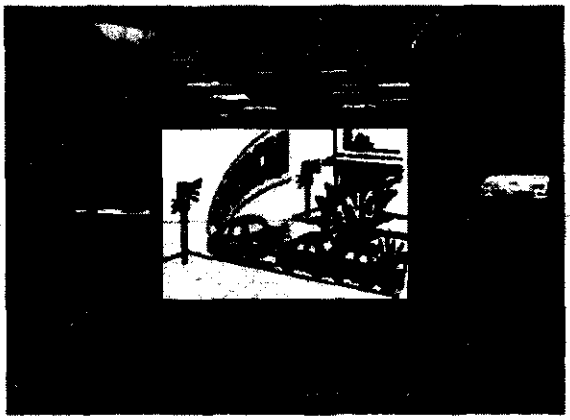
The Relationship Between On-Road Wireless Phone Use and Crashes



DRAFT 07/07/03

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Note

The material contained herein is a working document, currently under revision, and as such should not be disseminated.

This document has not yet undergone full, internal Agency review.

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Introduction

Over the past 10 years there has been considerable research and comment on the nature and magnitude of the problems as well as the benefits associated with cell phone use while driving. The various positions, interpretations and perspectives expressed are often in response to highly publicized studies. The conclusions from such studies are often characterized as being definitive or applicable to the population as a whole, and may sometimes serve as a basis for making policy decisions. Close examination of these studies, however, sometimes reveal shortcomings in terms of methodology, sampling, and assumptions, which can restrict the comparability of findings and the ability to generalize the results. These issues bear directly on our ability to determine the magnitude of the problem, the costs and the benefits. This document represents an update to NHTSA's 1997 report on the subject, and is intended to highlight the enormous complexities that surround this issue and to present what we currently know about the relationship between on-road wireless phone use and traffic crashes.

Presentation Outline

- Definitions
- History at NHTSA
- Questions – What Do We Need to Know?
- The Technology
- Legislation and Corporate Policies
- Cell Phone Crashes – How They Happen
- Hands-Free vs. Hand-Held
- Sources of Data and Limitations
- Estimating Fatalities
- Strategies For Addressing the Issue
- Summary & Conclusions
- Recommendations

What is Distraction?
Background

- There is great variation in how the terms inattention and distraction are defined and applied to issues involving crash causation, driver behavior, driver performance and driver error.
- Use of these terms revolves around the particular aspects of driving that are studied, the taxonomy of driving that is used, and the nature of the data that is available.
- NHTSA has typically separated distraction out as a component of inattention as a matter of convenience in partitioning the data that it collects since the crash records with which we deal best fit this strategy.

What is Distraction?

Distraction refers to the diversion of attention away from the primary task of driving due to other visual, cognitive, auditory or biomechanical activities.

- At least 25% of crashes are distraction related.
- Examples of sources of distraction include:

Animals	**Eating/Drinking**	**Reading**
Cell Phone	**Passengers**	**Rubber-necking**
Children	**Radio**	**Smoking**

- It is not necessary for such activities to result in adverse consequences to be considered a distraction.

Cell Phones:
Definition & Applicability

The issues discussed in the material that follows relate to all forms of wireless communications that are typically used for voice communications, but may be used for other functions as well (e.g., instant messaging, access to email). In an effort to simplify the language we have elected to use the more familiar phrase "cell phone" throughout the presentation. It should be noted, however, that the issues addressed here are independent of the underlying technology, service or carrier and apply to all wireless devices (regardless of protocol), and associated systems that are capable of voice communications. It should also be noted that because the demands of the cell phone are similar to the demands of other distracting activities, some consider it to be a surrogate of other distractions and thus, many of the issues discussed may be relevant to other devices not involving voice communications (e.g., navigation) as well as other non-technological distractions (e.g., eating).

Abbreviated NHTSA History 1989-2003 (Cell Phones & Distraction)

- 1989 – NHTSA receives first documented Letter of Concern about the potential for cell phones to result in distraction related motor vehicle crashes
- 1991 – Cursory review of motor vehicle crash data reveals crashes due to cell phone use
- 1992 – NHTSA initiates cell phone safety overview research program
- 1995 – NHTSA incorporates distraction/cell phone data into FARS and NASS
- 1997 – NHTSA publishes report on the issue of wireless communications while driving
- 2000 – NHTSA holds Distraction Public Meeting, Internet Forum, and Subject Matter Expert Workshop
- 2000-2001 – NHTSA conducts on-road research on cell phones and navigation devices, and on-road naturalistic study on hand-held and hands-free cell phone architectures
- 2001 – NHTSA Executive Director L. Robert Shelton presents testimony before the Subcommittee on Highway and Transit, Committee on Transportation and Infrastructure, U.S. House House of Representatives on May 9, 2001
- 2001 – NHTSA publishes results of 2000 Motor Vehicle Occupant Safety Survey (MVOSS), including questions on driver distractions and cell phone use
- 2001 – NHTSA publishes results of 2000 National Occupant Protection Use Survey (NOPUS), including observed use of hand-held cell phones while driving
- 2002 – NHTSA conducts MVOSS, NOPUS, and National Survey of Distracted and Drowsy Driving Attitudes and Behaviors. Surveys include issues related to driver distraction and cell phone use while driving
- 2003 – NHTSA initiates distraction/cell phone research program on National Advanced Driving Simulator (NADS)

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What Constitutes a Cell Phone Problem Requiring Formal Action

Whereas the specifics of such a determination are vague, any formal action should be founded on a valid and complete set of data and associated analyses. Lacking such information, decisions must be based on careful consideration of available data and any actions must be evaluated as to consequences.

It is clear that there are at least three fundamental considerations that must be factored into determining the nature and scope of any action. These include:

- The magnitude of the problem
- The costs and benefits of cell phone use from vehicles
- The risks associated with cell phone use while driving

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Primary Questions

- **What is the magnitude of the problem?**
  - Fatalities?
  - Injuries?
  - Property damage only crashes?
  - Non-police reported crashes?
- **What are the costs, and what are benefits?**
  - Economic?
  - Social Network?
  - Community?
  - Personal?
  - Family/Household?
  - Safety?
  - Congestion?
  - Medical?
- **What is the relative risk?**
  - How do cell phone crashes compare with other distraction related crashes?
  - How do cell phone crashes compare with other crashes in general?

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Can We Examine Costs Relative to Benefits?

The difficulties in determining the costs and benefits of cell phone use while driving have already been highlighted. Potential costs along with a host of potential benefits have been identified throughout the literature. Inherent in a series of notable analyses (Brookings Joint Center for Regulatory Studies and Harvard Center for Risk Analysis) are a number of assumptions that attempt to address a subset of these benefits and costs. Careful analysis of these assumptions and their implications for the analyses associated with these efforts raise significant questions as to the validity of the conclusions. Many of these assumptions are "soft" in that there is no easy way to gauge the true magnitude or monetary value for the elements discussed (e.g., convenience). Furthermore, the tendency to characterize a ban on cell phones as "complete" may be viewed as unrealistic. Certainly emergency calls would be permitted and any degree of restriction that reduces calls from a moving vehicle does not imply that the calls would not be made at all.

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Secondary Questions

- **What is the nature of the problem?**
  - Who?
  - What?
  - When?
  - Where?
  - How?
- **What contribution does exposure make to risk?**
  - Frequency of use?
  - Duration of use?
  - Calls per unit time?
  - Calls per unit distance?
  - Calls per trip?

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Wireless Technology

Over the past 15 years wireless technology has undergone a dramatic change in capability, architecture, and availability.

This evolution has had a significant impact on in-vehicle use and the potential risks associated with such use.

Unlike the situation for other in-vehicle distractions, the high rate of change in cell phone technology, associated changes in usage, and the uncertain influence of these factors on driver behavior and performance, have made the determination of safety impact difficult to assess, and contributes to the inherent instability of the available distraction related crash data from year to year.

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Some Specific Changes in Wireless Technology

- **Transition from fixed to portable devices**
- **Smaller, more portable size**
- **Flip-phones**
- **Hands-free devices – headsets, earpieces*, and speakerphones**
  - Some with voice dialing
  - Some with both voice dialing and voice command
- **Lower service rates with more free minutes**
- **Phones with increased functionality**
  - Voice messaging, short text messaging, electronic mail, internet access, address/contact info,
  - Phones that can receive and transmit digital images
- **PDA based phones**

*Other names include Portable HF, Earset, EarWrap, EarLite, EarGlove, Ear Bud, & Ear Boom Mic

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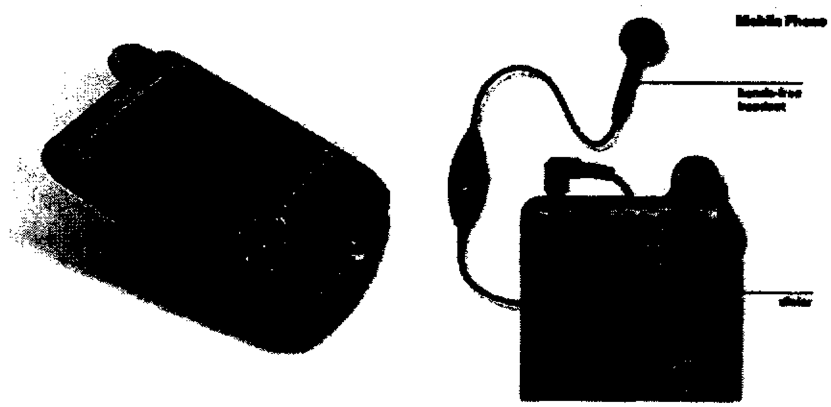
Advancing Technology

"It's a phone, it's a Web browser, it's a Palm!"*



* from Federal Computer Week, April 14, 2003

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Changes in Wireless Technology and Associated Risks

Many of the changes that have taken place suggest safer use (e.g., hands-free), but to the extent that conversation itself contributes to increased risk, and given the manner in which the different architectures appear to be used, the expectations may not be valid.

However, these changes can reduce the risks associated with certain actions or populations. For example hands-free, voice dialing reduces manual/visual demand and in so doing may reduce the risks associated with manual operation of the cell phone while driving. This is particularly important for older drivers.

Nevertheless, to the extent that improving usability will increase in-vehicle use (exposure), any net safety benefit will be reduced and may in fact, result in a decrease in overall safety.

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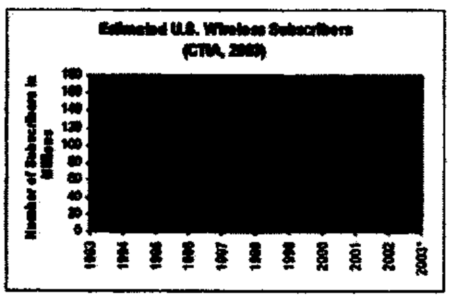
Dramatic Growth in Cellular Subscribers

There has been tremendous growth in the number of cellular subscribers in the United States since the introduction of cellular phones in 1983.

The greatest increase to date occurred between 1998 and 2002, when the number of subscribers more than doubled from over 60 million subscribers in 1998 to over 137 million subscribers in 2002. [43]



At the current pace, there will be more than 150 million U.S. subscribers by the end of 2003.

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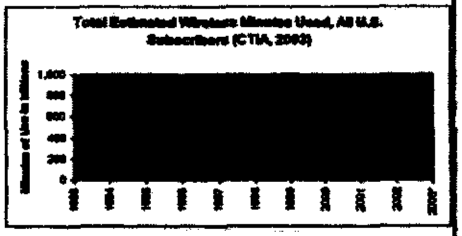
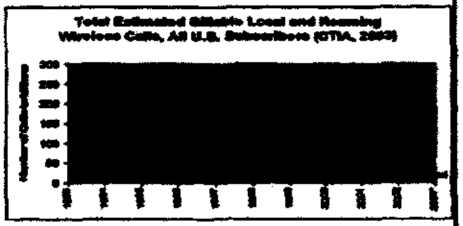
Dramatic Growth in Overall Use

The amount of cellular phone usage in the United States has increased significantly in recent years.

Overall, Cellular Telecommunications & Internet Association (CTIA) data indicate that wireless minutes of use and the number of wireless calls have increased by a factor of 5 since 1999.





Notes:
1. Starting with the June 1999 CTIA market survey, estimates of local billable calls and local minutes of use data include prepaid minutes and calls.[49]
2. The estimates of monthly minutes of use are based on estimates of billable prepaid, local and roaming minutes of use.
3. The estimates of monthly calls are based on estimates of billable prepaid, local and roaming calls.

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Dramatic Growth in Minutes of Use

The average amount of time that subscribers use their cell phones on a monthly basis has increased from an estimated 140 minutes per subscriber per month in 1999 to more than 350 minutes per subscriber per month in 2002.

Overall, monthly use continues to climb with increasing access to affordable service, and the monthly average will likely exceed 400 minutes per subscriber by the end of 2003.

Notes:
1. Estimates derived from CTIA data.[49] Average monthly minutes of use calculated from annual total minutes of use averaged over 12 months and divided by annual total estimated U.S. subscribers. (CTIA, 2003)
2. Starting with the June 1999 CTIA market survey, estimates of local billable calls and local minutes of use data include prepaid minutes and calls. (CTIA, 2003)
3. The estimates of monthly minutes of use are based on estimates of billable prepaid, local and roaming minutes of use.

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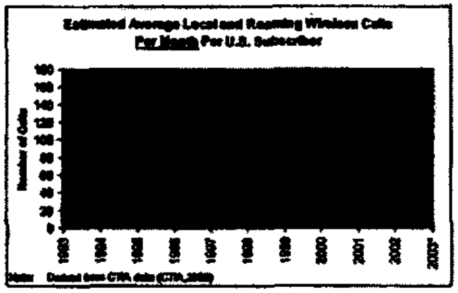
Dramatic Growth in Frequency of Use

On a monthly per subscriber basis, this translates to an increase from an estimated 47 local (including prepaid) and roaming wireless calls per month in 1999 to an estimated average of more than 120 calls per subscriber per month in 2002.



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3. The estimates of monthly calls are based on estimates of billable prepaid, local and roaming calls.

Projected

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U.S. Subscribership
Total Population, States, Metro Areas

A quarterly online survey by Telephia, Inc. and Harris Interactive (i.e., Telephia Attitude and Behavior Survey) revealed that 53% of the total U.S. population in major metropolitan areas subscribed to mobile phone service in December of 2002, and confirmed that subscribership rates in metropolitan areas are significantly greater than the statewide estimates.[68]

City Subscription Rate	Statewide Subecription Rate
Boston, Massachusetts: 63%	Massachusetts: 51%
Atlanta, Georgia: 64%	Georgia: 49%
Raleigh, North Carolina: 65%	North Carolina: 53%
Orlando, Florida: 65%	Florida: 49%
St. Louis, Missouri: 69%	Missouri: 40%
Greenville, South Carolina: 71%	South Carolina: 42%
Washington, DC: 64%	

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U.S. Mobile Phone Use
Young Adults, SMS messaging

- Results from 2002 quarterly Telephia surveys indicate the following:
  - About 35% of young adults (ages 18-24) use their wireless service for more than 500 minutes per month, compared to 20% of all users. [69]
  - Use of SMS and other 2-way messaging services has increased from 12% in 2001 to 20% in 2002. [70]
  - 45% of young adults say they frequently use wireless data services, including SMS and the wireless internet, compared with 22% of all users combined. [69]
- A 2000 study by market research firm Cahners In-Stat Group predicted that the wireless market for young people ages 10 to 24 would experience tremendous growth, and suggested that half of all teenagers will own of cell phone by 2004.[64]

Note: SMS refers to Short Message Service more commonly know as Instant Messaging

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Estimates of Exposure While Driving in 2002

Percent of Daylight Driving Time Spent Using a Cell Phone (2002 NOPUS)	6%
Number of Drivers Using Cell Phones During the Average Daylight Moment (2002 NOPUS)	601,000 drivers per moment
Daylight Hours of Cell Phone Use While Driving Per Day (derived from 2002 NOPUS data)	7,440,000 hours per day
Daylight Miles Driven Using a Cell Phone Per Day (derived from 2002 NOPUS data)	243,800,000 miles per day
Trips While Taking Incoming Cell Phone Calls Per Day **Trips While Making Outgoing Cell Phone Calls Per Day** (derived from National Survey of Distracted and Drowsy Driving Attitudes and Behaviors 2002)	113,000,000 trips per day 111,000,000 trips per day

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Estimates of Exposure While Driving in 2002

Compared to Overall Wireless Phone Use

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Total Hours of Wireless Phone Use in 2002, all wireless use regardless of whether user was driving or not (from CTIA 2003 data [49])	10,329,000,000 hrs for 2002
Total Hours of Wireless Phone Use during Daylight (8AM–6PM), all wireless use regardless of whether user was driving or not (Recent data extracted from the University of Montreal's 2001 epidemiological study indicates that ~75% of all wireless calls were made between 8AM and 6PM. [78] Assume that Total Hours of Wireless Phone Use During Daylight Hours is 75% of Total Hours of Wireless Phone Use in 2002.)	7,746,700,000 hrs during daylight for 2002
Total Hours of Daylight (8AM-6PM) Wireless Cell Phone Use Per Day, all wireless use regardless of whether user was driving or not (Total Hours of Daylight (8AM-6PM) Wireless Cell Phone Use Per Day is average of Total Hours of Wireless Phone Use during Daylight (8AM–6PM) over 365 days.)	21,200,000 hours per day for 2002
Daylight Hours of Cell Phone Use While Driving Per Day (from previous slide)	7,440,000 hours per day
How Much Daylight Wireless Phone Use Takes Place While Users Are Driving? (Daylight Hours of Cell Phone Use While Driving Per Day) divided by (Total Hours of Daylight (8AM-6PM) Wireless Cell Phone Use Per day, all wireless use regardless of whether user was driving or not) = 7,440,000 hrs per day use while driving / 21,200,000 hrs per day total use	35%

Legislative Update: Public Opinion

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Surveys of public opinion confirm the driving public's concern over the safety of using cell phones while driving and willingness to accept some restrictions. However, there are clear differences in the opinions of users and non-users. For example, data from a 2002 national survey[44] indicate that:

- 88% of all drivers support increased public awareness of the risks of wireless phone use while driving.
- 57% of all drivers supports a ban on all wireless phone use while a car is moving (except for 911 calls). About one-fourth of drivers who use cell phones support such a ban compared to 69% of drivers who do not use cell phones.
- 62% support increased fines for traffic violations involving cell phone use. About 40% of drivers who use cell phones support such fines compared to about 70% of drivers who do not use cell phones.

