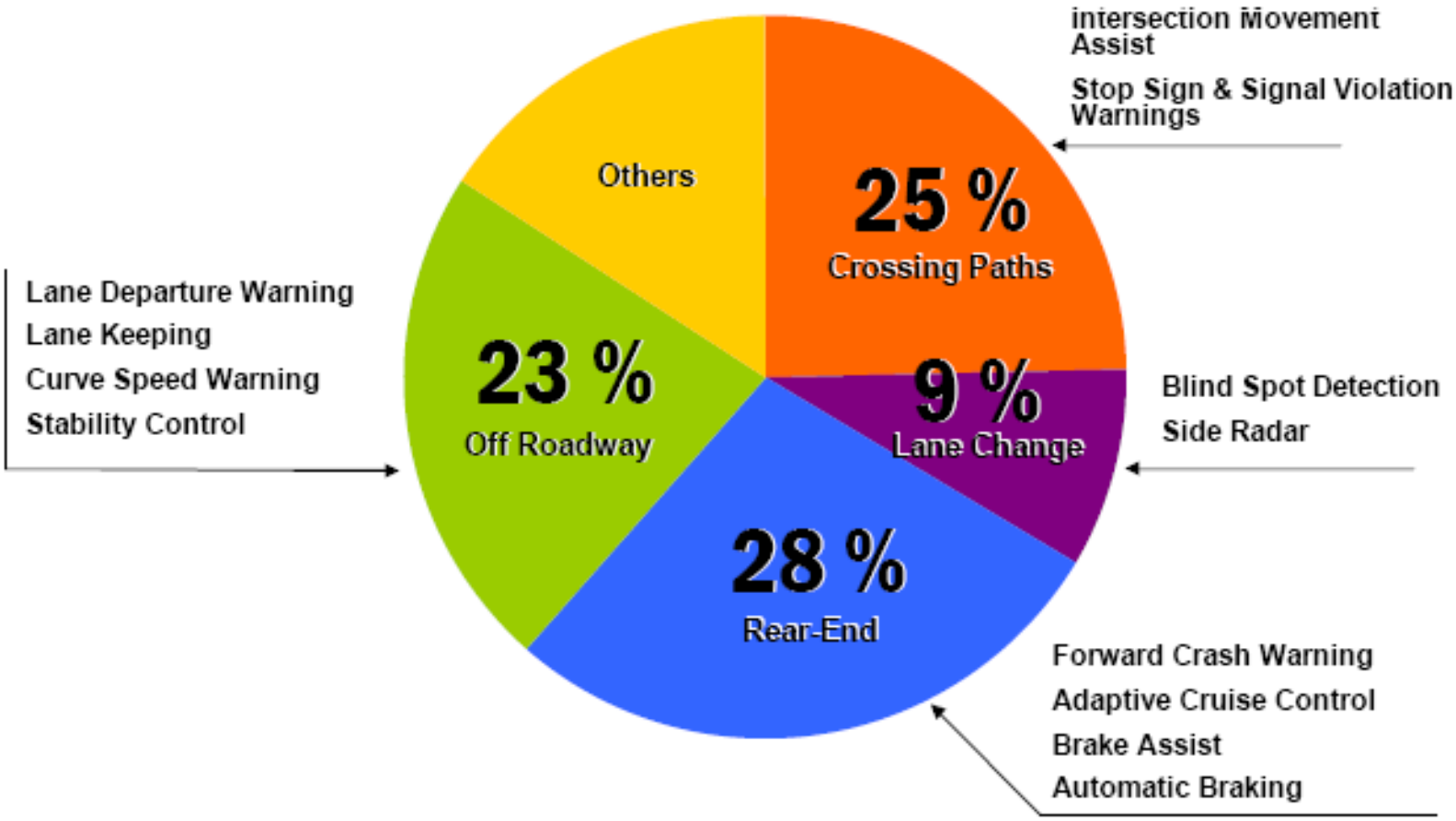
Improving Device Designs: Progress and Priorities

- Many metrics of distraction potential developed
- Many design guidelines and principles exist
- Vehicle manufacturers may be incorporating some guidelines based on metrics, but to what extent?
- Continue to Enhance Human Factors Guidelines
  - focus on cognitive tasks, such as voice interfaces
  - increase applicability to portable devices
- Phone Interfaces: Is hands free an acceptable risk?
- Relate distraction metrics to safety metrics
  - Application to consumer ratings