Legislative Update: *State Activity*

- NY is the only state to restrict use of hand-held phones while driving by general public.
- On May 29, 2003, the California State Assembly voted in favor of legislation that would prohibit the use of hand-held cell phones while driving, and that legislation is currently being considered by the State Senate.
- Several local jurisdictions have also restricted hand-held cell phone use while driving.
- Several states have restricted use of cell phones by novice drivers and/or school bus operators.
- Several states have established task forces and/or have set up special data collection activities on this issue.
- A few states have prohibited local restrictions.
- More than 30 states have considered legislation on the issue in the last year.

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Legislative Update: *States Restricting Novice Drivers & School Bus Operators*

- **New Jersey** enacted legislation in 2002 that prohibits the holder of a driver examination permit from using any interactive wireless device while operating a motor vehicle, with emergency use exceptions.
- **Maine** enacted legislation in 2003 that requires persons under 21 to obtain an instruction permit and receive education and training prior to obtaining a driver's license. This legislation also prohibits drivers with only an instruction permit from using a mobile telephone while driving.
- **Arkansas, Illinois, Massachusetts, New Jersey, Rhode Island,** and **Tennessee** have enacted legislation that prohibits the use of cell phones while operating a school bus.

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Legislative Update: Activity in Other Countries

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At least 42 countries restrict or prohibit use of cell phones and other wireless technology in motor vehicles, and several more are considering legislation.

Israel, Portugal and Singapore prohibit all mobile phone use while driving.

Countries that prohibit the use of hand-held mobile phones while driving:

Australia	Czech Rep.	India (New Delhi)	Kenya	Russia	Taiwan
Austria	Denmark	Ireland	Malaysia	Slovak Rep.	Thailand
Belgium	Egypt	Isle of Man	Netherlands	Slovenia	Turkey
Brazil	Germany	Italy	Norway	South Africa	Turkmenistan
Canada (Newfoundland)	Greece	Japan	Philippines	South Korea	Zimbabwe
Canada (Labrador)	Hong Kong	Jersey	Poland	Spain	
Chile	Hungary	Jordan	Romania	Switzerland	

Drivers in France and United Kingdom may use cell phones but can be fined if involved in crash while using the phone. Drivers in United Kingdom and Germany can lose insurance coverage if involved in crash while talking on the phone.

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Legislative Update: Laws in Japan

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Japan banned drivers from using hand-held cell phones and discouraged use of hands free phones while in the car in November, 1999.

- Advertisement of hands-free devices as a solution to distraction is discouraged.
- Reported cell phone-related crashes before and after institution of ban

	6 months *Before* Law Enactment	6 months *After* Law Enactment	Decrease
Number of Crashes	1,473	580	-893 (-60.6%)
Deaths	12	7	-5 (-41.7%)
Injuries	2,174	846	-1,328 (-61.1%)

- Decrease in reported crashes may be due to reduction in use, greater care when using, and (or) failure to admit a phone was being used.

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Corporate Issues

Wireless communication is increasingly being applied in the corporate environment to improve productivity and efficiency. Such utilization has sometimes resulted in crashes where drivers were confirmed to be using a cell phone at the time of the crash. The resulting lawsuits have heightened corporate awareness of the potential liability whether the driver was using the phone for business or personal reasons. In some cases the corporate response resulted in formal policies regarding the use of cell phone while on company time or while using a company vehicle.

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Corporate Views

- **Wilkes Artis, Washington DC-based law firm (2001)** [72]
  - "Our policy is that personnel are not to conduct business while using cell phones, unless they pull over and stop or use a hands-free device."
- **U.S. Cellular Co. (2002)** [73]
  - From the company's cell phone policy statement: "Stopping on the side of the road is not acceptable. It is encouraged that associates exit the roadway and find a proper parking space prior to using their cellular phone."
  - Mandates hands-free equipment for employees who drive on company business.

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Corporate Views

- **State Farm Insurance Co. (2002)** [73]
  - "Since using a cellular phone, two-way radio or wireless device may become a distraction while driving, using any of these devices is discouraged when the car is in motion. If it is absolutely necessary to us one of these devices while driving, the vehicle should be equipped with equipment that allows the individual's hands to remain on the steering wheel."
- **Farmers Insurance Group (2000)** [16]
  - "While Farmers Insurance Group promotes the idea of drivers carrying a cell phone while in their car in case of emergencies, we don't recommend people use a phone while they are driving."

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GSA (2002)

- *Recommended policy (FMR Bulletin B-2* [58]*) on the use of wireless phones while driving motor vehicles owned or leased by the Federal Government.* Federal agencies should:
  - Discourage the use of hand-held wireless phones by a driver while operating motor vehicles owned or leased by the Federal government.
  - Provide a portable hands-free accessory and/or hands-free car kit for government owned wireless phones.
  - Educate employees on driving safely while using hands-free wireless phones.

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Industry Guidelines

- **CTIA's "Guide to Safe and Responsible Wireless Phone Use" [3]**
  1. Get to know your phone and its features, such as speed dial and redial.
  2. When available, use a hands free device.
  3. Position your phone within easy reach.
  4. Let the person you are speaking to know you are driving; if necessary, suspend the call in heavy traffic or hazardous weather conditions.
  5. Do not take notes or look up phone numbers while driving.
  6. Dial sensibly and assess the traffic; if possible, place calls when you are not moving or before pulling into traffic.
  7. Do not engage in stressful or emotional conversations that may divert your attention from the road.
  8. Dial 9-1-1 to report serious emergencies -it's free from your wireless phone!
  9. Use your phone to help others in emergencies.
  10. Call roadside assistance or a special non-emergency wireless number when necessary.

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How Do Cell Phones Contribute to Crash Causation?

- **Review of cell phone related crashes provides insight into how driver actions and responses associated with cell phone use lead to crashes.**
- **For simplicity we identify four categories of distraction:**
  - **Visual** – e.g., Looking away from road to dial a number
  - **Biomechanical (manual)** – e.g., Manipulating a device
  - **Cognitive** – e.g., Lost in conversation or thought
  - **Auditory** – e.g., Startled by ringing phone
- **These forms of distraction may occur independent of one another or in combination depending upon the specific activity (e.g., trying to remember a number, looking at a phone, dialing the number).**

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Some Factors Influencing Crash Risk

- Individual differences (e.g., in skill, abilities, experience, personality)
- Learning / Behavioral Adaptation
- Device demand
- Context (e.g., traffic, weather, roadway)
- Willingness to engage
- Perceived urgency
- Driver state (e.g., emotional, sick, drugs)
- Other concurrent distracting activities
- Exposure (duration, frequency)

The relationship of these factors to the risk of a crash while using a cell phone is very complex as illustrated in the diagram that follows.

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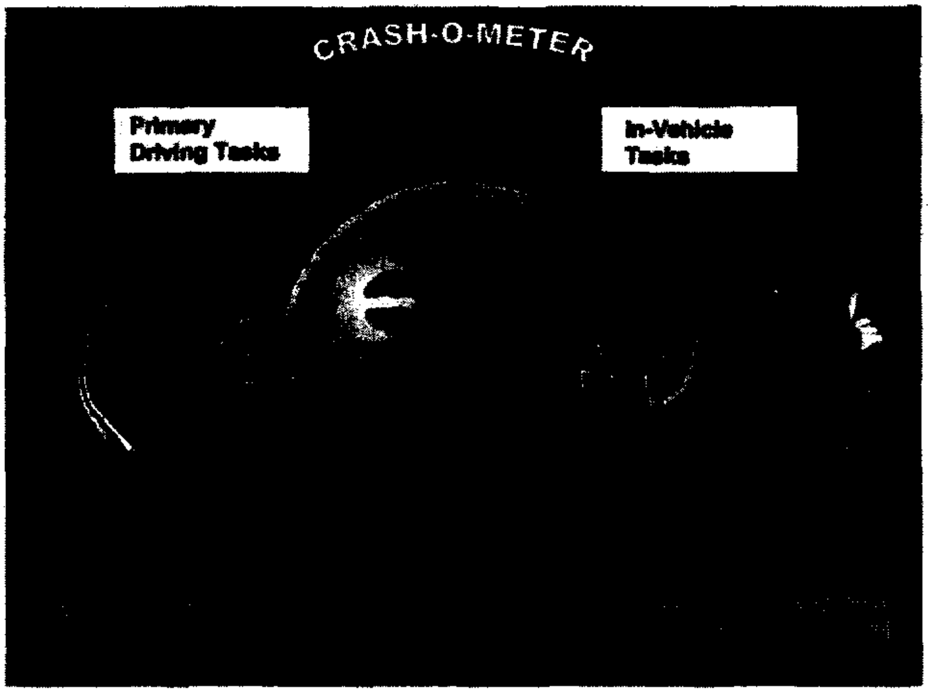

Factors Influencing Crash Risk

- **Individual Differences**

  Individual factors such as skills and abilities, experience, risk taking, and aggressiveness can significantly influence the potential for a driver to be involved in a cell phone related crash. Driver decisions about willingness to use and conditions of use are a key to understanding how these factors influence risk.

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Factors Influencing Crash Risk

- **Learning / Behavioral Adaptation**

  An analysis of crash data reveals that drivers of new vehicles are at increased risk of a crash for some period of time. As they gain experience with the vehicle, this risk is reduced. Likewise, drivers who use new technologies may, over time, develop techniques for adjusting their behavior to improve usability and efficiency. It is the increased confidence that it safe to use a particular technology that can get drivers into trouble. This *behavioral adaptation* may take the form of complacency, may result in increased use, and may extend the driving conditions (context) in which the device is used (e.g., in heavy traffic rather than just light traffic). Since most distraction related crashes occur when a distracted driver encounters an unanticipated event, any increase in exposure (i.e., frequency, duration or context) may ultimately place the driver at greater risk.

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Factors Influencing Crash Risk

- **Device Demand**

Device demand is determined by a large number of device design features (e.g., legibility, button size, display size, color) that determine the degree of (e.g., how difficult it is to read a display), and nature of (e.g., requiring visual attention) distraction.

Factors Influencing Crash Risk

- **Context**

Context refers to the conditions that exist at the time of distraction. These include, for example, traffic conditions, time of day, weather, roadway type/ characteristics, and visibility. Context can have a significant impact on the willingness of a driver to engage in distracting activities and hence, on the risk of engaging.

Factors Influencing Crash Risk

- **Willingness to Engage**

  The willingness of a driver to use a particular device is closely related to the demands of the device, the context of the driving situation (e.g., traffic and weather conditions), the urgency of the task, and driver characteristics. For example, there may be situations and contexts when a driver is willing to answer an incoming call, and other situations when he or she is not.

Factors Influencing Crash Risk

- **Perceived Urgency**

  Urgency refers to the motivation of the driver to engage in a distracting activity. Thus, drivers may not normally carry out a task under certain circumstances, but will if there is a perceived urgency (e.g., running late and there is a need to notify someone, a need to adjust a mirror for better visibility under adverse conditions, need to answer a call or make a call for business deadline).

Factors Influencing Crash Risk

- **Driver State**

  The state or condition of the driver at any given time (e.g., drowsiness, emotional) can have a significant influence on the risks associated with operating a device. These effects may simply be in terms of degrading performance further, influencing willingness to engage, or influencing driver judgment. Some of these effects may be transient (e.g., emotional call) or continuous (effects of a drug).

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Factors Influencing Crash Risk

- **Other Concurrent Distracting Activities**

  Other concurrent distracting activities refer to concurrent performance of multiple distracting activities that divert the driver's attention from the road. For example, the driver may be concurrently talking on the phone and eating while driving, sometimes leaving both hands off of the wheel. Concurrent activities while driving can have a significant impact on risk.

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Factors Influencing Crash Risk

- **Exposure**

  Exposure refers to the frequency and duration of involvement with a distraction, whether it be visual, cognitive, auditory, manual, or some combination thereof. It is exposure, combined with individual differences, device demand, context, willingness to engage and urgency that determines the degree of risk associated with a particular activity.

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Factors Influencing Crash Risk
Transactional Risk vs. Exposure

Each task (transaction; e.g., dialing a phone, talking on a phone, adjusting the volume) associated with an activity (e.g., using a phone) is also associated with some degree of risk based on the demands of that task. This risk is further influenced by the duration and frequency with which we engage in the task. While some tasks may produce less demand than others, their greater frequency and duration of use may result in greater overall risk. For example, dialing a phone vs. conversation.

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What Is a Hands-free Phone?

The sensitivity of driver behavior and performance to device demands has already been highlighted. In the case of hands-free phones in particular, this is a potentially significant issue since not all hands-free phones are created equal, taking into account the specific features of the phone, the accessories used and manner in which the "system" is used. Generally these differences are associated with the degree to which the phone must be manipulated (e.g., to dial, open), the method of communications (e.g., speaker/mic vs. earphone/mic), the nature of the connection (e.g., wired vs. wireless), the location of the phone (e.g., cradle vs. on driver), whether the phone has a voice command capability (e.g., "dial 555-5555"), and when the "system" is set up (e.g., vehicle moving or stationary). Since the distribution and manner of use of these different system architectures is unknown, they are considered in aggregate as "hands-free" phones in the discussion that follows. Thus, any phone that does not require the driver to hold the phone for dialing or conversation is considered "hands-free."

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Hands-Free vs. Hand-Held

Over the past several years there has been tacit acceptability of hands-free phones for mobile use by state (through legislation) and federal (GSA) authorities. That hands-free phones are somehow safe or safer has been promoted by elements of the wireless industry for some time ("hands-free lets you keep your hands on the wheel and eyes on the road"). It appears that this is generally believed by users as reflected by the growing use of hand-free devices. Nevertheless, this expectation does not appear to be supported by either experimental or epidemiological research, both of which indicate little if any difference between the architectures in terms of risk or safety relevant behavior and performance. This is not to say that hands-free and hand-held devices adversely influence driving in the same way, but rather that beyond the common cognitive demand of conversation itself, the use of each architecture may be associated with unique attributes that have the potential to increase crash risk. The following slides summarize empirical evidence suggesting the lack of clear distinction in risk associated with the two architectures.

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Hands-Free vs. Hand-Held

- **Studies that compared Hands-free (HF) and Hand-held (HH) phones found that both architectures resulted in:**
  - Delayed reaction times [12, 15, 24, 29, 38, 50, 75]
  - Missed events [20, 50]
  - Speed variations [24]

Hands-Free vs. Hand-Held

- **Studies have shown that the cognitive aspects of conversation seem to be the greater source of distraction (regardless of HH or HF):**
  - Delayed reaction times [12, 15, 24, 29, 38, 50]
  - Missed events [20, 50]
  - Reduced situation awareness [37]
  - Narrowing of visual field [26, 40, 48]
  - Reduced visual scanning [10, 34]
  - Inattention blindness [49]
  - Higher subjective mental workload [4, 33, 53]

These refer to the same general phenomenon but reflect the terminology of the reporting authors. (This note refers to reduced situation awareness, narrowing of visual field and reduced visual scanning.)

Hands-Free Is Not Risk Free

Complicating the issue is the lack of clear understanding of how these hands-free and hand-held devices are used in the real world. For example, it is not at all clear that drivers using hands-free phones drive with both hands on the wheel or attend more to the road, nor can it be said that they always use the phone in a hands-free mode while driving. As will be seen later, this latter point is supported by survey data. Similarly, while the act of dialing with a hand-held may place a driver at greater risk, a hands-free phone on the console may actually require more visual attention where manual dialing is used. In addition, there is evidence that hands-free calls are longer than hand-held calls, which would increase exposure and hence risk. Finally, use of hands-free phones may involve using an earpiece. Drivers have been observed putting on these devices while driving, an activity that can require two hands and would clearly increase the risk of crash. Survey data specifically indicates that one in five headset/earpiece users place the headset on while driving (2003 MVOSS [36]). Clearly, hands-free is not risk free.

Note: 2003 MVOSS data is preliminary.

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Sources of Information and Data on Cell Phone Use, Consequences of Use, and Association with Crashes

- **Anecdotal**
- **Survey and Focus Group Data**
- **Experimental Research**
- **Crash Data**
- **Cost-Benefit and Risk Analyses**

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Sources of Anecdotal Information

- **Media reports and articles**
- **Letters to NHTSA**
- **Various internet sources**
- **Discussions with researchers and conversations with callers to NHTSA**
- **Noted observations and interview comments from researchers**
- **Observations from law enforcement officers**

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Anecdotal Information

Some of What We Have Learned

- **Drivers will not readily admit to being distracted.**
- **There are differences in the willingness of drivers to report different distractions; they may be more willing to admit to one form of distraction rather than another.**
- **Many cell phone users gesture with their free hand when they speak, sometimes leaving no hands on the wheel for short periods of time.**

[illegible] 57

Anecdotal Information

Some of What We Have Learned

- **Cell phone drivers are perceived to drive like intoxicated drivers (e.g., slow speed, excessive, and slow lane motion, reduced situational awareness).**
- **Other drivers are involved in crashes caused by cell phone users who themselves are not involved.**
- **Anecdotal data, not unlike survey data, reveal that the public is very concerned about this problem behavior. They have witnessed or experienced the adverse effects and were concerned enough to pass that information along to the media, police or NHTSA.**

[illegible] 58

Examples from the Media

- 2002 – An Arkansas woman talking on a cell phone was killed after driving into the path of an Amtrak train.
- 2001 – Supermodel Niki Taylor was critically injured in a crash that resulted when her driver lost vehicle control while reaching for a ringing cell phone.
- 2000 – A Virginia attorney conducting business using cell phone while driving struck and killed a teenage girl.
- 1999 – An investment firm employee ran a red light while searching for dropped cell phone and struck a motorcyclist.

Sources of Information and Data on Cell Phone Use, Consequences of Use, and Association with Crashes

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Survey Data

- **NHTSA-sponsored surveys**
  - Bi-Annual Motor Vehicle Occupant Safety Survey (MVOSS) [8, 38]
  - 2002 National Survey of Distracted and Drowsy Driving Attitudes and Behaviors [44]
- **NHTSA-sponsored Focus Groups**
  - VTTI Study 2002 [9]
- **Other independent surveys**
  - North Carolina Statewide Survey 2002 [61, 63]
  - Montreal Study 2000 [30]
  - CTIA market survey [43]
  - Other Public Opinion Surveys [18, 39, 54, 71]

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Survey Data: User Characteristics

- **The following are estimates based on several surveys and do not reflect the full ranges of values reported.**
  - About two-thirds of drivers have cell phones.
  - Over half with phones keep phones on for all trips, and two-thirds for most or all trips.
  - About three-fourths of those with phones report having used phones while driving; this translates to about one-third to one-half of *all* drivers.
  - About one quarter of those with phones report *never* talking on phones while driving.