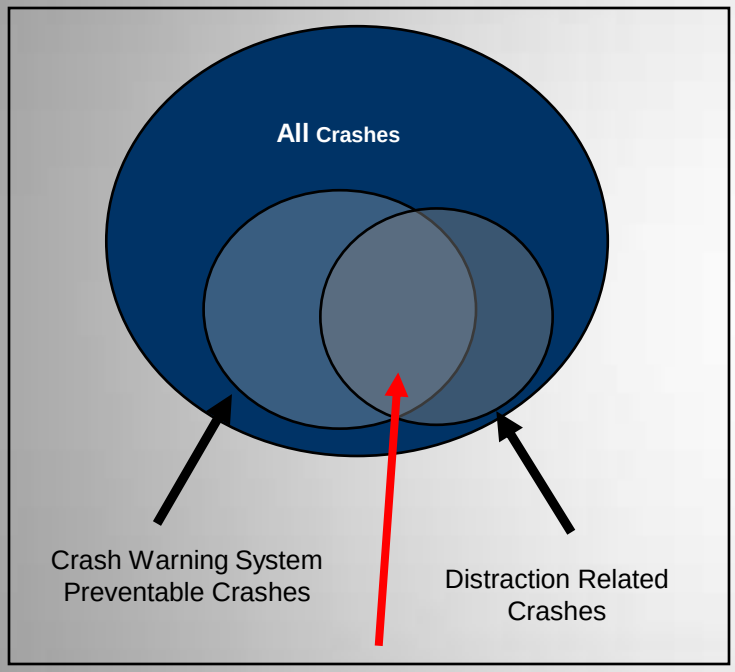
Warning Distracted Drivers

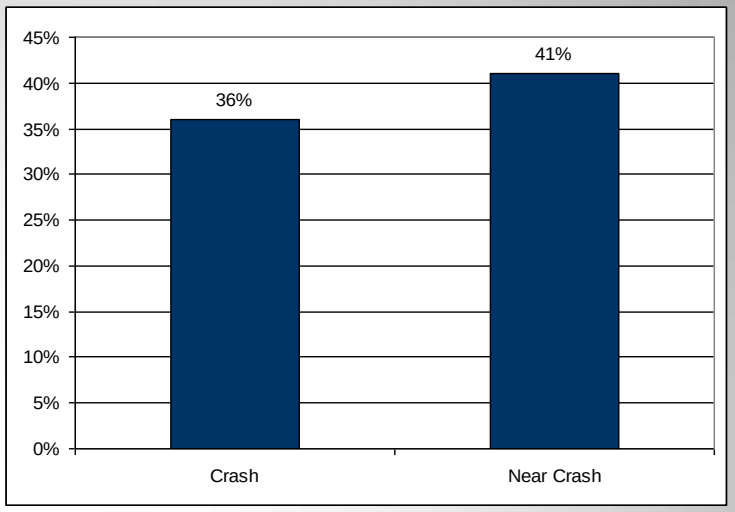


All Crashes (2005)

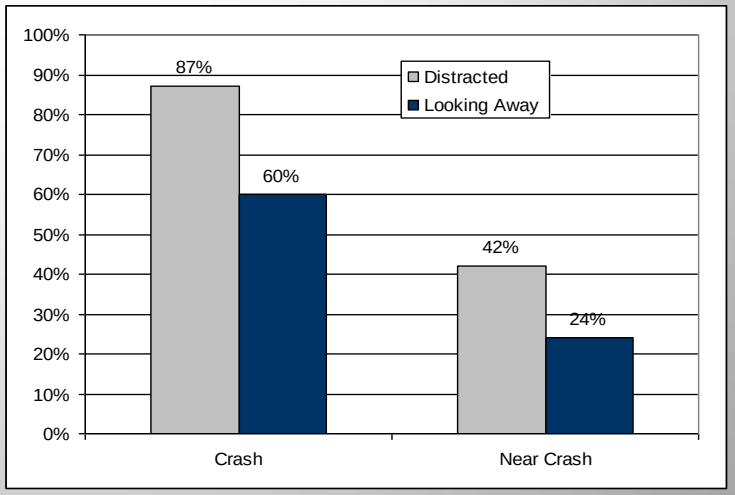


Distraction Crash Prevention Opportunities





Percent of Run-Off-Road Conflicts with Distraction/Inattention as a Contributing Factor (100 Car Data)



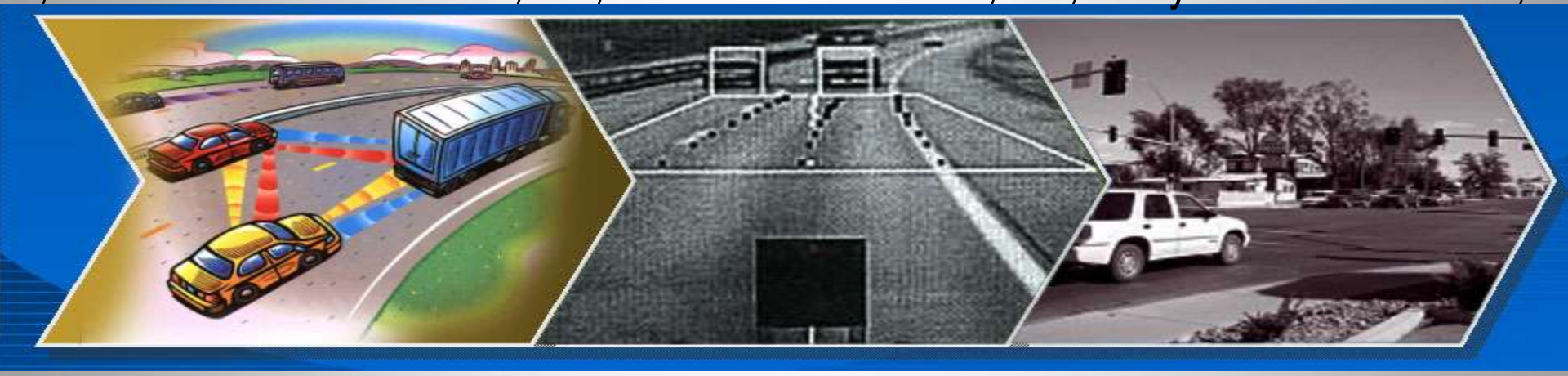
100-Car Data, Percent of Rear-End Conflicts Involving Distraction