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Survey Data: Phone Use & Driving

NHTSA
People Saving People

Average Duration of Calls Or Daily Talk Time While Driving

- **CTIA** [43]
  - length of average local cellular call in 2002 was 2.73 min
    (compared with average of 2.74 min in 2001)
- **2002 National Survey of Distracted and Drowsy Driving Attitudes and Behaviors** [44]
  - Mean 4.5 minutes *per call* while driving
- **North Carolina Statewide Survey 2002** [51]
  - Mean 14.5 min *per day* while driving
    (Median = Mode = 5 min per day while driving)

Note: MVOSS data is preliminary

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Survey Data: Phone Use & Driving, Monthly vs. Daily Use

NHTSA
People Saving People

- **1999 PCIA poll** [39]
  - 10% no <u>MONTHLY</u> use
  - 40% less than 10 min per <u>Month</u>
  - 20% said 10-30 min per <u>Month</u>
  - 30% said 30 min or more per <u>Month</u>
- **North Carolina Statewide Survey 2002** [51]
  - 18.4% less than one min per <u>DAY</u>
  - 29.6% said 1-4 min per <u>Day</u>
  - 20% said 5-9 min per <u>Day</u>
  - 32% said 10 or more min per <u>Day</u>

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Survey Data: Phone Use & Driving

Answering the Phone

- **NHTSA 2003 Motor Vehicle Occupant Safety Survey (MVOSS) [38]**
  - Of drivers who report having a wireless phone turned on at least some of the time when they drive
    - 40% also report that they *always* answer an incoming call while driving
    - 31% report that they *usually* answer the call
    - Less than 10% report that they *never* answer the incoming call while driving

Notes: It is not clear what proportion of drivers have voicemail as an option.
MVOSS data is preliminary.

Survey Data: Phone Use While Driving

per Trip Use

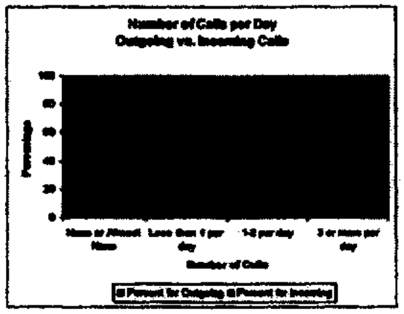
- **NHTSA MVOSS, 2003 [38]**
  - 23% report they never talk on phone while driving
  - 47% report they talk on phone for less than half of trips
  - Nearly 16% report they talk on phone for half of trips
  - 13% report they talk on phone for most or all trips.
- **NHTSA Distracted Driving Survey 2002 [44]**
  - 58% report they rarely or never make outgoing calls
  - 18% report they make calls on one-quarter of trips per week (5-6 trips per week)
  - 10% report they make calls on one-half of trips (11 trips per week)
  - 13% report they make calls on three-fourths or more trips (20-30 trips per week)

Note: 2003 MVOSS data is preliminary

Survey Data: Phone Use & Driving

Calls per Day

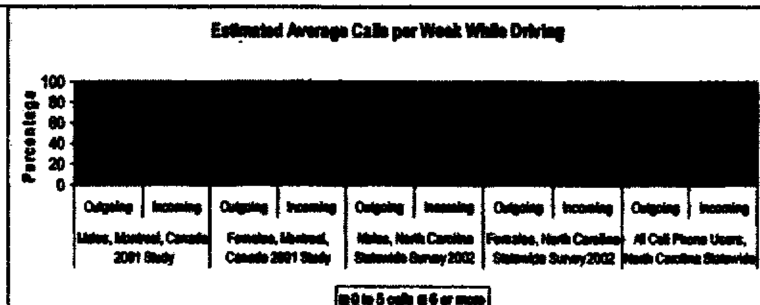
- About one-half of cell phone users surveyed in the North Carolina Statewide Survey in 2002 reported making or answering at least 1-2 calls daily while driving. [61]
- Overall, cell phone users were more likely to make outgoing calls than to answer incoming calls while driving.
- 24.5% reported making none or almost no daily outgoing calls while driving.
- 34.9% reported answering none or almost no daily incoming calls while driving.



(Source: Stutts et al., 2003)

67

Survey Data: Phone Use & Driving - Trends



(Sources: Laberge-Nadeau, et al., 2001; Stutts, et al., 2003; Stutts, 2003)

- Canadian survey data, collected in 2000, indicate that drivers are more likely to make and receive *fewer* (<6) calls weekly. Data for drivers in North Carolina, collected in 2002, indicate that more drivers are making and receiving more calls. [38, 51, 63]
- The data also indicate that males are more likely to make more calls while driving than females.

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Survey Data:
Hand-Held vs. Hands-Free

NHTSA

- **For drivers who reported usually carrying a wireless phone in the vehicle:**
  - The 2000 NHTSA MVOSS [8] data showed that:
    - Hand-held phone use rate was about 73%
    - Hands-free phone use rate was about 22%
- **For drivers who reported talking on the phone while driving:**
  - The 2002 North Carolina Statewide Survey [51] suggested that the hand-held usage rate is about 72%
  - The NHTSA 2002 Distracted Driving Survey [44] and the NHTSA 2003 MVOSS [36] data showed that:
    - Hand-held phone use rate is between 60-63%
    - Hands-free phone use rate is between 34-38%

Note: 2003 MVOSS data is preliminary

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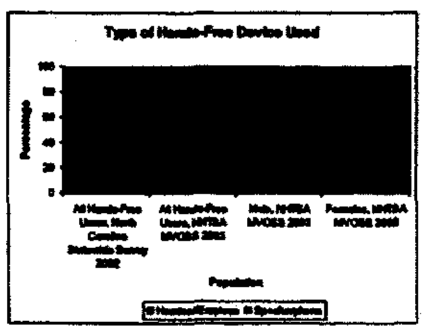
Survey Data:
Use of Hands-Free Systems

NHTSA

- Survey data show that about two-thirds of drivers who "usually" use hands-free systems report use of a headset or earpiece. [51, 36]
- Survey data also indicate that female users are more likely to use the headset or earpiece, whereas male users are more likely than the females to use the speakerphone feature. [51, 36]



Note: 2003 MVOSS data is preliminary

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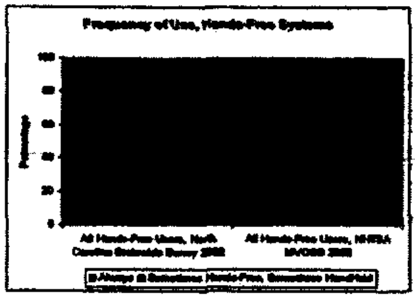
Survey Data:
Frequency of Use - Hands-Free Systems

Survey data indicate that only one-third to one-half of hands-free system users report *always* using the hands-free system. This suggests that the number of hand-held phone users on the road is actually greater than that observed (e.g., NOPUS) and includes some portion of the hands-free users who also sometimes use their phones in a hand-held mode. [51, 35]



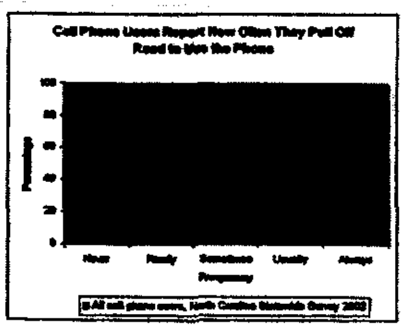
Note: 2003 MVOSS data is preliminary

71

Survey Data:
Do People Pull Off Road To Use The Phone?

- The North Carolina Statewide 2002 survey of drivers revealed that more than one-half of cell phone users report that they *rarely or never* pull off the road to use the phone. [51]

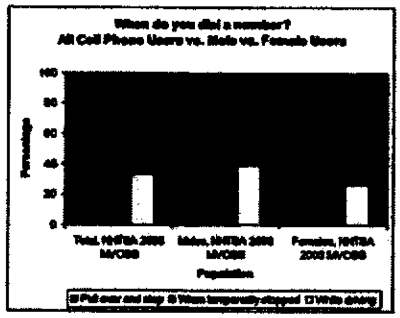
- Only one in ten drivers always pulls off the road to use the phone.



72

Survey Data:
Where Do People Dial A Number?

- NHTSA 2003 MVOSS data show that about one-third of drivers who reported using a cell phone on at least some trips also reported a tendency to dial phone numbers while driving. [36]
- The male drivers were more likely to dial while driving.
- The female drivers were more likely to dial while temporarily stopped, though they were equally likely to dial after pulling over to stop.



Note: 2003 MVOSS data is preliminary

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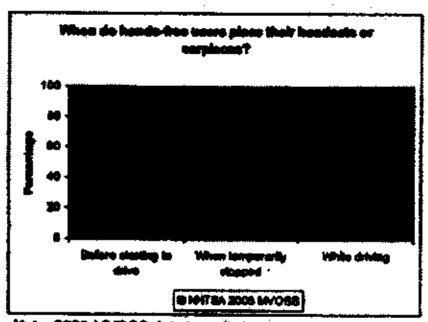
Survey Data:
When Do People Place The Headset/Earpiece On For Use?

- According to the NHTSA 2003 MVOSS data, four out of five hands-free users of a headset / earpiece report that they place the device on prior to driving or when stopped temporarily. [36]
- But one out of five users reported that they do this while driving.



Note: 2003 MVOSS data is preliminary

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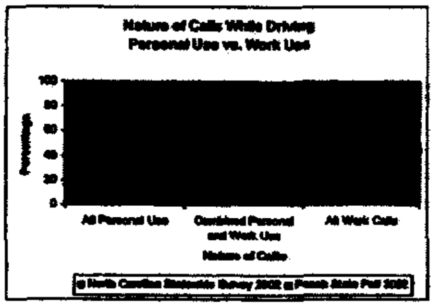
Survey Data:
Reported Reasons For Calls While Driving

Recent survey data (NC [50], GA [71]) show:

- 6-10% reported work use only use while driving.
- 40-54% of cell phone users reported a combination of personal and work calls while driving.
- 34-53% of cell phone users reported personal use only while driving.



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Survey Data:
Reports Of Real Problems W/ Vehicle Control

- In 2000, more than 22% of male and 22% of female cell phone users in the Montreal study reported having experienced difficulty staying in their lane when using a phone while driving at some time in the last 24 months. [30]
- In 2003, more than 10% of drivers polled in the NHTSA MVOSS reported having had to take sudden quick action to avoid another vehicle or to avoid some object at some time in the past 12 months when talking on the phone while driving, and about 4% have had to act quickly to move back onto the roadway at some time in the past 12 months. [36]

Note: 2003 MVOSS data is preliminary

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Survey Data:
Reports Of Close Calls Or Near Misses

- In 2000, more than 40% of drivers polled by Farmers Insurance reported having experienced a close call or near miss situation at some time with another driver who was using a cell phone. [16]
- In 2000, about 6% of male and 4% of female drivers, respectively, in the Montreal study reported having experienced a close call or near miss situation at some time when they were using the phone while driving. [30]

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Survey Data:
Other Messaging Features and Functions While Driving

- **NHTSA 2003 MVOSS data [36] show that drivers who usually have a wireless phone of some type in the vehicle report also having access to additional phone features that include:**

Voice Mail (75%)
Address/Phone Book (20.9%)
Internet Access (28%)
Short Messaging (23%)
E-mail (20.9%)

Note: 2003 MVOSS data is preliminary

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Limitations of Survey Data

Many of the lessons learned from anecdotal data apply to survey data.

Whereas much data is available, there are significant variations in the manner in which the data is collected and reported.

For example, multiple surveys ask about frequency with which driver uses phone while driving. Question has been asked in terms of: daily use, weekly use, per trip use, percentage of trip use, often vs. rarely, calls per day, calls per week, calls per trip, and so on.

This makes data comparison difficult and limits the ability to draw definitive conclusions on exposure and relative risk.

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Limitations of Survey Data

Survey data is subjective, and is vulnerable to a multitude of factors that contribute to inconsistencies in recalled data. As a result these data may not be completely reliable. For example:

- The excitement that results from a collision may cause a driver to forget what distracted him/her just prior to the collision.
- A driver may want to hide the true reason for his/her distraction prior to a collision to avoid consequences.
- A driver may not realize the relationship between what distracted him/her and the resulting collision, so he/she does not know to report it in the survey.
- A driver may have difficulty recalling exact details of crash from several years past.

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Sources of Information and Data on Cell Phone Use, Consequences of Use, and Association with Crashes

- Anecdotal
- Survey and Focus Group Data
- **Experimental Research**
- Crash Data
- Cost-Benefit and Risk Analyses

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Experimental Research

- **Large body of independent and NHTSA-sponsored studies (dozens of studies since the early 1990s) directed at issues associated with cell phone use while driving and traffic safety**
  - In the laboratory
  - Using driving simulators
  - On-the-road research (controlled and naturalistic)
  - Observational research such as NHTSA's National Occupant Protection Use Survey (NOPUS)

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Prominent Driver Performance Effects: Experimental Research Findings

- Narrowing of visual field or "tunnel vision" [26, 40, 48]
- Failure to process visual information despite fixations "inattention blindness" [49]
- Delayed reactions to traffic events [12, 15, 24, 29, 38, 50]
- Failure to respond to events or targets [20, 50]
- Delayed braking and more intense braking [25, 28]
- Reduced lane position stability (e.g., lane excursions) [37, 60]
- Increased headway variability (reduced safety margins) [4]
- Increased speed variability [24, 29, 37, 38]
- Reduced situation awareness [26, 37, 75]
- Reduced capability for vehicle control [26, 37, 60]

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Driver Performance: Results from an On-Road Study

- **Harbluk, Noy, and Eizenman (2002)** [26]
  - Conducted an on-road study to examine the impact of distraction when using a hands-free phone while driving.
  - Concluded that significant changes in driver behavior (narrowed visual scanning behavior and reductions in vehicle control) under real-world driving conditions may result due to the cognitive distraction associated with the use of in-vehicle, hands-free devices, and that these changes support the idea that these extra demands on the driver contribute to late detection, reduced situation awareness and a reduced margin of safety.

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Driver Performance: Results from a Simulator Study

- **Strayer and Johnston (2001) [50]**
  - Conducted a set of experiments using a part-task driving simulation to contrast the effects of hand-held and hands-free wireless phone conversations on a simulated driving task.
  - Results showed that cell phone users missed more traffic signals and had longer reaction times to those signals they noticed, with users of hands-free devices performing no better than those using hand-held phones.

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Driver Performance: Results from a Simulator Study

- **Haigney, Taylor, and Westerman (2000) [24]**
  - Conducted a study using a driving simulator to investigate the effects of hand-held and hands-free mobile phone use on driving performance.
  - Found that changes in heart rate indicated an increase in cognitive demand experienced by drivers when using mobile phones.
  - Found that using a phone, either hands-free or handheld – leads to variations in driver behaviors, which are strongly associated with subjective risk manipulation and crash involvement.
  - Results showed significant variations in vehicle speed, decrement in driver responsiveness to traffic conditions, and decreased driver responsiveness following a phone call.
  - Both handheld or hands-free phones seriously affected the driver's ability to consistently attend to the driving task.

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Driver Performance: Other Important Factors

- **Hand-held vs. hands-free phones**
  - Whereas hands-free phones may have some performance benefits, evidence indicates that drivers who use hands-free phones use them more frequently and for longer durations [29, 60]
  - In addition, there is a growing body of evidence that the complexity of the conversation task is a far greater contributor to the deleterious effects on driver performance [12, 15, 34, 35, 38, 53]
    - Even when hands-free phones result in better performance than hand-held, both are usually significantly worse than a no-phone condition [29]
- ***Conversation complexity***
  - Strong evidence that complex conversation tasks contribute significantly to reduced driver performance [12, 34, 35, 38, 53]
  - Even simple conversation results in some decrements [28, 35, 37, 38, 53]

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Driver Performance: Other Important Factors

- **Driver Characteristics**
  - Nearly all effects are much worse for older drivers, but research has shown that they can benefit from voice-interface designs. [34, 35]
  - In one study, teens (16-18 yrs) were found to choose unsafe following distances, have poor vehicle control skills and to be more prone to distraction from hand-held phone tasks. [20]
- **Other distractions**
  - Some evidence that radio tuning, HVAC operation, and listening to books on tape result in fewer decrements than phone conversations. [20, 29, 60]
  - CD case manipulations and map reading have been shown to be more detrimental to driving performance than cell phone use.

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Observational Research

In addition to driver performance data, observational data plays an important role in our understanding of cell phone use while driving.

NTHSA's National Occupant Protection Use Survey (NOPUS) and other observational studies are essential for determining current levels of cell phone use by drivers.

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Observational Research

NHTSA's Bi-Annual National Occupant Protection Use Survey (NOPUS)

NOPUS is a probability–based observational survey that focuses on seat belt use in the United States. As a part of this data collection effort, use of hand-held cell phones was also captured. For 2002, approximately 38,000 drivers were observed at 1,141 randomly selected road sites involving controlled intersections (i.e., stop sign or signal). Data was collected during daylight hours between 8:00 AM and 6:00 PM.

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Observational Research
NHTSA's Bi-Annual NOPUS

- In 2000, at any given time during daylight hours, 3% of drivers are using a hand-held phone. [53]
  - Higher rate for vans and SUVs (4.8%)
  - Additional 0.9% use hands-free equipment (estimated)
- In 2002, the portion of drivers estimated to be using a hand-held phone at any given time during daylight hours increased to 4%. [17]
  - Additional 2% use hands-free equipment (estimated)
  - In total, at least 6% of drivers are using some kind of wireless phone at any given time
  - Significant increase in urban areas from 2000

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Observational Research
Other Studies

- The observed rate of cell phone use by drivers was 3.1% in a 2001 University of North Carolina study. [42]
  - Cell phone users were more likely to be without a front-seat passenger, driving a SUV, younger, white, and wearing a safety belt.
- In 2000, five percent (5%) of all drivers observed on Dallas area highways were using a hand-held cell phone during the afternoon peak period. [13]
  - Ranged from 3% (rural) to 7% (urban)
- At any given time during daytime hours in 2001, 3.5% of drivers in the state of Washington were observed to be using a hand-held phone. [46]
  - Sport Utility Vehicle and Van drivers had the highest rate at 4.59% and 4.23%, respectively

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Observational Research

Conclusions

- The most recent evidence (2003) shows that, at any given time during daylight hours (8 am-6 pm), 6% of drivers are talking on a wireless device while driving, on average
- The observed use varies depending on road type (rural or urban) and vehicle type
  - Higher percentage in urban areas
  - Higher percentage for SUV and van drivers

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Epidemiological Research

1996 Rochester Study [55]

- Talking more than 50 minutes per month on cell phone in a vehicle was associated with 5.59-fold increased risk of a traffic crash.
- Combined use of cell phones and motor and cognitive activities while driving were also associated with increased traffic crash risk.

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Epidemiological Research

- **1997 Toronto Study** [41]
  - Reported an association between the use of cellular telephones in a motor vehicle and a quadrupled risk of crash during the call.
  - Authors "observed no safety advantage to hands-free as compared to hand-held unit telephones."
- **2003 Montreal Study** [62]
  - Results from a 2003 Montreal Study that examined the case-crossover design used in the 1997 Toronto Study suggest that the resulting estimated relative risk factor reported in the Toronto Study was two to three times larger than the true relative risk when randomness of the time of collision in the police report was introduced.

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Epidemiological Research

2001, 2003 Montréal Studies [30, 61]

- Relative risk of all traffic crashes and of crashes with injuries is 38% higher for cell phone users than for non-users.
- Heavy cell phones users (defined in terms of frequency of use and duration of individual calls) are exposed to twice the risk compared with those who make minimal use of their phones or are non-users, taking into account age, exposure to risk and driving habits.

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Epidemiological Research

2001 Norwegian Study [45]

- Reported an overall relative risk of 2.2 of driver being involved as responsible party in an accident while using a mobile phone as compared to driving without using the phone.
  - RR=1.8 for Hands-free users
  - RR=1.2 for dash-mounted users
  - RR=3.6 for hand-held users

    *Not statistically significant difference in RR between HF and HH.
- Increased risk is most likely a consequence of the telephone use *per se* and is not attributable to differences in risk-related behaviors between users and non-users of mobile telephones.

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Epidemiological Research: Limitations

- **Nature of crash data**
  - Vehicle-based vs. Crash-based
  - Crashes that involve Property Damage Only vs. Injury and/or Fatality
- **Missing data**
- **Limited sample sizes**
- **Methodological issues related to**
  - Comparisons of phone users vs. non-users
  - Comparisons of those who have had prior crashes vs. those who have not
- **These studies showed statistical associations but did not establish causal relationships.**

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Epidemiological Research: Limitations of Existing Data

Lack of exposure data and details on phone use that would be helpful to link crash risk with specific user behavior and cell phone architecture. In particular, it would be useful to know:

- Length of calls
- Frequency of calls
- Number of calls in a trip
- Device configuration information

It should be noted that in the 2001 Montreal Study, the finding of a dosing effect (the greater the use of cell phones, the greater the risk), added credibility to the findings. [30, 61]

99

Limitations of Research Studies

- Research studies have varying objectives and experimental circumstances, and employ a range of dependent measures. This variety provides much information, but can limit comparability.
- Research often involves commanded tasks in situations which may not represent the conditions under which a particular subject would actually carry out the task. This may bias the results against the technology if task demands are such that the subject would not normally carry out the task in the experimental context used.
- There is a need to understand behaviors in naturalistic settings; the research rarely uses benign conditions, which are most often associated with distraction related crashes.
- Observational surveys are snapshots in time. Information is gathered about population exposure at a point in time, but not necessarily the overall amount of exposure.

100

Issues with Research Studies
Behavioral Adaptation

Within the context of driving, *behavioral adaptation* refers to the changes in behavior and performance that take place over time as we gain experience with various aspects of our environment or vehicle.

Such adaptation may involve, for example, learning, strategy changes, complacency or other changes that take place in response to our experience, perceptions, and beliefs. These changes may be conscious or unconscious.

As indicated earlier, behavioral adaptation is a potentially important phenomenon in assessing risk. We know that drivers are at increased risk in unfamiliar vehicles. Likewise, when subjects are asked to use unfamiliar technology they are likely placed at greater risk while using it. With time they will adapt to using the technology while driving, and may develop specific time-sharing strategies. Research that provides very little exposure to a new technology may not address the long-term changes that may occur with experience using that particular technology.

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- Experimental Research
- **Crash Data**
- Cost-Benefit and Risk Analyses

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Crash Data

Objective, well-documented and complete crash data can help to identify and characterize the role of cell phones in crash causation and the magnitude of the problem. The challenge is to determine how "good" and complete the data are, how it can best be utilized to answer the questions at hand and how to improve it where it falls short.

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Crash Data

In reviewing crash data it is also important to recognize that the reporting of distraction as a causal factor appears to be conservative (the greater the depth of investigation, the greater involvement discovered) and may be biased by differences in reporting associated with the severity of a crash. In addition, the data have a very high level of "unknowns" associated with both general crash data and distraction related crash data.

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Crash Data

- **Available NHTSA data sources**
  - FARS
  - GES
  - CDS
- **NHTSA special investigations and analyses of state crash data**
- **State-initiated analyses of crash data and special investigations [14, 18, 77]**
- **Other independent analyses and epidemiological studies**

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General Trends in Distraction-Related Crash Data, 1997-2001

According to <u>both</u> FARS and GES, distraction related crashes most frequently occurred under the following conditions:

Road Characteristic	FARS [1]			GES [2]		
Alignment	Straight 76%	Curved 24%	–	Straight 83%	Curved 9%	Other 8%
Environment	Rural 66%	Urban 34%	–	–	–	–
Profile	Level 72%	Grade 24%	Other 4%	Level 50%	Grade 13%	Unknown 36%
Surface Condition	Dry 86%	Wet 12%	Other 2%	Dry 82%	Wet 14%	Other 4%
Atmospheric Condition	Normal 90%	Rain 7%	Other 3%	None 88%	Rain 9%	Other 3%
Light Condition	Daylight 59%	Dark 26%	Other 15%	Daylight 75%	Dark 7%	Other 17%

Note: distraction includes: emotional, inattentive, cell phone, fax machine, computer, on-board navigation system, 2-way radio, HUD

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North Carolina Crash Data

The following crash data was drawn from the Huang & Stutts (2003) analysis of North Carolina data covering the period 1996-2000 [27]

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Characteristics of Cell Phone-Related Crashes – Crash Severity

	Crash Severity		
	More Severe Injury	Possible Injury	No Injury
Cell Phone Crashes	9.0%	36.2%	54.8%
Non-Cell Phone Crashes	14.3%	27.3%	58.4%

North Carolina data, 1996-2000 (Source: Huang & Stutts, 2003)

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Characteristics of Cell Phone-Related Crashes – Crash Types

	Crash Type		
	Rear-end	Run-off-road	Angle Impact
Cell Phone Crashes	45.1%	18.5%	18.3%
Non-Cell Phone Crashes	25.6%	20.5%	14.6%

North Carolina data, 1996-2000 (Source: Huang & Stutts, 2003)

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Characteristics of Cell Phone-Related Crashes – Vehicle Maneuver

	Most Frequent Vehicle Maneuver		
	Going-Straight	Slowing/ Stopping	Left Turn
Cell Phone Crashes	76.1%	8.8%	5.3%
Non-Cell Phone Crashes	54.5%	20.1%	9.7%

North Carolina data, 1996-2000 (Source: Huang & Stutts, 2003)

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Characteristics of Cell Phone-Related Crashes – Prior Traffic Violations

- **92.5% of cell phone drivers in crashes had prior traffic violations**
- **50.6% of non-cell phone drivers* in crashes had prior traffic violations**

* "non-cell phone drivers" refers to drivers in crashes that did not involve cell phones.

North Carolina data, 1996-2000 (Source: Huang & Stutts, 2003)

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Characteristics of Cell Phone-Related Crashes – Prior Traffic Violations

	Prior Traffic Violations			
	Safe movement & other	Failure to reduce speed	Traffic Signal	Following too close
Cell Phone Crashes	42.1%	23.5%	9.6%	3.5%
Non-Cell Phone Crashes	18.3%	12.5%	1.8%	1.3%

North Carolina data, 1996-2000 (Source: Huang & Stutts, 2003)

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Possible Significance of Prior Violation History

Examination of violation data for cell phone involved crashes suggests that these drivers tend towards more aggressive driving behavior. It is not clear how such behavior relates to the willingness of drivers to use the phone, the conditions under which they use the phone or the degree to which their aggressive behaviors contributed to the cell phone related crashes. It is also unknown how many cell phone related crashes were characterized in terms of an aggressive driving behavior or vice-versa. Nevertheless, use of cell phones by aggressive drivers may heighten the crash risk.

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Characteristics of Cell Phone-Related Crashes – Time of Day

For time of day, there are no differences between cell phone users and non-users

	Time of Day					
	10pm – 1:59am	2am – 5:59am	6am – 9:59am	10am – 1:59pm	2pm – 5:59pm	6pm – 9:59pm
Cell Phone & Non-Phone Users	7.5%	4.3%	16.8%	21.6%	32.0%	17.4%

North Carolina data, 1996-2000 (Source: Huang & Stutts, 2003)

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Characteristics of Cell Phone-Related Crashes – Roadway Classification

The North Carolina crash data revealed that over two-thirds (69.8%) of crashes involving cell phone users occurred on local streets, compared with slightly more than one-third (37.9%) of crashes involving non-users.

North Carolina data, 1996-2000 (Source: Huang & Stutts, 2003)

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Characteristics of Cell Phone-Related Crashes – Roadway Feature

	Roadway Feature		
	No Special Feature	Intersection	Other
Cell Phone Crashes	64.4%	29.3%	6.3%
Non-Cell Phone Crashes	55.7%	28.0%	16.3%

North Carolina data, 1996-2000 (Source: Huang & Stutts, 2003)

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Where Are These Crashes In The Crash Record?

Given the dramatic increase in cell phone use and the preponderance of observed cell phone related traffic events reported, it is often asked why we do not see a dramatic increase in the fatality rate if, in fact, cell phones represent a major crash problem. Noting that the fatality rate has remained relatively stable for a number of years, there are many safety relevant changes that have taken place in the vehicle/highway system during the same period of time. The consequence of these changes may tend to decrease or increase crash rates. Examples expected to improve safety would include improvements to roadways (e.g., rumble strips, traffic calming), air bag improvements (e.g., side airbags), brake improvements (ABS), vehicle stability improvements (ESC), and greater vehicle conspicuity and visibility (reflectors and lighting). On the other hand, increased vehicle speeds, availability of in-vehicle technology and the growing number of SUVs might be expected to decrease safety. Any change in cell phone related crashes might therefore be masked by other contributing factors.

Issues In Establishing Crash Involvement

- There is no post-crash test for distraction.
- Crashes may have multiple contributing factors that make it difficult to isolate the primary cause.
- Cell phone distracted drivers may cause crashes in which they themselves are not involved.
- There is often uncertainty about the role of cell phone use in crashes "caused" by other drivers.
- Data collection difficulties include:
  - Inconsistent and underreporting of contributing factors is problematic.
  - Drivers may be unwilling to admit to being distracted.
  - Phone records are not easily accessible.
  - Not all states require law enforcement officers to collect information specifically related to distraction in general, and cell phone use in particular, at time of crash.

Recent Special Studies: California

- Department of California Highway Patrol (CHP) recently completed a special study of crash data from April 1, 2001, to June 30, 2002. [14]
- Of the 13,637 inattention-related crashes, cell phone use accounted for 11% of inattention-related crashes, more than any other specific inattention factor ("Other" accounted for 66%).
  - The results also indicated that cell phones accounted for 11% of fatalities and total inattention crashes between April 1, 2001, and June 30, 2002.
  - While cell phone use accounted for 11% of total inattention crashes between January 1, 2002, and June 30, 2002, cell phones use while driving contributed to 20% of inattention-related fatalities during that period.
- This data revealed that a cell phone was known to be in use by at least 12,733 parties involved in crashes during the 18-month period.

Recent Special Studies: California

- The CHP concluded that driver distraction is the issue, not the particular device, and it suggested, given the crash data collected, that any action regarding cell phones should also address issues related to other distracting activities (e.g., car radio/CD player).
- Recommendations from the California Highway Patrol [14]
  - Continue collection and reporting of collision data related to driver distraction.
  - Consider whether to require use of the hands-free option when using a cellular telephone while driving.
  - Improve consumer education.
  - Add an "Inattentive Driving" section to the Vehicle Code.
  - Continue training law enforcement agencies statewide on the proper documentation of inattention factors, if the requirement for inattentive driver data collection is extended.

Recent Special Studies: California – Limitations of Study

- The CHP analysis does not include all crashes in which cell phones may have been in use and a contributing factor. The report noted that "officers statewide often failed to document on the [crash] report whether a cellular telephone was in use, present, or unknown." [14]
- It is also important to note the following about the Traffic Collision Coding form:
  - Information on whether driver inattention contributed to the crash is only collected under "Other Associated Factors" for the involved party cited for having caused the crash. Officers check the box "F" indicating "Inattention" and note the cause next to it (e.g., officer must write in "P-Cell Phone").
  - Information on Cell Phone Use by involved parties is specifically requested under the section entitled, "Special Information." Use or non-use is indicated for all parties involved. No distinction is made between condition in which no phone is present and condition in which the officer is unable to determine presence/use of phone.

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Recent Special Studies: Virginia

- A statewide pilot study to test a standard list of distracted driving behaviors used in crash investigations was conducted to provide data for the Virginia State Legislature. The study was conducted for the Virginia Department of Motor Vehicles by Virginia Commonwealth University in 2002 to investigate driver distraction.[16] The study involved completion of a supplemental survey for each distraction crash; the surveys were submitted for review as a part of this study.
- The survey contained questions regarding the MAIN driver distraction and did not address other additional contributing factors.
- The results indicated that 13% of traffic crashes in Virginia are due to driver distraction, and 62% of distractions reported as factors in these crashes were inside the vehicle.
- Cell phones accounted for about 5% of the reported distractions associated with these distraction crashes.

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Recent Special Studies: Virginia

- General recommendations from Virginia's Pilot Study of Distracted Drivers [18]
  - Collect information at the driver level rather than the crash level.
  - Reconsider and standardize the framework and terminology used to categorize distractions and driver inattention
  - Conduct focus groups and training for troopers and officers regarding collection of distraction and inattention-related crash information.

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Recent Special Studies: Virginia – Limitations of Study

- Only police-reportable crashes were included in the survey. 75% of data came from State Troopers, and only 24% of data came from city or county police departments. In addition while the survey was statewide, law enforcement agencies responded with varying levels of success.
- One main distraction was listed as cause of the crash. Phone use was only cited in the survey if identified as main cause of the crash, and information was not generally collected regarding whether phones were otherwise present or in use by involved parties (or if phone was an additional contributing factor).
- 63% of the reported crashes occurred in rural areas. The report notes that implementation problems may have contributed to the low number if urban crashes because the locations of the agencies reporting implementation difficulties were urban.
  - Recall that data from North Carolina show cell phone crashes to be mostly rear-end crashes and that more than two-thirds of cell phone crashes occur on local streets.[27]

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NHTSA Ongoing and Planned Research

NHTSA has carried out research related to drivers' use of technology since 1991. Past efforts have focused on developing methodologies, tools and techniques for assessing driver workload and device demand within the context of safety. More recent efforts have focused on the application of these methods, tools and techniques to specific technologies, including cell phones. These cell phone studies have typically focused on issues associated with device architecture (e.g., hand-held vs. hands free). Three of these programs of research are briefly described in the material that follows.

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Small-Scale Naturalistic Driving Study

NHTSA researchers at the Vehicle Research & Test Center (VRTC) in Ohio completed a small-scale naturalistic driving study comparing three phone architectures. Participants drove instrumented vehicles equipped with hand-held, hands-free and totally hands-free phones over the course of several weeks. Although preliminary analyses have not yielded driver performance differences between the phone architectures, the lessons learned from this effort were invaluable to the development of the larger scale naturalistic driving study currently underway. In addition, NHTSA is conducting a separate analysis on the conversation content to identify any associations between high demand conversations and driving performance.

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Long-Term Naturalistic Driving Study

This effort is currently underway and has deployed 100 instrumented vehicles in the Northern Virginia area to record driver behavior and performance over a period of one year. Data collected will detail driver distractions in general and the use of cell phones in particular. Of particular interest will be the role these distractions play prior to crashes. Because the instrumented vehicles record both performance and video data, the effects of distractions will be quantified in a more ecologically valid context than ever before. This study will also produce much needed objective data for cell phone use patterns that have thus far relied on surveys and observational studies.

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National Motor Vehicle Crash Causation Survey

NHTSA is planning a research effort that will enable us to determine the factors responsible for the most frequent causes of crashes on the Nation's roads. The last update of crash causation data was generated comprehensively in the 1970s. Vehicle design, traffic patterns, numbers and types of vehicles in use, on-board technologies and lifestyles have changed dramatically in the last 30 years. Old assumptions about the causes of crashes may no longer be valid. Updating the crash causation data will allow NHTSA to focus our efforts on the factors that are most frequently associated with crashes, and will provide additional insights into the relationship between distraction and crashes.

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Driver Distraction Research on the National Advanced Driving Simulator (NADS)

Three studies specific to cell phones are planned for NADS. A fourth study will focus on cognitive driver distraction covering cell phones and other in-vehicle technologies. The first study is currently underway.

Study 1 - Examine effects of different interfaces (hands-free, hand-held, & command based) on dialing, talking and answering phone in driving situations that vary in driving task demand.

Study 2 - Examine whether dimensions of conversation affects distraction potential while driving.

Study 3 - Assess drivers' willingness to make/receive calls under a variety of traffic conditions and situations.

Study 4 - Develop assessment techniques for evaluating cognitive driver distraction.

Sources of Information and Data on Cell Phone Use, Consequences of Use, and Association with Crashes

- Anecdotal
- Survey and Focus Group Data
- Experimental Research
- Crash Data
- **Cost-Benefit and Risk Analyses**

Using Crash Data to Assess the Magnitude, Costs, and Benefits of the Problem

While the magnitude, costs, and benefits associated with cell phone use can theoretically be assessed in terms of relevant fatality, injury, property damage only and non-police reported crashes, it is becoming increasingly clear that obtaining a complete and accurate set of data to support this determination is not practical using traditional data sources and techniques. Nevertheless, available crash data is useful in characterizing the nature of the problem and documenting trends that take place over time.