Driver Assistance Systems To Alert Distracted Drivers

Forward Collision Warning System

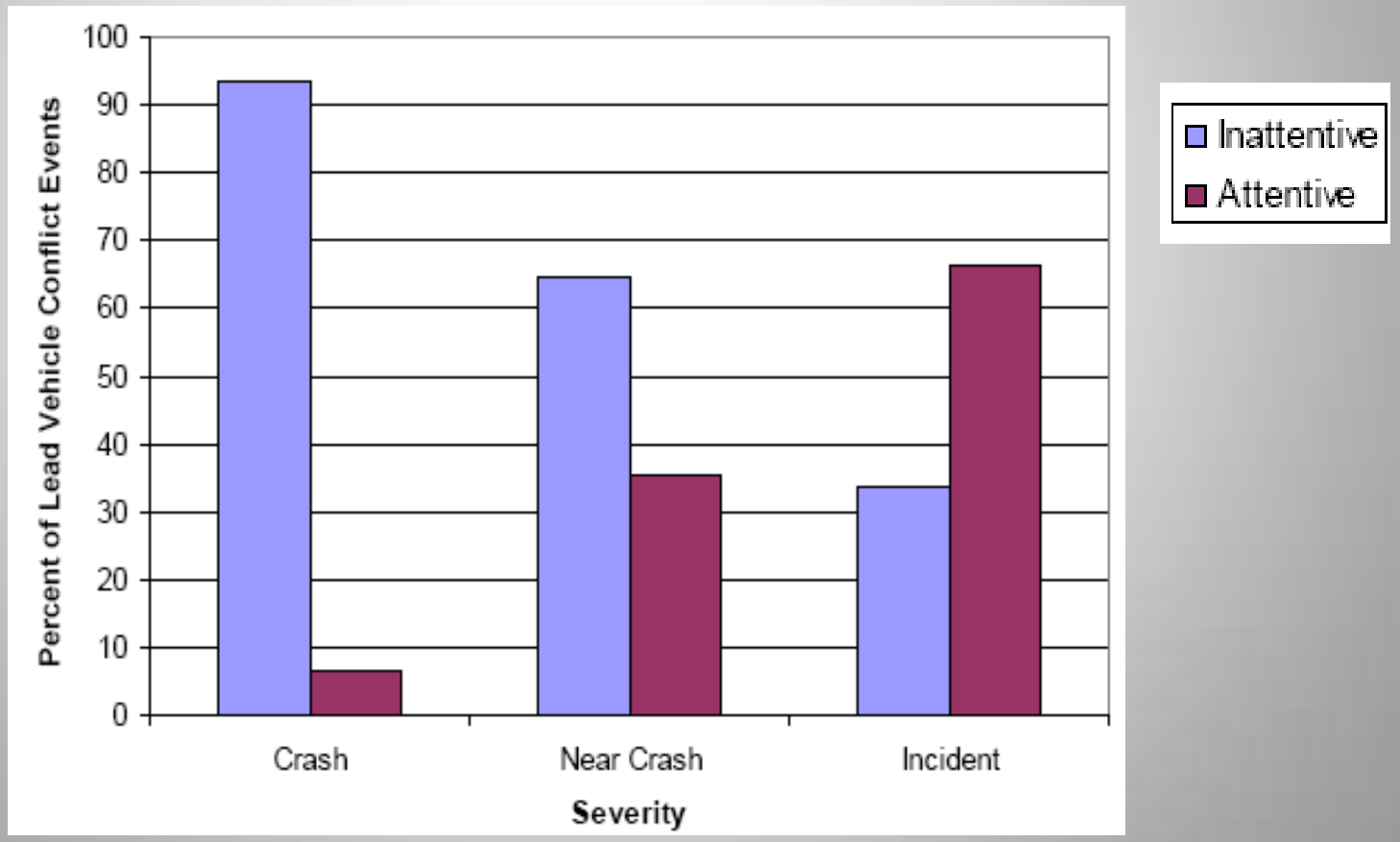
Road Departure Warning System

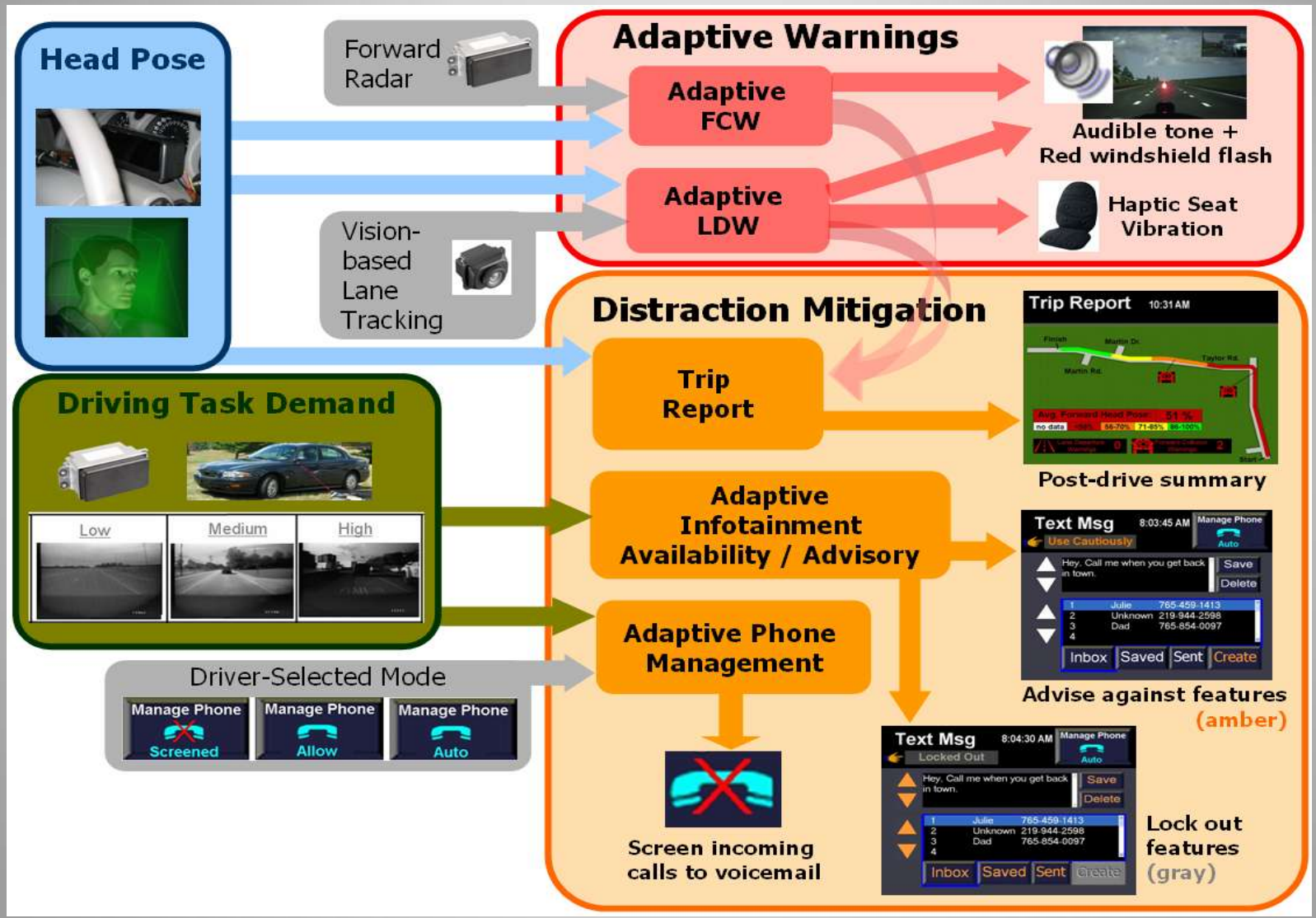
Intersection Collision Warning System



1. **Improving system effectiveness and acceptability with designs that are human engineered to match drivers' capabilities**
2. **Evaluating system safety benefits**

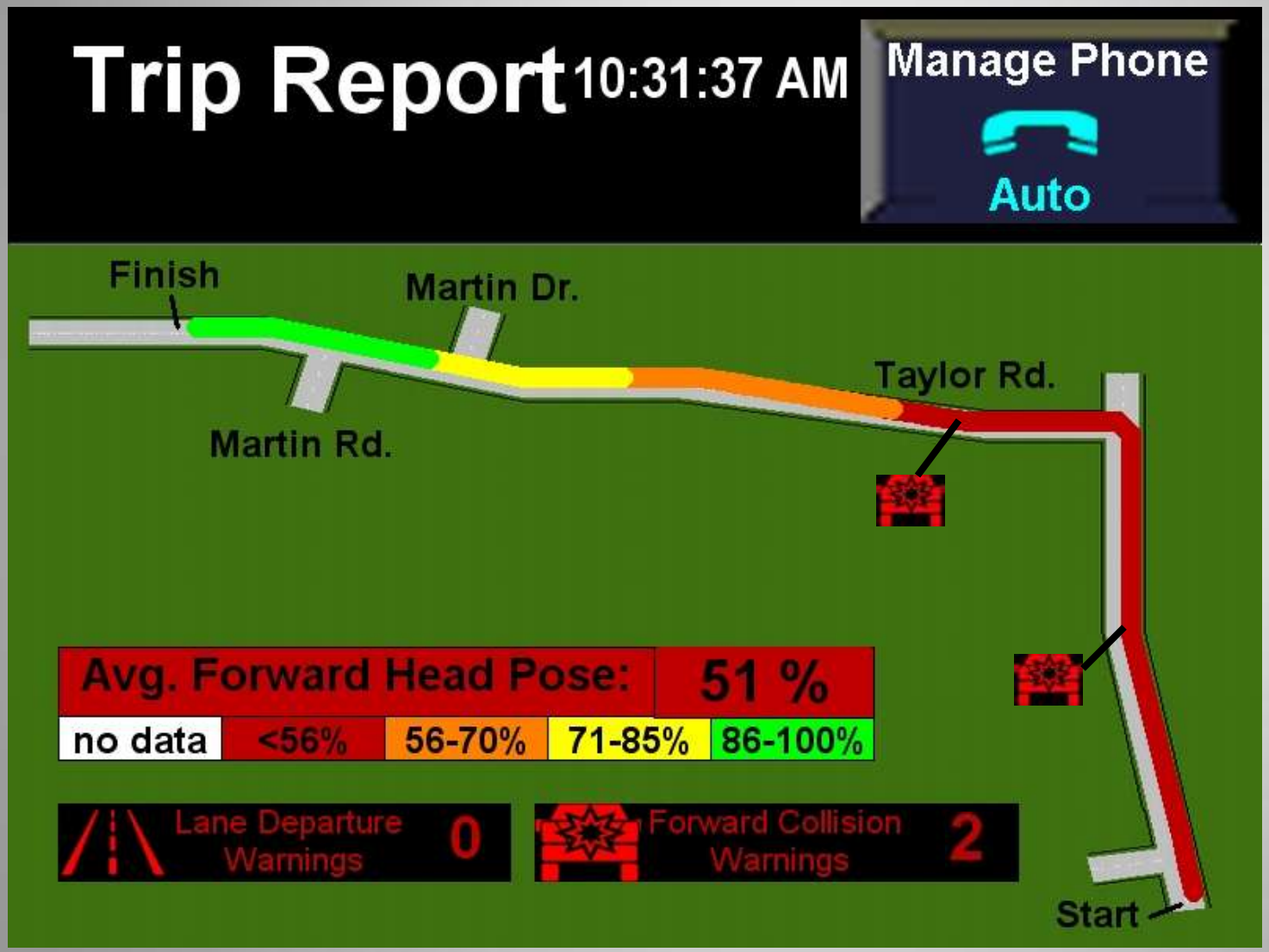
100 Car Data: Suggests that warning systems may be less useful when the driver is looking forward