Attempts at estimating problem magnitude, costs and benefits have been made using epidemiological studies and industry data that provide estimates of relative risk and exposure, respectively. In the material that follows, these efforts are reviewed and summarized, associated risk analyses are explored and, using the most recent information, estimates of problem magnitude are calculated.

Cost-Benefit and Risk Analyses

- **Includes:**
  - Efforts to understand the degree of increased risk that results from cell phone use while driving, and
  - Efforts to establish an empirical basis for determining the impact of regulating use of cell phones while driving in terms of costs and benefits.

Risk Comparisons

- **Harvard researchers (2000, 2003) describe two types of risk: [11, 32]**
  - The risk of fatality to the driver who chooses to use the cell phone ("voluntary risk") (primary focus of the present analysis)
  - The risk of fatality to other road users (e.g., occupants of other vehicles, pedestrians, bicyclists) that is associated with cell phone use. This "involuntary risk" accounts for:
    - Number of individuals using a cell phone while driving,
    - Annual probability of being in a collision while driving and using a cell phone, and
    - Average number of fatalities per collision to individuals not riding with cell phone user.
  - *Risk estimates omit risks incurred by passengers traveling with driver who uses cell phone because the nature of the risk to those passengers is unclear (i.e., is risk exposure voluntary or involuntary)*

Magnitude of the Problem As A Basis for Cost-Benefit Analysis

- Studies by the Harvard Center for Risk Analysis and the AEI-Brookings Joint Center for Regulatory Studies have attempted to weigh the many costs and benefits of cell phone use while driving, and to examine the relative risks associated with this behavior.
- Inherent in each of these analyses are fundamental issues involving the assumptions made and methodology used.
- It should be noted that estimates of fatalities based on each of these approaches are at the extremes (given a relative risk factor of 4.3, which will be discussed in more detail later).

• AEI-Brookings 1999:	78 fatalities per year (range 10-1000)*
• Harvard 2000:	900 fatalities per year (calculated)
• Harvard 2003:	2,600 fatalities per year

(*estimates cited from various studies)

- The disparity and changes in fatality estimates reflects the sensitivity of this issue to variances in the underlying assumptions, the data that is referenced, and the analytical techniques that are utilized. Note also that both Harvard estimates include fatalities associated with both voluntary and involuntary risks related to cell phone use while driving.[11, 32] The AEI-Brookings estimates "assume that all accidents and fatalities associated with cellular phone use are caused by cellular phones" (p. 12).[21]

Cost-Benefit Analyses

- **2000 AEI-Brookings [22]**
  - Estimated that costs of a ban are likely to exceed benefits.
  - Claim that estimates of accidents and fatality reductions do not take into account how drivers would alter their behavior in response to regulation, which has implications for net reductions in accidents and fatalities.
  - Technology is moving toward voice activation, which they claim is likely to reduce risks.

Cost-Benefit Analyses

- **2000 Harvard Study [32]**
  - "The weight of the scientific evidence to date suggests that use of a cellular phone while driving does create safety risks for the driver and his/her passengers as well as other road users."
    - However, they note that the magnitude of this risk is unknown
  - Acknowledged that hands-free may not be the best solution because of evidence that conversation per se may be responsible for the risk.
  - Note multiple public health and safety considerations as benefits to using cell phones while driving.

Cost-Benefit Analyses

- **2002 AEI-Brookings** [23]
  - Disconnect between Policy and Data (synthesis report)
    - "The economics and science on this issue are fairly clear: a total ban does not seem to be justified on economic grounds and the effectiveness of hands-free devices in reducing phone-related crashes is unclear."
    - However, states and local jurisdictions continue to enact laws prohibiting hand-held phone use while driving.
  - Unintended consequences of a ban should be considered (e.g., drivers may use paper maps while driving if a call for directions was to be banned).
  - Any legislation should extend beyond cell phones as they are just one example of advanced technologies available to the driver.

Cost-Benefit Analyses

- **2002 Harvard Study** [11]
  - Revised estimate of previous Harvard study (2000) [32]
    - Updated estimated number of cell phones users.
    - Revised the assumed amount of time spent on the phone while driving based on 2000 NOPUS results.
    - Increased assumed consumer surplus value of the calls made while driving from $25 billion to $43 billion annually.
  - Best estimate of zero for the net benefit of cell phone use while driving.

Analysis of the Crash Risks and Societal Costs

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People Saving People

The following slides contain information related to studies attempting to establish the relationship between cell phone use while driving and the associated increase in crash risk.

The analysis is based on existing studies and the assumptions made therein.

The goal of this effort is to illustrate the range of crash risks that have been associated with this issue and the potential implications of those risks. It must be recognized, however, that the results of this analysis do not provide definitive answers and are based on a very incomplete and sometimes undefined dataset.

Defining Exposure Time (ΔT)

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Exposure Time (ΔT)

Percentage of driving time spent using a cell phone (time on phone while driving divided by driving time), or approximate percentage of driving population on cell phone at any given daylight moment. The higher the exposure time, the greater the overall risk.

Note that neither definition accounts for the frequency or duration of calls during a single trip or over a daily number of trips. There is evidence suggesting that both frequency and duration of calls influence crash risk. These factors may also interact with other factors, such as traffic density, to influence actual risk.

Other Relevant Risk Definitions

Relative Risk (RR)

- Defined as the amount of increase in crash risk (i.e., an *incremental* crash risk) for cell phone users in comparison to non-cell phone users, specifically the ratio of the risk of a crash for cell phone users compared to the risk of a crash for non-cell phone users.
  - If RR > 1, then the risk of a crash for cell phone users is greater than risk of a crash for non-cell phone users.
  - If RR = 1, then the risk of a crash is the same for cell phone users and non-users.
  - If RR < 1, then the risk of a crash is less for cell phone users than for non-users.

Odds Ratio (OR)

- Defined as the amount of increase in crash risk for cell phone users in comparison to non-cell phone users, specifically the ratio of the odds of a crash for cell phone users compared with the odds of a crash for non-cell phone users.
  - If OR > 1, then the odds of a crash for cell phone users is greater than the odds of a crash for non-cell phone users.
  - If OR = 1, then the odds of a crash is the same for cell phone users and non-users.
  - If OR < 1, then the odds of a crash is less for cell phone users than for non-users.

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Defining a Model of Total Risk

$$\text{Total Risk} = (1 - \Delta T) * R_0 + \Delta T * RR$$

Where R_0 = general crash risk (R_0=1), ΔT = Exposure Time, and RR = relative risk.

Total Risk is a measure of the risk for all crashes, and includes users and non-users of cell phones. Total Risk is defined here as a function of the amount of exposure time (phone time/drive time) and of the relative risk of a crash event.

The increase over a risk value of 1 represents how much the total risk increases when the driver uses a cell phone while driving. For example, a calculated total risk of 1.05 represents a 5% risk increase over normal conditions. Thus Total Risk is the risk of a crash for drivers not using cell phones plus the additional risk of a crash for drivers using cell phones.

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Example Using the Model of Total Risk

- Given the following model:

  Total Risk = (1 - ΔT) * R_0 + ΔT * RR

- Example:
  - Assume that, on average, drivers are using phone 6% of driving time (i.e., ΔT=.06)
  - Suppose that the relative risk of a crash while driving and using a cell phone is 1.2 (i.e., RR=1.2, where the incremental risk is thus 20%)
  - Total Risk = (1-.06)*1 + (.06*1.2)

    0.94 + 0.072 = 1.012
  - Thus the Total Risk is increased by approximately 1.2%

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Plotting General Estimates of Total Risk

The following slides provide an explanation and a graphical representation of general estimates of total risk for all drivers based on exposure time and relative risk values. The exposure time is determined from estimated "one-way" driving trips for all drivers[44], one-way trips in which the driver used a cell phone[44], time-on-phone per call while driving[43,44], and average trip time[74]. The total risk is calculated using the model described in the previous slides.

It is important to note that these figures do not account for call frequency, which has been found to influence the magnitude of the increase in crash risk.

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Assumptions Used to Estimate Total Risk:
Estimating Exposure Time - Background

Estimates of Exposure Time (ΔT) are based on:

Estimated total number of one-way driving trips in a typical week for all drivers in 2002[44]: 4,200,000,000 trips/week

Average vehicle trip duration according to 2001 National Household Travel Survey [74]: ~20 min/trip

Minimum estimated number of calls made or received while driving based on estimated number of one-way trips involving such calls (translate trips involving phone use to number of calls while driving)

- Estimated number of one-way driving trips in a typical week in 2002 in which a driver receives at least one wireless phone call (this is included within the total 4,200,000,000 trips per week)[44]: 792,000,000 trips/week
- Estimate number of one-way driving trips in a typical week in 2002 in which a driver makes at least one wireless phone call (this is included within the total 4,200,000,000 trips per week)[44]: 776,000,000 trips/week
- If we assume 1 call per trip of the specified call type (incoming or outgoing; there is overlap in number of trips for each type of call so we translate into number of calls rather than trips), then combined number of trips equals minimum number of calls. So, Minimum Estimated Number of Calls Made or Received While Driving = 792,000,000 + 776,000,000 = 1,568,000,000 calls/week

Estimates of exposure will be show for the following range of call lengths:

- 1 min/call (minimum included for comparison)
- 2.73 min/call (average CTIA local call length, 2002)[illegible]
- 4.5 min/call (average self-reported call length while driving, 2002 National Survey of Distracted and Drowsy Driving Attitudes and Behaviors)[44]
- 8 min/call (hypothetical call length included for comparison and indicative of increasing exposure given dramatic growth in cell phone use as noted earlier)

Estimates of Total Risk (and the corresponding risk increases) will be shown for relative crash risks (RR) from 1.0 to 4.5

Assumptions Used to Estimate Total Risk:
Estimating Exposure Time – Example

Example – Estimating Total Exposure Time in 2002:

Given the average call length while driving is 4.5 minutes per call for drivers who use cell phones [44] (average time per call for drivers who use cell phones, not average call time across all drivers)

From previous slide:

Estimated total number of one-way driving trips in a typical week for all drivers: 4,200,000,000 driving trips in a typical week

Average vehicle trip duration, all drivers: 20 min/trip

Minimum Estimated number of calls made or received while driving based on estimated number of one-way trips involving such calls: 1,568,000,000 calls made or received while driving in a typical week

Estimated total driving time for all drivers in a typical week (convert trips to time in minutes)

= Number of driving trips in a typical week * average number of minutes per driving trip

= 4,200,000,000 trips*20 min/trip = 84,000,000,000 min total driving time in a typical week

Estimated time using phone while driving in a typical week (convert phone calls while driving to time in minutes)

= Number of calls made or received while driving in a typical week * average call length while driving

= 1,568,000,000 calls*4.5 min/call = 7,056,000,000 min total phone use while driving in a typical week

Total Exposure Time (ΔT)

= Estimated time using phone while driving in a typical week in 2002 (based on drivers who use phones while driving) divided by Estimated total driving time in a typical week in 2002 (based on all drivers)

= 7,056,000,000 min total phone use while driving / 84,000,000,000 min total driving time

= 8.4% Estimated Total Exposure Time when average call length is 4.5 minutes per call

Estimates of Risk as a Function of Exposure Time and Relative Risk of Crash

Average Call Length (min)	Exposure Time, ΔT	RR=1.5	RR=2.0	RR=3.0	RR=4.3
		Percentage Increase in Total Risk of Crash			
1.0 min	1.9%	1.0%	1.9%	3.8%	6.3%
2.74 min	5.1%	2.6%	5.1%	10.2%	16.8%
4.5 min	8.4%	4.2%	8.4%	16.8%	27.7%
8.0 min	14.9%	7.5%	14.9%	29.8%	49.2%

Example - 2002 (cont'd):
If the exposure time (ΔT) is 8.4% given an average call time while driving of 4.5 min and given the estimated trip and call information as detailed on the previous slides, then the resulting Total Risk (TR) of a crash for all drivers is increased by 1.7% if RR=1.2 (TR=1.017), by 3.2% if RR=1.38 (TR=1.032), by 4.2% if RR=1.5 (TR=1.042), and so on. As indicated by the data shown in the table above, the Total Risk of a crash increases with both exposure time and the relative risk of a crash.

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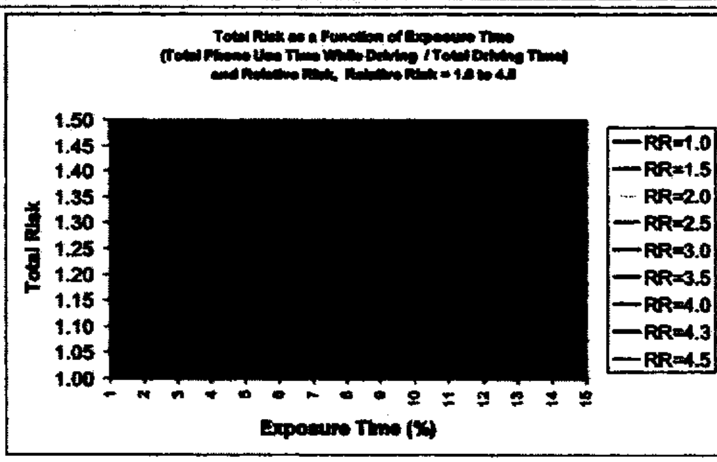
General Estimates of Total Risk



Total Risk of a crash increases with both exposure time and the relative risk of a crash.

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Attempts to Assess the Relative Risk and Societal Costs of Cell Phone Use While Driving

Several recent studies, including those already mentioned, have examined the relative risks associated with cell phone use while driving. Some studies have focused on determining societal costs assuming a given relative risk. The results of these studies have been employed in the analyses that follow to explore potential societal costs associated with cell phone use while driving. Some of the underlying assumptions made by the researchers, as well as some additional assumptions for the purpose of this analysis, are presented on the following slide.

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Summary of the Bases for Determination of Relative Crash Risks in Relevant Studies

- **AEI-Brookings 1999**
  - Given a sample population of cell phone users who were involved in traffic collisions, risk of a collision when using a cellular phone was four times higher for the user than risk when the same user was not using a cell phone (RR=4.3, i.e., incremental risk is 330%). Does not account for risk of injury or fatal crashes.
- **Harvard 2000**
  - Same as above (RR=4.3)
- **Harvard 2003**
  - Same as above (RR=4.3)
- **Violanti and Marshall 1996**
  - Talking more than 50 minutes per month on cellular phones in a vehicle was associated with 5.59-fold increased risk of a traffic crash. Study compared random sample of drivers involved in recent crashes versus random sample of drivers not involved in crashes; included some crashes not reported to authorities.
- **Laberge-Nadeau et al, 2001**
  - Relative risk of all crashes and of crashes with injuries is 1.38 (i.e., incremental risk is 38%) for users of cell phones when compared to non-users.
- **Sagberg 2001**
  - Relative risk of a driver being involved as a responsible party in a crash while using a mobile phone is two times greater than when driving without using the phone.
- **ICBC 2002**
  - Relative risk of crash involvement is 1.16 for drivers observed using handheld phones compared to drivers observed not using handheld phone.

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Assumptions Based on Relevant Studies of Crash Risks
Cell Phone Use While Driving

- **AEI-Brookings 1999**
  - 5.4×10^{12} min annual driving time, all drivers; 5.9×10^{10} min annual time on phone while driving; 0.7% of driving time on phone; 1200 min talk in car / yr per user; 60 million driver/users
  - RR=4.3
- **Harvard 2000**
  - 4×10^{12} min annual driving time, all drivers; 1.9×10^{10} min annual time on phone while driving
  - 318 minutes of talk in car / yr per user (or ~26 min talk in car / month per user); 60 million driver/users*
  - RR=4.3
- **Harvard 2003**
  - 4×10^{12} min annual driving time, all drivers; 3.6×10^{10} – 1.5×10^{11} min annual time on phone while driving (use central estimate of 7.7×10^{11} min)
  - 300 to 1200 min talk in car / yr per user (use central estimate of 600 min); 128 million driver/users
  - RR=4.3
- **Violanti and Marshall 1996**

  (Note: Estimated values derived for 1992-1993 timeframe used in study)
  - 3.2×10^{12} min annual driving time, all drivers*; 4.6×10^{9} min annual time on phone while driving*; 50 min talk in car per month per user*
  - 8 million driver/users*
  - Odds Ratio = 5.59

  (Note: Authors associated 50 minutes of talk in car per month with odds ratio of 5.59)
- **Laberge-Nadeau et al, 2001**
  - RR = 1.38 overall
- **Sagberg 2001**
  - RR=2.2, risk of a driver being involved as a responsible party in an accident while using a mobile phone as compared to driving without using the phone.
- **ICBC 2002**
  - RR = 1.16

* Assumption made for present comparison

Estimating the Risks Using the Preceding Studies:
What Data is Presented

- The following table and graph present a summary of estimated total risk as a function of *exposure time* and *relative risk.*
- The table and graph contain data points for studies from the United States, Canada and Norway, as well as for exposure rates obtained from NHTSA's 2000 and 2002 NOPUS efforts.
- NOPUS estimates yield higher exposure times than other studies.
- Most of the studies are based on a relative risk factor of 4.3, as calculated by Redelmeier & Tibshirani (1997). This is risk of crash when using phone compared to when not using phone, for same set of drivers. Note again that the most recently reported analysis by the University of Montreal (2003),[62] which examined the methodology employed by Redelmeier & Tibshirani, suggests that the reported relative risk of 4.3 is 2 to 3 times larger than the actual relative risk value.
- Thus, it is likely that the actual relative risk values are lower than those predicted by these studies.

Graph Summary: Increase in Crash Risk Based on Some Recent Studies

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	Increase in Total Crash Risk	Exposure Time, ΔT	RR	Estimated Fatalities/yr as Reported by Author
Violanti & Marshall 1996	0.9%	0.2%*	5.6[2]	No Estimate Given
AEI-Brookings 1999	2.3%	0.7%	4.3	78 (range 10-1000)
Harvard 2000	1.7%	0.5%*	4.3	1200
Laberge-Nadeau, et al 2001	(Range 0.4-3.8%)[3]	(Range 1-10%)[3]	1.38	No Estimate Given
Sagberg 2001	(Range 1.2-12%)[3]	(Range 1-10%)[3]	2.2	No Estimate Given
Harvard 2003	6.3%*[1] (Range 2.3-12.7%)	1.9%*[1] (Range 0.70-3.04%)	4.3	2600
ICBC 2002	(Range 0.2-1.8%)[3]	(Range 1-10%)[3]	1.16	No Estimate Given

*Derived for the present analysis using assumptions as shown earlier.
[1]Based on central estimate of time on phone while driving.
[2]Odds Ratio used here as approximation of relative risk.
[3]Derived from plot.

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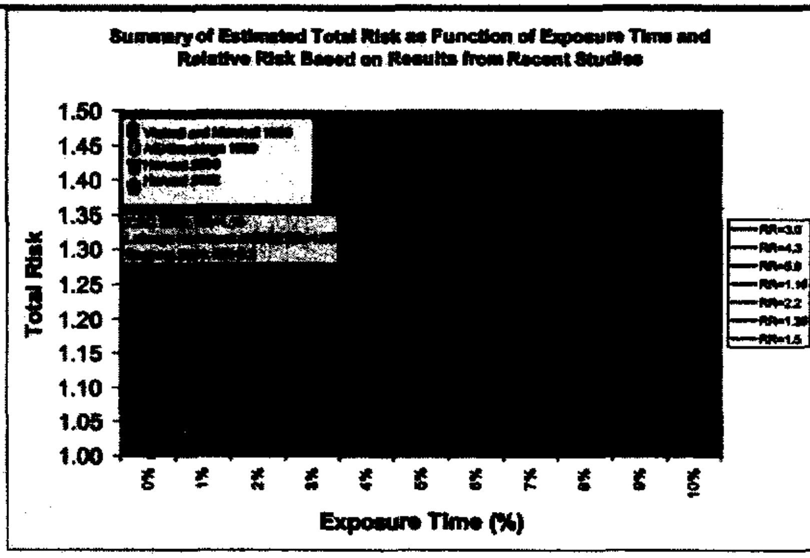

The concern is that as exposure time (ΔT), device functionality and complexity increase, the slope of the line corresponding to the actual relative risk (and corresponding incremental risk) will increase accordingly, leading to greater total risk.

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Summary of Findings:
Increased Crash Risk Based on Recent Studies

The range of results illustrated in the preceding graph and table reflects their reliance on a limited set of assumptions and associated "soft" values. It would appear that the capability for characterizing and determining, with confidence, the magnitude of any increase in either total crash risk or relative ~~risk associated with using a cell phone while driving continues~~ to be elusive.

Furthermore, estimates of the crashes, injuries and fatalities associated with cell phone use while driving appear to be even more difficult to determine.

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Best Estimate of Crashes as a Function of Relative Risk

In an effort to use available information to estimate crashes across a range of relative risks, an analysis was carried out using the recent NOPUS [17] results as a basis for establishing exposure.

The approach outlined represents one method for approximating the number of property damage only (PDO), injury, and fatal crashes associated with cell phone use given a base set of relative risks as well as those associated with known studies.

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Framework for Calculating An Estimate of Expected Crashes in 2002 In Which Cell Phone Use Was Contributing Factor

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Assumptions:

1. From NOPUS 2002, 6% of drivers are using a cell phone at any daytime moment (this is exposure time, ΔT=.06).
2. This leaves 94% (or 1- ΔT = .94) of drivers not using a cell phone at any given daytime moment.
3. NHTSA estimates 6,279,356 police reported crashes in 2002.
4. If the risk of a crash is equal for cell phone users and non users, Total Risk = 1.0

Example:

For condition in which Relative Risk (RR) = 1.2 (i.e., incremental risk = 20%)
Total Risk (TR) = 0.94 + 0.06*RR = 0.94 + 0.06*1.2 => TR = 1.012

Estimated Police Reported Crashes in 2002 if no one was on cell phone:
Crashes = Total Crashes * R_0 / TR,
so 6,279,356*1.000/1.012 = 6,204,897 crashes in 2002 (no cell phone involved)

Estimated Number of Police Reported Cell Phone Crashes if Relative Risk = 1.2:
6,279,356 total crashes – 6,204,897 crashes if no driver was using a cell phone = 74,459 police-reported crashes where cell phone use was contributing factor

The table and graph that follows provide estimates of crashes across a range of relative risks.

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2002 Estimates of Police-Reported Crashes Cell Phone Use Was Contributing Factor: 6% Exposure Time (ΔT=.06)

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Relative Risk (RR)	Total Risk (TR), TR = 0.94+ RR*0.06	Estimate of Police-Reported 2002 Crashes in which Cell Phone Use <u>Was Not</u> a Contributing Factor to the Crash	Estimates of Police-Reported Crashes in 2002 in which Cell Phone Use <u>Was</u> a Contributing Factor to the Crash
1.00	1.000	6,279,356	0
1.20	1.012	6,204,897	74,459
1.38*	1.023	6,139,378	139,978
1.50	1.030	6,096,462	182,894
2.20**	1.072	5,857,608	421,748
4.30***	1.198	5,241,533	1,037,823

*Laberge-Nadeau et al 2001; [30] **Sagberg, 2002; [45]
***Harvard, 2000, [32] 2003; [11] AEI-Brookings, 1999 [21]

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NHTSA Data Underlying Estimates of Crashes Where Cell Phone Use Was Contributing Factor

NHTSA People Saving People http://www.nhtsa.dot.gov

Description	2000	2001*	2002
Persons Killed	41,821	42,116	42,850
Persons Injured	3,189,000	3,033,000	2,914,000
Total Crashes (Fatal + Nonfatal)	6,396,400	6,322,795	6,279,358
Fatal Crashes	37,409	37,795	38,358
Nonfatal Crashes	6,358,000	6,285,000	6,241,000
Injury Crashes	2,070,000	2,003,000	1,934,000
PDO Crashes	4,286,000	4,282,000	4,307,000
Portion of Total Crashes that are Fatal	0.6%	0.6%	0.6%
Ratio of Nonfatal Crashes to Fatal Crashes	170	166	163
Ratio of Injury Crashes to Fatal Crashes	55	53	50
Ratio of PDO Crashes to Fatal Crashes	115	113	112
Ratio of Persons Killed to Fatal Crashes	1.12	1.11	1.12

*Shown for comparison purpose only.

Note: Unreported PDO crashes account for an estimated 48% of all PDO crashes.
Unreported injury crashes account for an estimated 21.42% of all injury crashes. *

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Calculating Estimates of Crashes in 2002 Where Cell Phone Use Was Contributing Factors

NHTSA People Saving People http://www.nhtsa.dot.gov

Example:

For condition with 6% exposure time (ΔT=.06), RR = 1.2 and resulting Total Risk = 1.012

Estimated Total Police-reported crashes in 2002 where no one on cell phone = 6,204,897

Estimated Total Police-reported crashes where cell phone use was contributing factor
= 6,279,358 – 6,204,897 = 74,460 total police-reported crashes

Estimated Number of Fatal Crashes where cell phone use contributed (About 0.6% of Total Police-Reported Crashes)
- Fatal Crashes = Total police-reported crashes * 0.006 = 455 fatal crashes

Estimated Number of Injury Crashes where cell phone use contributed (Assume ~ 50 injury crashes : 1 Fatal crash)
- Police Reported Injury Crashes = Fatal Crashes * 50 = 22,933 (This is the 78.58% of injury crashes that are police-reported)
- Non-reported Injury Crashes = 22,933*0.2142/0.7858 = 6,251 (This is the 21.42% of injury crashes that are not reported to/by police)
- Total Injury Crashes = 22,933 + 6,251 = 29,184 injury crashes

Estimated Number of PDO crashes where cell phone use contributed (Assume ~ 112 PDO : 1 Fatal crash)
- Police-Reported PDO Crashes = Fatal Crashes * 112 = 51,071 (This is the 52% of PDO crashes that are police-reported)
- Non-reported PDO crashes = 51,071*0.48/0.52 = 47,143 (This is the 48% of the PDO Crashes that are not reported to/by police)
- Total PDO Crashes = 51,071 + 47,143 = 98,214 PDO crashes

Total Number of Crashes = Fatal crashes + Total injury crashes + Total PDO crashes
= 455 + 29,184 + 98,214
= 127,853 total crashes where cell phone use was contributing factor

Note that calculations assume distribution of crash severity (fatal, injury, PDO) is same for total police reported crashes and for crashes in which cell phone use was a contributing factor to the crash. Equivalence in relative risk is assumed across all levels of crash severity (fatal, injury, PDO), and for daytime and nighttime.

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NHTSA 2000 Crash Estimates Given 4% Exposure Time (ΔT=.04)

Year 2000	RR=1.0	RR=1.2	RR=1.38	RR=1.5
Total Risk	1.0000	1.0078	1.0148	1.0195
Estimated Total Police Reported Crashes in which Cell Phone Use Was Not a Contributing Factor to the Crash	6,393,409	6,343,926	6,300,042	6,271,122
Estimated Police Reported Crashes in which Cell Phone Use Was a Contributing Factor to the Crash	0	49,483	93,367	122,287
Estimated Total Crashes (*CP) (Reported plus Non-reported)	0	84,470	159,383	208,752
Estimated PDO Crashes (*CP) (Reported plus Non-reported)	0	63,792	120,367	157,651
Estimated Injury Crashes (*CP) (Reported plus Non-reported)	0	20,388	38,470	50,386
Estimated Fatal Crashes (*CP)	0	290	546	716
Estimated Fatalities (*CP)	0	324	611	800

*CP = Cell Phone Was a Contributing Factor to the Crash

Note that calculations assume distribution of crash severity (fatal, injury, PDO) is same for total police reported crashes and for crashes in which cell phone use was a contributing factor to the crash; and equivalence in relative risk is assumed across for daytime and nighttime.

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NHTSA 2002 Crash Estimates Given 6% Exposure Time (ΔT=.06)
~50% increase from Year 2000 estimates

Year 2002	RR=1.0	RR=1.2	RR=1.38	RR=1.5
Total Risk	1.0000	1.0120	1.0228	1.0300
Estimated Total Police Reported Crashes in which Cell Phone Use Was Not a Contributing Factor to the Crash	6,279,358	6,204,897	6,139,378	6,096,462
Estimated Police Reported Crashes in which Cell Phone Use Was a Contributing Factor to the Crash	0	74,459	139,978	182,894
Estimated Total Crashes (*CP) (Reported plus Non-reported)	0	127,853	240,355	314,046
Estimated PDO Crashes (*CP) (Reported plus Non-reported)	0	98,214	184,636	241,243
Estimated Injury Crashes (*CP) (Reported plus Non-reported)	0	29,184	54,864	71,685
Estimated Fatal Crashes (*CP)	0	455	855	1,117
Estimated Fatalities (*CP)	0	508	955	1,248

*CP = Cell Phone Was a Contributing Factor to the Crash

Note that calculations assume distribution of crash severity (fatal, injury, PDO) is same for total police reported crashes and for crashes in which cell phone use was a contributing factor to the crash; and equivalence in relative risk is assumed across for daytime and nighttime.

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Apportioning the National Fatality Estimate by State: Introduction

Given the wide diversity in the distribution and use of cell phones nationally, and the differences in population statistics, roadway systems and a number of other state specific factors, it is reasonable to expect a wide range of differences in fatalities associated with cell phone crashes in each state. Using available information along with the preceding analyses, the material that follows uses three approaches for estimating the distribution of state fatalities for crashes in which cell phones were a contributing factor. Since relevant state data is not complete for the year 2002, estimates for this year are based on an assumed 50 percent increase in total fatalities (as reflected in the previous analysis) over the 2000 estimate in conjunction with the more complete set of 2000 state data. Each set of calculations is preceded by a detailed example presenting the methodology. Multiple approaches were used to establish a sense of confidence that the estimated distributions appropriately reflect state cell phone related fatal crashes as represented by the ranges across the different approaches for each state.

Methodology for Calculating State Estimates of Expected Fatalities in Which Cell Phone Use Was Contributing Factor (1)

Methodology #1

This method employs the same framework for Total Risk and Estimated Crashes described previously to calculate national estimates of traffic fatalities in which cell phone use was a contributing factor (recall that this framework accounts for the influence the relative risk of a crash when using a cellular phone on the total risk of a crash). In estimating state fatalities this framework was applied to the overall traffic fatality estimate reported for each State in NHTSA's *Traffic Safety Facts 2000*. Estimated fatalities were then calculated for 2002.

This methodology, on which the earlier national crash estimates are based, takes the following information into account in estimating fatalities for each state in which cell phone use was a contributing factor:

- Number of estimated traffic fatalities within each state in 2000 (based on NHTSA Traffic Safety Facts 2000).
- A range of relative risks factors and the associated total risk values.

A sample calculation is provided.

Methodology for Calculating State Estimates of Expected Fatalities In Which Cell Phone Use Was Contributing Factor (1)

NHTSA People Saving People

Assumptions and NHTSA data:

1. From NOPUS 2000, 4% of drivers are using a cell phone at any daytime moment ($\Delta T = .04$). Assume this is true for all States.
2. This leaves 96% (or $1 - \Delta T = .96$) of drivers not using a cell phone at any given daytime moment.
3. If the risk of a crash is equal for cell phone users and non users, Total Risk = 1.0
4. The calculation of 2002 fatality estimates that follows is based on a 50% increase assumed from the earlier calculation of national fatalities.

Example - California:

NHTSA estimates 3,753 traffic fatalities in California in 2000.
For condition in which Relative Risk (RR) = 1.2 (i.e., incremental risk = 20%)
Total Risk (TR) = 0.96 + 0.04*RR = 0.96 + 0.04*1.2 => TR = 1.008

Estimated California Traffic Fatalities in 2000 if no one was on cell phone:
Fatalities = Total Fatalities * R_o / TR,
so 3,753*1.000/1.008 = 3,723 CA fatalities in 2000 (no cell phone involved)

Estimated Number of California Fatalities in 2000 if Relative Risk = 1.2:
3,753 total fatalities – 3,723 fatalities if no driver was using a cell phone
= 30 fatalities in California where cell phone use was contributing factor in 2000

Estimated Number of California Fatalities in 2002 if Relative Risk = 1.2:
2002 fatalities = 2000 Fatalities * 150%
so 30*150% = 45 fatalities in California when cell phone was contributing factor in 2002

The table that follows provides estimates of fatalities for each State across a range of relative risks using the methodology outlined above.

NHTSA 2000 & 2002 State Estimates of MV Fatalities (1a)
Cell Phone Use was Contributing Factor

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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
United States	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Alabama	8	16	20	12	22	29
Alaska	1	2	2	1	2	3
Arizona	8	16	26	12	23	38
Arkansas	5	10	13	8	15	19
California	30	56	74	45	84	110
Colorado	6	10	13	9	15	20
Connecticut	3	5	7	4	8	10
Delaware	1	2	2	1	3	4
District of Columbia	0	1	1	1	1	1
Florida	24	46	59	36	69	88
Georgia	12	23	30	18	35	45
Hawaii	1	2	3	2	3	4
Idaho	2	4	5	3	6	8
Illinois	11	21	28	17	32	42
Indiana	7	13	17	10	20	26
Iowa	4	7	9	5	10	13
Kansas	4	7	9	5	10	14
Kentucky	7	12	16	10	18	24
Louisiana	7	14	18	11	21	28
Maine	1	3	3	2	4	5
Maryland	5	9	12	7	13	17
Massachusetts	3	6	8	5	10	13
Michigan	11	21	27	16	31	41
Minnesota	5	9	12	7	14	18
Mississippi	8	14	19	11	21	28

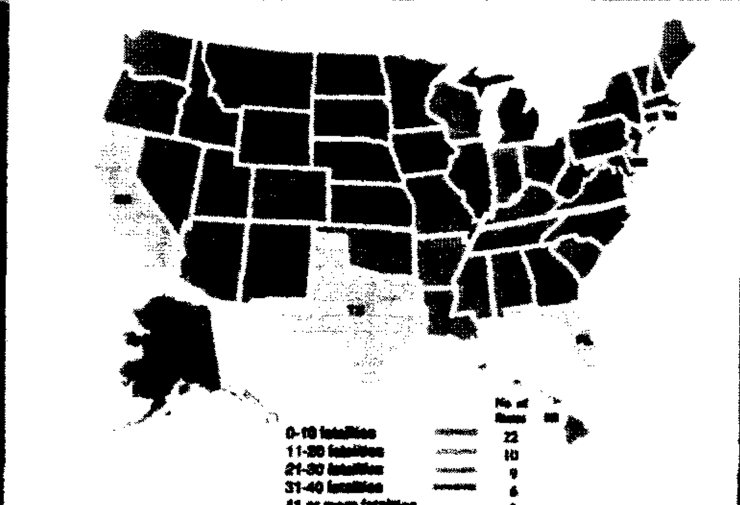
Note: The calculation of 2002 fatality estimates is based on a 50% increase assumed from the earlier calculation of national fatalities.

NHTSA 2000 & 2002 State Estimates of MV Fatalities [illegible]

[illegible]

State						
[illegible]	9	17	[illegible]	14	[illegible]	[illegible]
[illegible]	[illegible]	4	[illegible]	[illegible]	[illegible]	7
[illegible]	2	4	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	4	7	[illegible]
[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	4
[illegible]	[illegible]	11	14	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	17	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1	1	[illegible]	1	[illegible]	[illegible]
Ohio	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	4	7	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1	1	[illegible]	1	[illegible]	2
[illegible]	[illegible]	[illegible]	21	13	[illegible]	21
[illegible]	1	[illegible]	[illegible]	2	4	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	111
Utah	[illegible]	[illegible]	7	4	[illegible]	11
[illegible]	1	1	[illegible]	1	2	2
[illegible]	7	14	[illegible]	11	[illegible]	27
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1	2	[illegible]	2	[illegible]	4

Distribution of Estimated Fatalities in which Cell Phone Use was Contributing Factor



Methodology for Calculating State Estimates of Expected Fatalities In Which Cell Phone Use Was Contributing Factor (2)

Methodology #2

This method apportions the national fatality estimate among the States based on the number of licensed drivers, within each state, who reported using the phone while driving, at least some times, based on year 2000 survey data [8], and the vehicle miles traveled by those drivers as reported for each state in NHTSA's *Traffic Safety Facts 2000* [67]. These state data were compared against the respective national totals to determine how the national estimate of fatalities in which cell phone use was a contributing factor was to be apportioned between the States in 2000. Estimated fatalities were then calculated for 2002.