- **Countermeasures and Adaptive Inputs**

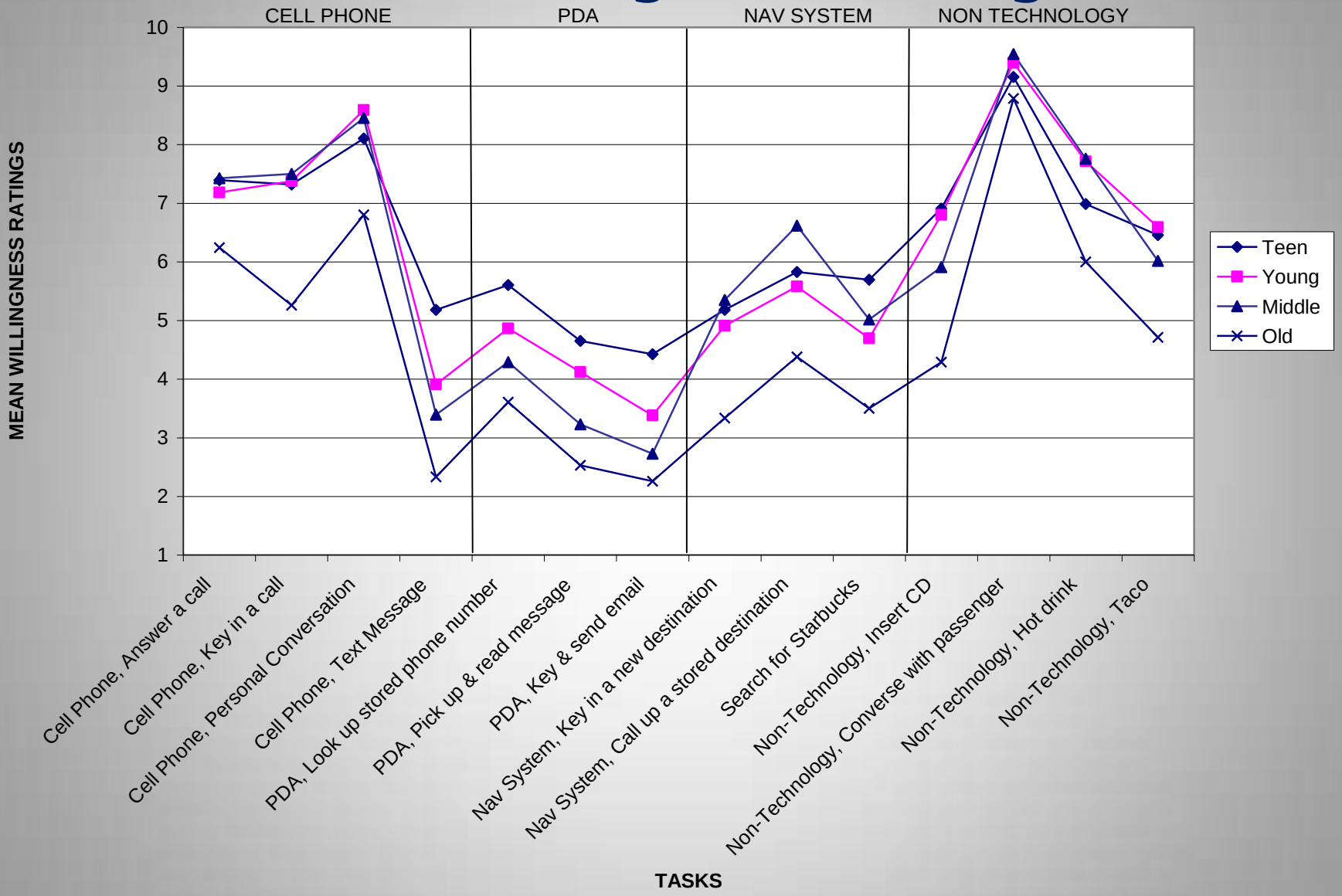
Trip Report



- By saving feedback to the end of the drive, we better avoid adding additional distraction

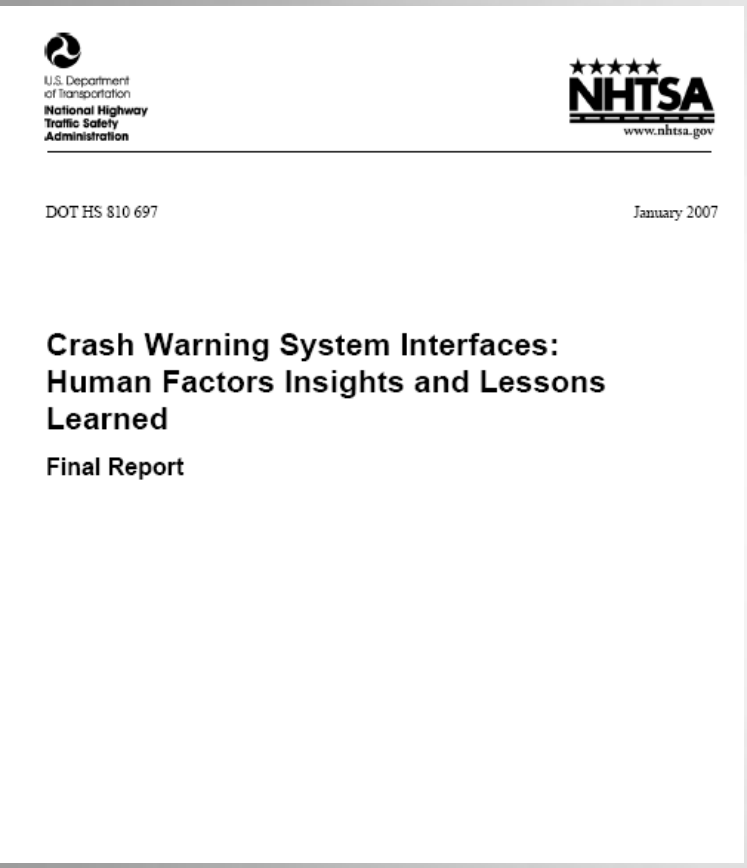
- Provided to the driver for a brief review after each drive but it can be ignored if they are not interested

Mean Willingness Ratings



On road study of drivers willingness to engage in distracting tasks, 2008, DOT HS 810919

Crash Warning System Interfaces: Human Factors Insights and Lessons Learned


U.S. Department of Transportation
National Highway Traffic Safety Administration

NHTSA
www.nhtsa.gov

DOT HS 810 697 January 2007

Crash Warning System Interfaces: Human Factors Insights and Lessons Learned

Final Report

- General Guidelines for Crash Warning System (CWS)Design
- Auditory Warnings
- Visual Warnings
- Haptic Warnings
- Controls for CWS Devices
- Forward Collision Warning Systems
- Lane Change Warning Systems
- Road Departure Warning Systems
- Application to Heavy Trucks and Buses

Campbell et al. DOT HS 810 697, January 2007 (www.nhtsa.gov)

Format

Introduction

Guideline Title

Abbreviated Handbook Title (*Both Pages*)

Abbreviated Chapter Title (*Both Pages*)

Revision Version (*Both Pages*)