This methodology takes the following information into account in estimating fatalities for each state in which cell phone use was a contributing factor:

- **Number of licensed drivers who report talking on car or cellular phone on at least some trips, nationally and within each state (based on 2000 MVOSS [9]).**
- **Vehicle miles traveled by those drivers, nationally and within each state (based on NHTSA Traffic Safety Facts 2000 [67]).**
- **Estimated fatalities in which cell phone use is a contributing factor, national estimate to be apportioned between the states. These national estimates, for the range of relative risks, were calculated in the earlier analysis.**

A sample calculation is provided.

Methodology for Calculating State Estimates of Expected Fatalities In Which Cell Phone Use Was Contributing Factor (2)

Assumptions and NHTSA data:

1. From NOPUS 2000, 4% of drivers are using a cell phone at any daytime moment (ΔT=.04). Assume this is true for all States.
2. This leaves 96% (or 1- ΔT = .96) of drivers not using a cell phone at any given daytime moment.
3. If the risk of a crash is equal for cell phone users and non users, Total Risk = 1.0
4. The calculation of 2002 fatality estimates that follows is based on a 50% increase assumed from the earlier calculation of national fatalities.

Example – California (CA) [Data sources: NHTSA *Traffic Safety Facts 2000*, 2000 MVOSS]:

1. Calculate Number of Licensed CA Drivers in 2000 who report Having a Car or Cellular Phone in Vehicle, based on MVOSS 2000 data: 54% of persons age 16 or over

   Licensed CA Drivers w/ Phone in vehicle = 54%*Total Licensed CA drivers
   = 54%*21,244,000
   = 11,471,760 Licensed CA Drivers w/ Phone in Vehicle in 2000

   Similarly, 102,937,500 Licensed US Drivers w/ Phone in Vehicle in 2000

2. Calculate Number of Licensed CA Drivers in 2000 who report they talk on phone on at least some trips ("CP drivers"), based on MVOSS 2000 data: 74% of those who report having car or cellular phone in vehicle

   Licensed CA Drivers who talk on Phone on at least some trips = 74%*(54%*Total Licensed CA Drivers)
   = 74%*11,471,760
   = 8,489,102 Licensed CA Drivers who talk on phone on at least some trips ("CP drivers")

   Similarly, 76,173,750 Licensed US Drivers who talk on phone on at least some trips in 2000

Methodology for Calculating State Estimates of Expected Fatalities In Which Cell Phone Use Was Contributing Factor (2)

Example – California (cont'd):

3. Calculate vehicle miles traveled (VMT) per licensed driver in 2000

   VMT per CA driver = Total VMT(CA) / Total Licensed Drivers (CA)
   = 306,649,000,000 miles / 22,244,000 licensed drivers
   = 14,435 VMT per licensed driver in CA in 2000

   Similarly, 14,425 VMT per Licensed US Driver in 2000

4. Calculate VMT per licensed driver in the state who reports talking on phone on at least some trip in 2000

   VMT per CP drivers = VMT per driver * CP Drivers
   = 14,435 mi per driver * 8,489,102 CP drivers
   = 122,536,940,400 VMT for all CP drivers in CA in 2000

   Similarly, 1,098,821,278,800 VMT for all CP drivers in US

5. Calculate portion of Total VMT for All CP drivers in US that is VMT for all CP drivers in CA in 2000

   CA% = VMT for all CP drivers in CA in 2000 / VMT for all Licensed US drivers in 2000
   = 122,536,940,400 VMT / 1,098,821,278,800 VMT
   = 11.2% of all VMT for CP drivers in US was for CA CP drivers in 2000
   This is the apportionment factor that is multiplied by the national estimate to obtain the state estimate.

Methodology for Calculating State Estimates of Expected Fatalities In Which Cell Phone Use Was Contributing Factor (2)

Example – California (cont'd):

6. Calculate portion of Total Estimated Fatalities in which cell phone use was a contributing factor in CA in 2000, Relative Risk = 1.2

   Fatalities in CA in which cell phone use was contributing factor
   = Apportionment Factor * National Fatality Estimate when RR=1.2
   = 11.2%*324
   = 36 fatalities in which cell phone use was contributing factor in CA in 2000

7. Calculate Total Estimated Fatalities in which cell phone use was a contributing factor in CA in 2002, Relative Risk = 1.2. Assumption: The calculation of 2002 fatality estimates that follows is based on a 50% increase assumed from the earlier calculation of national fatalities.

   Estimated Number of California Fatalities in 2002 if Relative Risk = 1.2:
   2002 fatalities = 2000 Fatalities * 150%
   so 36*150% = 54 fatalities in California when cell phone was contributing factor in 2002 when the relative risk of a crash is 1.2

The table that follows provides estimates of fatalities for each State across a range of relative risks using the methodology outlined above.

NHTSA 2000 & 2002 State Estimates of MV Fatalities (2a)

Cell Phone Use was Contributing Factor

United States	100.0%	324	611	809	459	917	1200
Alabama	2.1%	7	13	16	10	19	25
Alaska	0.2%	1	1	1	1	2	2
Arizona	1.8%	6	11	14	9	17	22
Arkansas	1.1%	3	6	8	5	10	13
California	11.2%	36	68	89	54	102	134
Colorado	1.5%	5	9	12	7	14	18
Connecticut	1.1%	4	7	9	5	10	13
Delaware	0.3%	1	2	2	1	3	4
District of Columbia	0.1%	0	1	1	1	1	2
Florida	5.5%	18	34	44	27	51	66
Georgia	3.8%	12	23	31	18	35	46
Hawaii	0.3%	1	2	3	2	3	4
Idaho	0.5%	2	3	4	2	5	6
Illinois	3.7%	12	23	30	18	34	45
Indiana	2.6%	8	16	21	13	24	31
Iowa	1.1%	3	7	9	5	10	13
Kansas	1.0%	3	6	8	5	9	12
Kentucky	1.7%	6	10	14	8	16	20
Louisiana	1.5%	5	9	12	7	14	18
Maine	0.5%	2	3	4	3	5	6
Maryland	1.8%	6	11	15	9	17	22
Massachusetts	1.9%	6	12	16	9	18	23
Michigan	3.6%	12	22	28	17	33	43
Minnesota	1.9%	6	12	15	9	18	23
Mississippi	1.3%	4	8	10	6	12	16

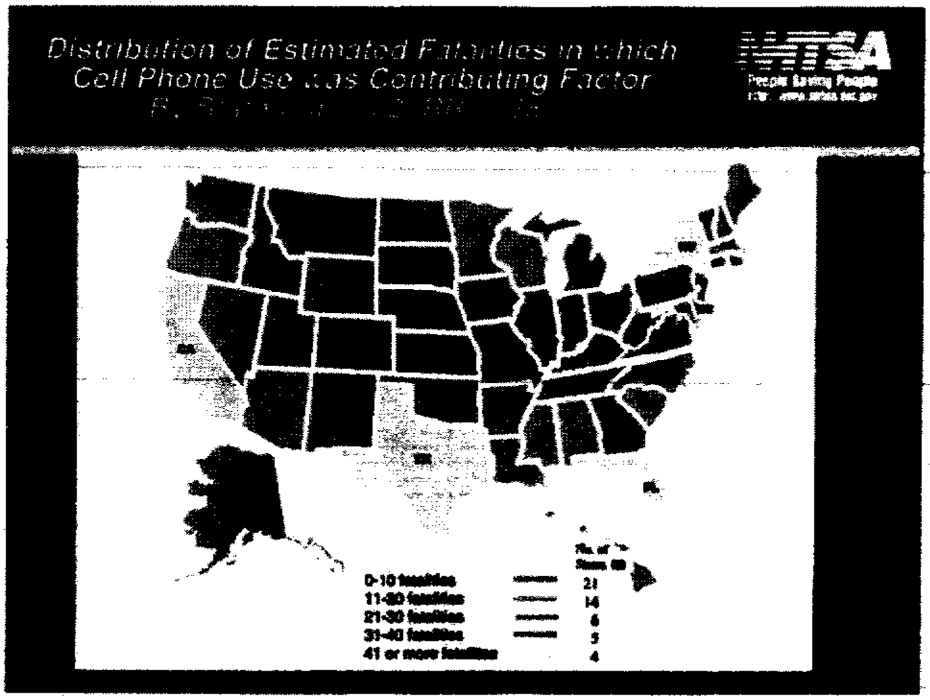
Note: The calculation of 2002 fatality estimates is based on a 50% increase assumed from the earlier calculation of national fatalities.

NHTSA 2000 & 2002 State Estimates of MV Fatalities (2b)

Cell Phone Use was Contributing Factor

Missouri	2.6%	8	16	20	12	23	29
Montana	0.4%	1	2	3	2	3	4
Nebraska	0.7%	2	4	5	3	6	8
Nevada	0.8%	2	4	5	3	6	8
New Hampshire	0.4%	1	3	3	2	4	5
New Jersey	2.5%	8	15	20	12	22	29
New Mexico	0.6%	3	5	7	4	8	10
New York	4.7%	15	29	38	23	43	56
North Carolina	3.3%	11	20	26	16	30	39
North Dakota	0.3%	1	2	2	1	2	3
Ohio	3.8%	12	24	31	19	35	46
Oklahoma	1.6%	5	10	13	8	14	19
Oregon	1.3%	4	8	10	6	12	16
Pennsylvania	3.7%	12	23	30	18	34	45
Rhode Island	0.3%	1	2	2	1	3	4
South Carolina	1.7%	5	10	13	8	15	20
South Dakota	0.2%	1	2	2	1	3	4
Tennessee	2.4%	8	15	19	12	22	29
Texas	8.0%	26	49	64	39	73	96
Utah	0.8%	3	5	7	4	8	10
Vermont	0.2%	1	2	2	1	2	3
Virginia	2.7%	9	17	22	13	25	33
Washington	1.9%	6	12	16	9	18	23
West Virginia	0.7%	2	4	6	3	6	8
Wisconsin	2.1%	7	13	17	10	19	25
Wyoming	0.3%	1	2	2	1	3	4

Note: The calculation of 2002 fatality estimates is based on a 50% increase assumed from the earlier calculation of national fatalities.



Methodology for Calculating State Estimates of Expected Fatalities In Which Cell Phone Use Was Contributing Factor

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Methodology #3

Methodology for Calculating State Estimates of Expected Fatalities In Which Cell Phone Use Was Contributing Factor (3)

Example – California (CA) [Data sources: NHTSA *Traffic Safety Facts 2000*, CTIA data for 2000]:

Assumptions and NHTSA data:

1. From NOPUS 2000, 4% of drivers are using a cell phone at any daytime moment (this is exposure time, $\Delta T = .04$). Assume this is true for all States.
2. This leaves 96% (or $1 - \Delta T = .96$) of drivers not using a cell phone at any given daytime moment.
3. If the risk of a crash is equal for cell phone users and non users, Total Risk = 1.0
4. The calculation of 2002 fatality estimates that follows is based on a 50% increase assumed from the earlier calculation of national fatalities.
5. The apportionment factor (CA%) is the average value of the state portion of the national total of the following data: cellular subscribers, licensed drivers, VMT, and fatalities.

1. Calculate portion of Total cellular subscribers in US that were in CA in 2000 (CA%1)

    CA%1 = % of US Cellular subscribers in CA
    = Cellular subscribers in CA divided by Cellular subscribers in US
    = 12,283,369 CA subscribers / 90,643,058 US subscribers
    = 13.6% of all US cellular subscribers were in CA in 2000

2. Calculate portion of Total licensed drivers in US that were in CA in 2000 (CA%2)

    CA%2 = % of US Licensed drivers in CA
    = Licensed drivers in CA divided by Licensed drivers in US
    = 21, 244,000 CA licensed drivers / 190,625,000 US licensed drivers
    = 11.1% of all US licensed drivers were in CA in 2000

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Methodology for Calculating State Estimates of Expected Fatalities In Which Cell Phone Use Was Contributing Factor (3)

Example – California (cont'd):

3. Calculate portion of total US VMT that were in CA in 2000 (CA%3)

    CA%3 = % of US VMT in CA
    = VMT in CA divided by VMT in US
    = 306,649,000,000 VMT in CA / 2,749,803,000,000 VMT in US
    = 11.2% of all US VMT were in CA in 2000

4. Calculate portion of Total US Fatalities that were in CA in 2000 (CA%4)

    CA%4 = % of US Fatalities in CA
    = Fatalities in CA in 2000 / Fatalities in US in 2000
    = 3,753 CA fatalities / 41,821 US fatalities
    = 9.0% of all US fatalities were in CA in 2000

5. Calculate the apportionment factor (CA%)

    CA% = (CA%1 + CA%2 + CA%3 + CA%4) / 4
    = (13.6% + 11.1% + 11.2% + 9.0%) / 4
    = 11.2% apportionment factor for CA in 2000
    This is the apportionment factor that is multiplied by the national estimate to obtain the state estimate.

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Methodology for Calculating State Estimates of Expected Fatalities In Which Cell Phone Use Was Contributing Factor (3)

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Example – California (cont'd):

6. Calculate portion of Total Estimated Fatalities in which cell phone use was a contributing factor in CA in 2000, Relative Risk = 1.2

   Fatalities in CA in which cell phone use was contributing factor
   = Apportionment Factor (CA%) * National Fatality Estimate when RR=1.2
   = 11.2%*324
   = 36 fatalities in which cell phone use was contributing factor in CA in 2000

7. Calculate Total Estimated Fatalities in which cell phone use was a contributing factor in CA in 2002, Relative Risk = 1.2. Assumption: The calculation of 2002 fatality estimates that follows is based on a 50% increase assumed from the earlier calculation of national fatalities.

   Estimated Number of California Fatalities in 2002 if Relative Risk = 1.2:
   2002 fatalities = 2000 Fatalities * 150%
   so 36*150% = 54 fatalities in California when cell phone was contributing factor in 2002 when the relative risk of a crash is 1.2

The table that follows provides estimates of fatalities for each State across a range of relative risks using the methodology outlined above.

NHTSA 2000 & 2002 State Estimates of MV Fatalities (3a)
Cell Phone Use was Contributing Factor

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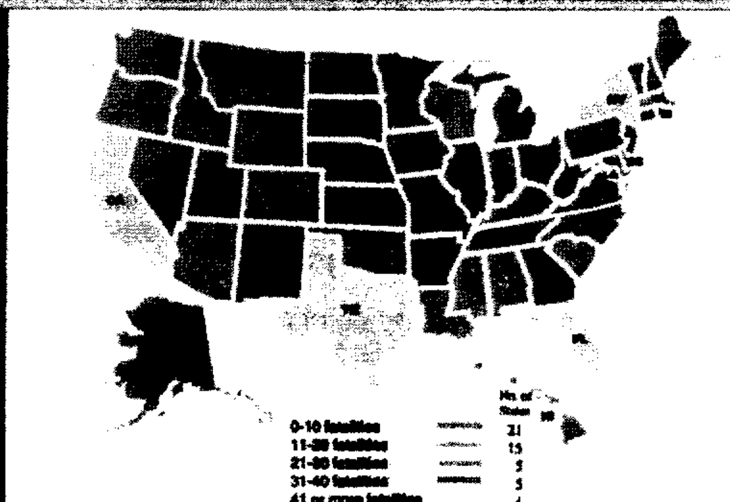
United States	100.0%	324	611	850	486	917	1275
Alabama	1.8%	6	12	16	9	18	25
Alaska	0.2%	1	1	2	1	2	3
Arizona	2.0%	6	12	16	10	18	24
Arkansas	1.1%	4	7	9	5	10	13
California	11.2%	36	68	96	54	103	134
Colorado	1.7%	5	10	13	8	15	20
Connecticut	1.1%	4	7	9	6	10	14
Delaware	0.3%	1	2	2	1	3	4
District of Columbia	0.2%	1	1	2	1	2	2
Florida	8.2%	26	50	69	39	57	75
Georgia	3.5%	11	20	27	16	31	40
Hawaii	0.4%	1	2	3	2	4	5
Idaho	0.5%	2	3	4	2	4	6
Illinois	4.0%	13	25	32	20	37	48
Indiana	2.2%	7	13	17	11	20	26
Iowa	1.1%	3	6	8	5	10	13
Kansas	1.0%	3	6	8	5	9	12
Kentucky	1.8%	5	9	12	8	14	18
Louisiana	1.7%	5	10	13	8	15	20
Maine	0.4%	1	3	3	2	4	5
Maryland	1.8%	6	11	14	9	17	22
Massachusetts	1.8%	6	12	16	9	18	23
Michigan	3.6%	12	22	29	17	33	43
Minnesota	1.7%	5	10	13	8	15	20
Mississippi	1.3%	4	8	10	6	12	16

Note: The calculation of 2002 fatality estimates is based on a 50% increase assumed from the earlier calculation of national fatalities.

NHTSA 2000 & 2002 State Estimates of MV Fatalities in which Cell Phone Use was Contributing Factor

State	[illegible] Factor	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Missouri	2.2%	6	14	19	11	21	29
Montana	0.5%	1	2	3	2	3	4
Nebraska	0.7%	2	4	6	3	6	8
Nevada	0.8%	2	4	6	4	7	9
New Hampshire	0.4%	1	2	3	2	4	5
New Jersey	2.5%	8	14	20	12	23	31
New Mexico	0.7%	2	4	6	4	7	9
New York	4.0%	15	30	30	25	44	60
North Carolina	3.5%	10	20	25	16	29	38
North Dakota	0.2%	1	1	1	1	2	2
Ohio	3.3%	12	23	30	18	34	45
Oklahoma	1.4%	4	8	11	7	12	16
Oregon	1.2%	4	7	10	6	11	13
Pennsylvania	4.0%	12	24	33	19	35	45
Rhode Island	0.2%	1	2	2	1	3	4
South Carolina	1.8%	6	11	14	8	14	21
South Dakota	0.5%	1	2	2	1	2	3
Tennessee	3.3%	8	15	20	12	23	30
Texas	7.8%	25	48	60	38	72	94
Utah	0.8%	3	5	6	4	7	10
Vermont	0.2%	1	1	1	1	2	3
Virginia	2.3%	8	15	20	12	22	30
Washington	2.0%	6	13	18	10	18	24
West Virginia	0.7%	2	4	6	3	6	8
Wisconsin	1.9%	6	11	15	8	17	22
Wyoming	0.3%	1	1	2	1	2	3

Distribution of Estimated Fatalities in which Cell Phone Use was Contributing Factor



Where Are The Fatalities?