Discussion

Design Guideline

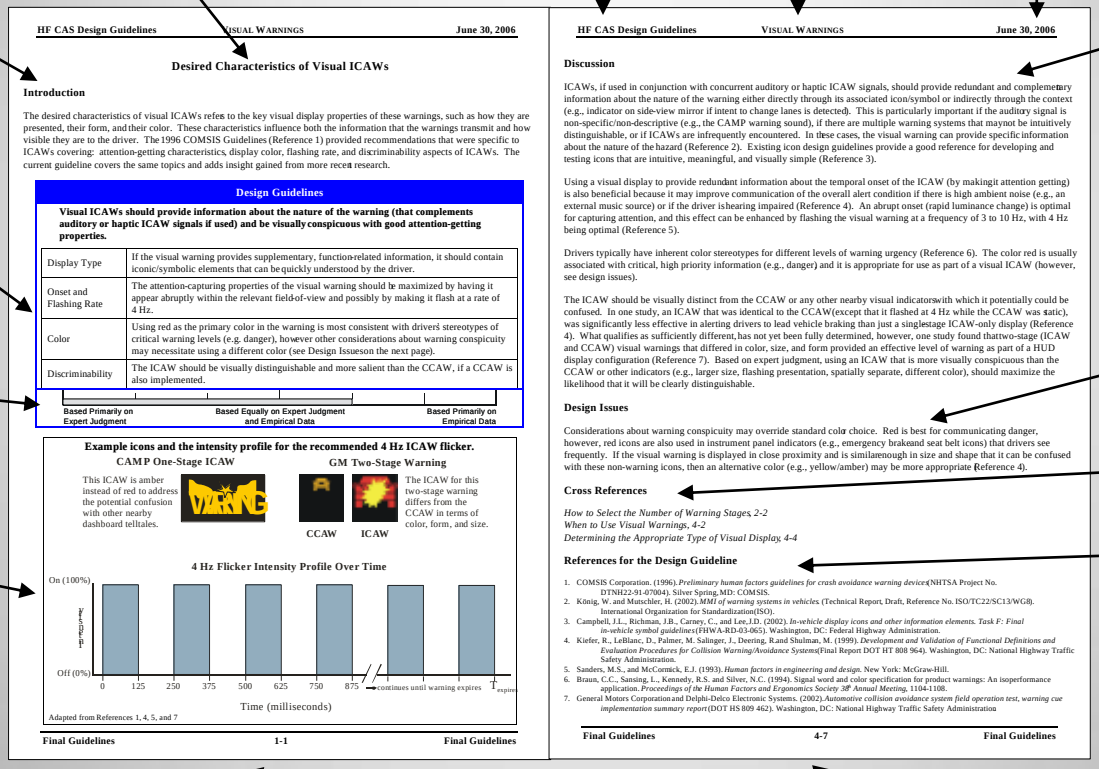
Design Issues

Bar Scale Rating

Cross References

Figure, Table, or Graphic

References



HF CAS Design Guidelines VISUAL WARNINGS June 30, 2006

Desired Characteristics of Visual ICAWs

Introduction

The desired characteristics of visual ICAWs refers to the key visual display properties of these warnings, such as how they are presented, their form, and their color. These characteristics influence both the information that the warnings transmit and how visible they are to the driver. The 1996 COMSIS Guidelines (Reference 1) provided recommendations that were specific to ICAWs covering: attention-getting characteristics, display color, flashing rate, and discriminability aspects of ICAWs. The current guideline covers the same topics and adds insight gained from more recent research.

Design Guidelines

Visual ICAWs should provide information about the nature of the warning (that complements auditory or haptic ICAW signals if used) and be visually conspicuous with good attention-getting properties.

Display Type	If the visual warning provides supplementary, function-related information, it should contain iconic/symbolic elements that can be quickly understood by the driver.
Onset and Flashing Rate	The attention-capturing properties of the visual warning should be maximized by having it appear abruptly within the relevant field-of-view and possibly by making it flash at a rate of 4 Hz.
Color	Using red as the primary color in the warning is most consistent with drivers' stereotypes of critical warning levels (e.g. danger), however other considerations about warning conspicuity may necessitate using a different color (see Design Issues on the next page).
Discriminability	The ICAW should be visually distinguishable and more salient than the CCAW, if a CCAW is also implemented.

Based Primarily on Expert Judgment | Based Equally on Expert Judgment and Empirical Data | Based Primarily on Empirical Data

Example icons and the intensity profile for the recommended 4 Hz ICAW flicker.

CAMP One-Stage ICAW

This ICAW is amber instead of red to address the potential confusion with other nearby dashboard telltales.

GM Two-Stage Warning

The ICAW for this two-stage warning differs from the CCAW in terms of color, form, and size.

CCAW ICAW

4 Hz Flicker Intensity Profile Over Time

On (100%)

Off (0%)

0 125 250 375 500 625 750 875 continues until warning expires

Time (milliseconds)

Adapted from References 1, 4, 5, and 7

Final Guidelines 1-1 Final Guidelines

HF CAS Design Guidelines VISUAL WARNINGS June 30, 2006

Discussion

ICAWs, if used in conjunction with concurrent auditory or haptic ICAW signals, should provide redundant and complementary information about the nature of the warning either directly through its associated icon/symbol or indirectly through the context (e.g., indicator on side-view mirror if intent to change lanes is detected). This is particularly important if the auditory signal is non-specific/non-descriptive (e.g., the CAMP warning sound), if there are multiple warning systems that may not be intuitively distinguishable, or if ICAWs are infrequently encountered. In these cases, the visual warning can provide specific information about the nature of the hazard (Reference 2). Existing icon design guidelines provide a good reference for developing and testing icons that are intuitive, meaningful, and visually simple (Reference 3).

Using a visual display to provide redundant information about the temporal onset of the ICAW (by making it attention getting) is also beneficial because it may improve communication of the overall alert condition if there is high ambient noise (e.g., an external music source) or if the driver is hearing impaired (Reference 4). An abrupt onset (rapid luminance change) is optimal for capturing attention, and this effect can be enhanced by flashing the visual warning at a frequency of 3 to 10 Hz, with 4 Hz being optimal (Reference 5).

Drivers typically have inherent color stereotypes for different levels of warning urgency (Reference 6). The color red is usually associated with critical, high priority information (e.g., danger) and it is appropriate for use as part of a visual ICAW (however, see design issues).

The ICAW should be visually distinct from the CCAW or any other nearby visual indicators with which it potentially could be confused. In one study, an ICAW that was identical to the CCAW (except that it flashed at 4 Hz while the CCAW was static), was significantly less effective in alerting drivers to lead vehicle braking than just a single-stage ICAW-only display (Reference 4). What qualifies as sufficiently different, has not yet been fully determined, however, one study found that two-stage (ICAW and CCAW) visual warnings that differed in color, size, and form provided an effective level of warning as part of a HUD display configuration (Reference 7). Based on expert judgment, using an ICAW that is more visually conspicuous than the CCAW or other indicators (e.g., larger size, flashing presentation, spatially separate, different color), should maximize the likelihood that it will be clearly distinguishable.

Design Issues

Considerations about warning conspicuity may override standard color choice. Red is best for communicating danger, however, red icons are also used in instrument panel indicators (e.g., emergency brake and seat belt icons) that drivers see frequently. If the visual warning is displayed in close proximity and is similar enough in size and shape that it can be confused with these non-warning icons, then an alternative color (e.g., yellow/amber) may be more appropriate (Reference 4).

Cross References

How to Select the Number of Warning Stages, 2-2
When to Use Visual Warnings, 4-2
Determining the Appropriate Type of Visual Display, 4-4

References for the Design Guideline

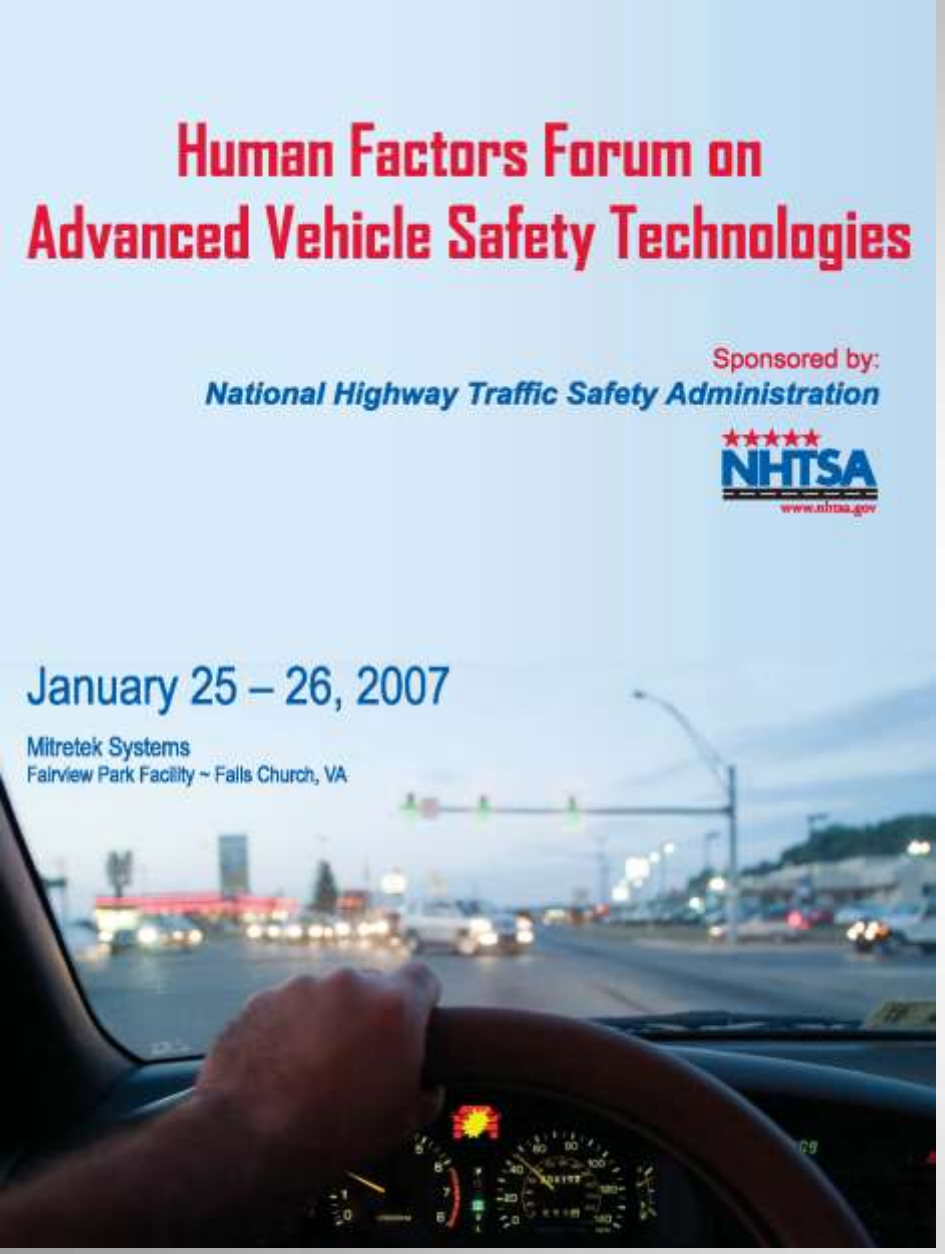
1. COMSIS Corporation. (1996). *Preliminary human factors guidelines for crash avoidance warning devices* (NHTSA Project No. DTNH22-91-07004). Silver Spring, MD: COMSIS.
2. König, W. and Mutschler, H. (2002). *MMI of warning systems in vehicles* (Technical Report, Draft, Reference No. ISO/TC22/SC13/WG8). International Organization for Standardization (ISO).
3. Campbell, J.L., Richman, J.B., Carney, C., and Lee, J.D. (2002). *In-vehicle display icons and other information elements. Task F: Final in-vehicle symbol guidelines* (FHWA-RD-03-065). Washington, DC: Federal Highway Administration.
4. Kiefer, R., LeBlanc, D., Palmer, M. Salinger, J., Deering, R. and Shulman, M. (1999). *Development and Validation of Functional Definitions and Evaluation Procedures for Collision Warning/Avoidance Systems* (Final Report DOT HT 808 964). Washington, DC: National Highway Traffic Safety Administration.
5. Sanders, M.S., and McCormick, E.J. (1993). *Human factors in engineering and design.* New York: McGraw-Hill.
6. Braun, C.C., Sansing, L., Kennedy, R.S. and Silver, N.C. (1994). Signal word and color specification for product warnings: An isoperformance application. *Proceedings of the Human Factors and Ergonomics Society 38th Annual Meeting*, 1104-1108.
7. General Motors Corporation and Delphi-Delco Electronic Systems. (2002). *Automotive collision avoidance system field operation test, warning cue implementation summary report* (DOT HS 809 462). Washington, DC: National Highway Traffic Safety Administration.

Final Guidelines 4-7 Final Guidelines

Left-hand page

Right-hand page

Page Numbers



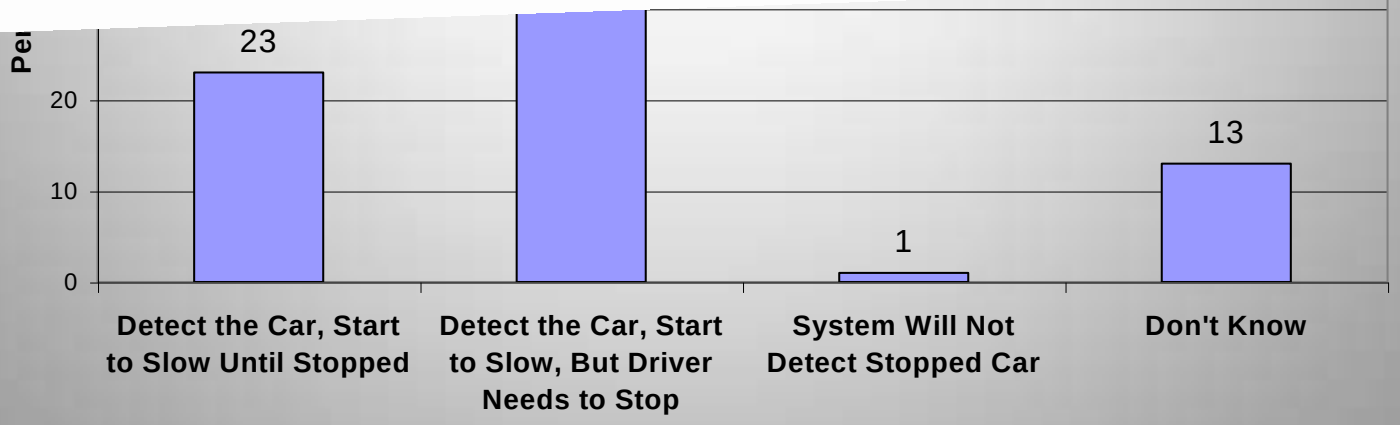
- Driver-Centered Design
- Unintended Consequences
- Standardization
- Integrating Multiple Systems
- Mechanisms for Collaboration

Human Factors Forum on Advanced Vehicle Safety Technologies
Summary & Proceedings, DOT HS 810918, March, 2008

Unintended Consequences

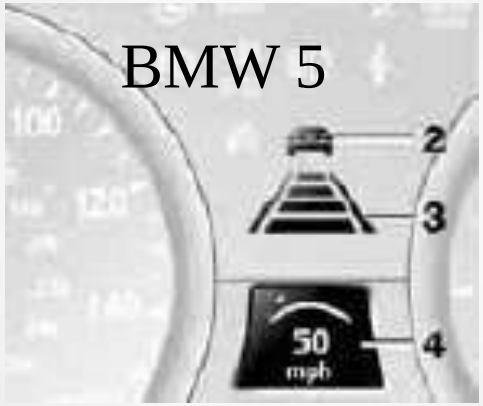
⚠ CAUTION

Under certain conditions where the vehicle in front slows drastically, or is stopped, the dynamic laser cruise control will neither warn you nor decelerate. The driver must depress the brake pedal to slow down, ensuring collision avoidance or that sufficient vehicle- to- vehicle distance is maintained.



Standardization

Audi A8



BMW 5

Lexus

Volvo

Mercedes

Integrating Multiple Systems

Assessing Benefits and Acceptability

FCW +ACC
163000 km
66 drivers
4 weeks

Road Departure+
Curve Speed
140000 km
78 drivers
4 weeks

FCW+RD+
Lane Change
108 drivers
6 weeks

- Field Operational Tests
  - Relatively few volunteers
  - Short exposure
  - No actual crashes
- Analytic Modeling
  - Crash statistics
  - System performance
  - Human factors experiments

- Estimated to reduce rear end crashes 10% ±7
- No unintended effects
- 25% would purchase FCW
- 44% would purchase ACC

•Evaluation of an Automotive Rear-end Collision Avoidance System, 2006, DOT HS 810569

- Estimated to reduce road departure crashes between 0.8% and 6.6%
- No unintended effects
- 42% would purchase LDW

Evaluation of a Road-Departure Crash Warning System , 2007, DOT 8210 854

Challenges of Warning Distracted Drivers

- Representativeness of volunteers and test area?
- How to best estimate benefits?
  - How well can estimates account for all the variables?
- Will drivers change behavior over time and become complacent?
- Will non-standardized warning interfaces confuse drivers?
- Will too many warnings increase driver workload?
- Will systems be acceptable to drivers?
  - Cost
  - Annoyance

Warning Distracted Drivers: Progress and Priorities

- Technology has advanced considerably
- Warning systems and driver monitoring systems being deployed
- How can interfaces be evaluated objectively to determine effectiveness and acceptability?
- What can be learned from early adopters about acceptability, safety benefits, and improvements needed?
  - Possible large scale fleet experiment
  - Behavioral adaptation insights

Closing Thoughts: Unanswered Questions

- Is a true hands free phone safer than a hand held one? How much safer? How acceptable is the risk?
- How can research findings be accurately and meaningfully conveyed to the driving public and equipment designers?
- How can real time distraction monitoring be effectively used to be acceptable and effective in changing unsafe driver behaviors?
- What is the true safety benefit of crash warning systems for distracted drivers?

Your Questions and Comments

- m.perel@cox.net

- Most references at: www.nhtsa.gov