Crash data are typically used to provide an account of the fatalities due to a particular causal factor. However, as discussed previously, fatalities due to cell phone use may be masked by other contributing factors. The AEI-Brookings[21,22] and Harvard[11,32] studies provide estimates that suggest the possibility for a substantial number of fatalities (using a RR of 4.3) due to phone use while driving. If a relative risk of 4.3 were used in the current analysis, with an exposure rate of 6%, the estimated fatalities would be substantial in number (on the order of 7,000) and should be clearly evident in the crash record. Given these analytical results and the fact that such large numbers of fatalities have not been observed, it is reasonable to assume that the actual relative risk is much lower than 4.3. The 2001 Montreal Study[30] is the most complete epidemiological study on this issue to date and suggests a relative risk of 1.38. More recent work by the University of Montreal further demonstrates analytically that the earlier 4.3 estimate was flawed. [62] Using the 1.38 value as a base, it seems reasonable to assume that the relative risk is closer to this value and lies within a range of 1.2 to 1.5. Within this range, the current analysis suggests between 508 and 1,248 fatalities in 2002 given an exposure rate of 6%.

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Summary of 2000 and 2002 Crash Estimates

The results of this analysis show that the number of estimated crashes and fatalities in which cell phone use was a contributing factor has increased significantly (by about 50%) as a function of the relative risk from 2000 to 2002.

Within the range of relative risks from 1.2 to 1.5, the current analysis suggests approximately 300 to 800 fatalities in 2000 given an exposure rate of almost 4%.

Recall that within this same range of relative risk, the current analysis suggests an increase in fatalities to between 508 and 1,248 fatalities in 2002 given an exposure rate of 6%.

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How Do the Various Sources of Data Come Together?

In aggregate there is a wealth of information.

After more than a decade of research on the subject, however, conclusions and recommendations differ greatly due to differences in economic, political, personal and academic perspectives, that influence basic assumptions and interpretations of the research.

While the current analysis generated a range of estimated fatalities due to cell phone use while driving, definitive conclusions remain elusive, highlighting the complexity of the issues and the continuing lack of critical data for assessing the true nature and magnitude of the problem.

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Why Is Understanding the Problem So Elusive?

Some of the More Significant Reasons

- Estimates of the role of distraction in crash causation vary considerably from about 13% to more than 50%, depending on the data source and assumptions used.
- Collection and documentation of distraction related crash data is not consistent across jurisdictions.
- Most often there is no post-crash evidence of the role of distraction in precipitating a crash.
- Some drivers are not aware they were distracted or are not willing to admit it.
- Most state crash reporting forms do not generally address the issue of distraction or more specifically the issue of cell phones.

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Another Issue of Concern: Crashworthiness

There is one safety issue that extends beyond the influence of cell phones on driving behavior and performance. Keeping in mind that use of a cell phone increases the risk of a crash, this issue concerns crashworthiness related to the position of installed wireless devices as well as hand-held devices and those attached to the driver. This is an issue both from the standpoint of a deploying airbag and the potential for a device to become an injurious or lethal projectile. For phones held by drivers in the proximity of the face and head, for driver attached accessories such as microphones and earpieces, or placement in front of the steering wheel during use (e.g., dialing a phone) there is also concern. In addition, instances of devices installed over airbags have been noted by NHTSA. These situations are particularly dangerous given the seemingly obvious potential for serious injury during airbag deployment.

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Summary of What We Know

- The number of cell phone subscribers (and users) in the United States continues to grow (2003, > 146,800,000), as does the number of drivers using cell phones while driving.
- Use of either hand-held or hands-free phones increases the risk of a crash.
- Data suggests that the use of cell phones per subscriber is increasing (frequency and duration of calls).
- User demographics are related to how, when and where cell phones are used and the magnitude and types of crashes involved.
- Young, novice drivers who also use cell phones or other wireless communication devices are of particular concern.

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Summary of What We Know

- Nature of problem is changing with advances in technology and increased use.
  - Cell phone architecture (e.g., design features, placement) influences the risk of a crash.
  - Cell phone demands (i.e., specific tasks and their difficulty for using) influence the willingness of drivers to use the phone.
    - There is evidence that drivers who use hands-free phones use them more frequently and for longer durations than drivers who use handheld phones.
- Context of the driving environment influences the willingness of drivers to use the phone.
  - Most cell phone crashes occur under benign conditions (e.g., straight road, daytime, clear weather).
  - Most cell phone crashes occur in urban environments.
- Frequency and duration of use, both while driving and overall, influence the risk of a crash.

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Summary of What We Know

- The public is concerned about the safety implications surrounding the use of cellular phones while driving.
- Crash data is incomplete, inaccurate, and difficult to obtain.
- More than half of the States have proposed restrictive legislation.
  - Several states have initiated special studies.
- A variety of research studies are ongoing.

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What Others Are Saying

The following slides present a sample of statements from notable sources that have received considerable visibility in the media. These sources have addressed the cell phone issue either through research or through an analysis of existing information and data to better estimate the nature and/or magnitude of the problem.

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Notable Quotes

- Harvard Center for Risk Analysis, 2000
  - "The weight of the scientific evidence to date suggests that use of a cellular phone while driving does create safety risks for the driver and his/her passengers as well as other road users."
    - However, they note that the magnitude of this risk is unknown
  - "It is not clear whether hands-free cellular phone designs are significantly safer than hand-held designs, since it may be that conversation per se rather than dialing/handling is responsible for most of the attributable risk due to cellular phone use while driving."

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Notable Quotes

- **Harvard Center for Risk Analysis, 2000 (cont'd)**
  - "Traffic safety researchers do not find much reassurance in the data [Cellular subscribers vs. US mileage fatality rate, Traffic fatalities] ... because there are many powerful variables (beneficial and adverse) that influence overall fatal crash statistics."
  - "As an example, if cellular phones were in fact causing 500 additional fatalities each year in the U.S., the problem – even though large in absolute magnitude – might be masked in the aggregate data by recent reductions in accident fatalities from campaigns against drunk driving and for safety belt use."

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Notable Quotes

- **Harvard Center for Risk Analysis, 2000 (cont'd)**
  - "Alternatively, if cellular phone use were to increase the risk of motor vehicle collisions but primarily in less severe crashes (i.e., those collisions least likely to cause a fatality, such as rear-end impacts), then one would not expect to see a simple correlation between traffic fatalities and cellular phone use."
  - "For example, in rush-hour traffic where cellular phone use is common, fatal crashes account for a disproportionately small share of crashes because congestion produces low-speed collisions in which vehicles may be damaged but occupants receive little or no injury."

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Notable Quotes

- **Harvard Center for Risk Analysis, 2000 (cont'd)**
  - "Although fatal crashes are of obvious human significance, they may not be the most important outcome when scientists study the risks of using a cellular phone while driving."

Notable Quotes

- **University of North Carolina Highway Research Center, 2001**
  - "Clearly there is a critical need for better information if the risk of crashing while talking on a cell phone is to be appropriately estimated. Without this information, there remains a very important unanswered question: 'Just how dangerous is it to be talking on a cell phone while driving?'"

Possible Strategies

- **Addressing the Cell Phone Issue**
  - Training and education
  - Media campaign (PSAs)
  - Design changes / guidelines
  - Restrictive legislation
  - Corporate restriction
  - Restrictive designs
  - Cooperative systems
  - Insurance implications

Training, Education, Media Campaign (PSAs)

Traditional approaches have been used for some time with uncertain success. Application of such approaches to other issues (alcohol/seat belts) have shown relatively small benefits (10%-15%) and while some benefits may be realized on this specific issue, efforts may be best directed at establishing a uniform set of guidelines for use covering the range of phone architectures and also highlighting the distraction issue in general. It is clear from focus group discussions that there is a considerable lack of knowledge about distraction and the risks of a crash. Providing exposure to these issues at the high school level may have long term benefits.

Design Changes/Guidelines

The relationship between the "demands" of using a cell phone and risk has already been pointed out. Clearly, cell phone design is primary in determining the nature and degree of distraction associated with use. This issue highlights a paradox in that the more the use of cell phones is facilitated by design improvements (ease-of-use), the greater the likelihood it will be used (while driving). Indeed, hands-free systems have been touted by many as "safe." However, to the extent that conversation itself contributes to crash risk, any benefits of design improvements may be washed out by increased exposure. Survey data has indicated that if a device is too difficult to use while driving it will not be used. Nevertheless, there are many human factors design improvements that should be addressed. Some of these are highlighted on the slides that follow.

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Design Changes/Guidelines

- **Reducing Manual Demand**
  - Hands-free systems
    - Most hands-free set-ups are for hands-free conversation, manual dialing is still required
  - Voice interface
    - Allows for hands-free dialing and answering
    - Technology not cheap enough for satisfactory performance
  - Flip-phone vs. non-flip phone
    - Flip-phones are still very popular, but most require two hands to flip open
    - Cradles that require flip-phones to be open may help this issue

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Design Changes/Guidelines

- **Reducing Visual Demand**
  - Screen size
    - Larger screens allow for larger text sizes, but they also allow for more information and graphics
    - Recent incorporation of digital camera capabilities will potentially allow for more image-rich interfaces
    - Possibly include "driving" display mode that uses restricted (minimal) visual interface
  - Keypad design
    - Ensure that button size and spacing are adequate for minimal entry errors
    - Key feedback is essential to reducing the need for visual confirmation of inputs

Restrictive Legislation

In response to what is perceived as a significant problem, the state of New York and several local jurisdictions across the country have implemented legislation to limit the use of cell phone to hands-free devices. Inherent in these restriction is the assumption that hands-free architectures are safer. Because the success of these efforts in reducing cell phone related crashes is not easy to assess, it is impossible to determine whether such efforts will tend to improve overall safety, or in fact reduce it (through greater use). Both experimental and epidemiological studies have consistently shown little if any difference between hands-free and hand held architectures. The bases for the lack of a distinction, however, is not clear since each may be associated with attributes for use that can benefit or hinder safety. Until these issues are clarified or an appropriate assessment is made of legislative effectiveness, it would appear that the success of this approach in reducing cell phone related crashes will remain unknown.

Corporate Restriction

As highlighted earlier, corporate liability issues have motivated a number of companies to establish formal policies regarding cell phone use. Such policies have often been motivated by high profile, high cost crashes that have taken place on company time or using company vehicles. Businesses would appear to be highly vulnerable to lawsuits in these situations, which could significantly impact small business operations in particular. It would appear that corporate consideration of formal policies on where, when and how to conduct business on the cell phone would be prudent and has the potential to reduce a small, but significant (economic) component of the cell phone crash problem.

Restrictive Designs

While the focus of technological innovation has been on improving the capability and usability of in-vehicle devices, it has long been recognized that there may be a need to use innovative techniques to limit the availability of certain high demand functions on these devices. The most notable example is the restriction on navigations systems that limits destination entry from a moving vehicle. It has been suggested that such limitations can be applied to cell phones in order to prevent the making or receipt of calls if the vehicle is in motion. While such an approach may be viable for communications systems integrated into the vehicle, such an approach may not be easily implemented for carry-on devices. However, with the implementation of new call location requirements, the use of integrated GPS capabilities would allow determination of phone velocity which could be associated with use in a vehicle. Nevertheless, associating the motion of the phone with a car (as opposed to another type of vehicle such as a bus or train) and a driver (as opposed to a passenger), would still be a challenge.

Cooperative Systems

Another technological approach is related to the ongoing development of crash avoidance systems and the associated sensor suites. Recent developments in sensors and associated algorithms would theoretically allow determination of imminent threats (traffic conflicts) and determine, with some degree of reliability, whether the driver is distracted (visual or cognitive). With this coincidence of circumstances it may be possible to warn the driver (regain attention to driving) to allow an appropriate avoidance response. It remains to be determined whether such an approach would provide enough time for a driver to refocus attention and respond appropriately.

Insurance Implications

One approach adopted by several insurance companies (in Germany and Canada) is to limit insurance coverage if a cell phone was in use at the time of a crash. Other approaches that have been discussed include the addition of a surcharge if cell phones are used while driving. These approaches may have limited impact if adopted only by a few insurers since clients can simply move to another insurer without a cell phone consequence. More universal and publicized policies that spell out consequences of cell phone relevant crashes, however, might influence behavior.

Possible Strategies

- **Improving the State of Knowledge**
  - Epidemiological studies
  - Improved crash data collection
  - Laboratory, simulator and test track research
  - ~~Observational research~~
  - Surveys
  - Naturalistic data collection

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Epidemiological Studies

Perhaps the greatest contribution to understanding the real-world risks associated with cell phone use has come from the epidemiological studies that have focused on this issue. While not establishing a direct link between cell phone use and crashes, the relationships identified by these studies do come closer to providing a basis for establishing the magnitude of the problem. The key to the value of these studies is access to phone records, which is more readily obtained in Canada. However, as the following slides caution, the relevance of this data to the U.S. population may be limited.

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Epidemiological Studies

As the authors themselves stated, the 2001 Montréal Study[30] is "the first epidemiological study based on a substantial sample that shows a link between risk of having accidents and accidents with injuries and the fact of being a cell phone user as opposed to a non-user."

This study represents a significant step forward in understanding the magnitude of the risks associated with cell phone use while driving. However, there may be certain factors that impact generalizability of this data to the United States at the present time.

It is important to keep in mind that this was a retrospective epidemiological study done on two large cohorts – users and non-users of mobile (cellular) phones. The objective was to verify whether an *association* exists between cell phone use and crash rates, but this study did not (and could not) confirm a causal relationship based on the research methodology used. Recall also that the population sampled was selected to maximize the number of cell phone users.

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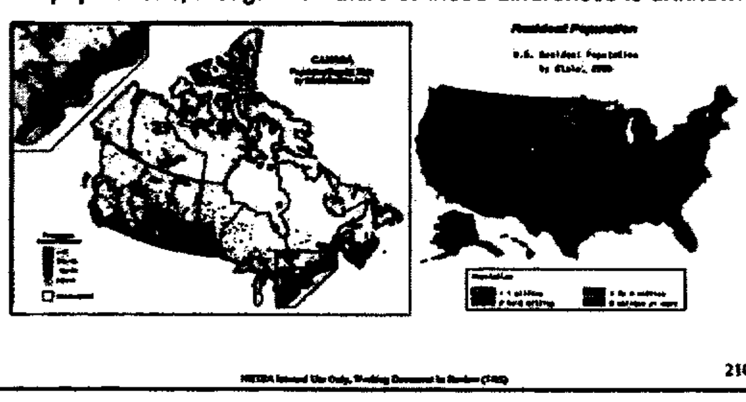
Epidemiological Studies

Geographic differences between Canada and United States – the lighter colored areas in the two figures represent the most sparsely populated regions – and the availability of cellular service nationwide would also likely effect differences in cell phone usage between the two populations, though the nature of those differences is unknown.



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Epidemiological Studies

- **Other considerations of note:**
  - The Canadian data, collected through 2000, indicated that a smaller portion of Canadian drivers reported having cell phones as compared with U.S. drivers who participated in NHTSA's 2000 MVOSS (35.2% to 54%).
  - Cell phone usage is somewhat different in Canada as compared to the U.S. For example, in 2000 about 90% of drivers who participated in the Canadian study and who had cell phones reported using phones at some time while driving, compared with about 75% of U.S. drivers with cell phones.
  - The Canadian data indicated a higher usage of hand-held phones than that reported in the U.S. at that time (more than 80% vs. 73%).
  - A comparison has not been done to consider how service plans may have differed between the U.S. and Canada over the years, however, variances in available service plans and service can impact on usage.

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Improved Crash Data Collection

It would appear that the mainstay of media reports on the role of cell phones in precipitating crashes is the crash data as reported by NHTSA and state resources and interpreted by others. The shortcomings of this data, however, as highlighted earlier, prevents any definitive statements about either the magnitude or nature of the problem. Given the diversity in data collection techniques and the subjective nature of data imbedded in crash reports on the subject of distraction in general, and cell phone in particular, not to speak of the unknowns, it would appear irresponsible to make much of the data other than to develop a general sense of the issues and provide guidance for more focused research. Improvements in the data collection process that would allow for greater comparability along with increased sensitivity to this issue among crash investigators would help improve the data quality, but would not provide a definitive source of information to guide the decision making process.

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Laboratory, Simulator and Test Track Research

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Perhaps the greatest contribution of experimental research into cell phones has been a better understanding of how cell phone use can influence safety relevant driver behavior and performance, and the mechanisms responsible for those effects. These issues are critical in influencing both the public information side of the issue and the design of these systems since they provide an empirical basis for determining what information (safety) users need to know and what design features offer the lowest level of demand. The research can also provide insight into the methods and timings necessary to warn drivers of traffic conflicts. There is a particular need to expand research to address the use of the broad range of functions now being incorporated into cell phones.

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Observational Research

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Observational research has proven to be a reliable approach for capturing the rate of hand-held phone use while driving at any given moment. However, the major drawback to this type of research is the inability to obtain accurate observational data on hands-free phone use. Currently, NHTSA relies on the use of survey data to fill this gap, and while such an approach appears to provide a reasonable estimate given the aggregate of other supporting information, it would be best if a more direct approach was employed to obtain hands-free use data. In this regard, it may be possible to utilize currently available, remotely located devices to detect phone use from afar to improve the accuracy and reliability of observational research in obtaining estimates of hands-free use.

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Surveys

Because the cellular phone industry has been incredibly dynamic in recent years in its subscriber and airtime growth, the trends for phones will most likely continue to change over time. Surveys are useful for understanding these trends and how people feel about their phones, and when and where they use them. In order to be sensitive to trends in phone use while driving, survey data must continue to be collected on a regular basis (at least annually).

Naturalistic Studies

The Missing Link:

In reviewing available sources of relevant data and the completeness and accuracy of the information they provide, it is clear that it is not possible at this time to determine the magnitude of the cell phone problem, either in terms of crashes or fatalities. All estimates provided in the literature are subject to significant data limitations and associated error, and are based on assumptions that may have little credibility. What is clear is that the key element that is missing is an accurate determination of relative risk. While the model approach to estimating fatal crashes presented earlier is not perfect, it does allow for approximating the magnitude of the problem, given a relative risk. It is argued here that the use of naturalistic driving studies, if implemented properly, can fill that gap as well as answer questions that cannot be addressed by traditional research approaches. In addition, the proposed research would also capture the use of other technologies as well as other distractions (e.g., tuning the radio, eating).

Naturalistic Data Collection

Large Scale, Statistically Representative Sample of Users

Unlike other experimental research, naturalistic studies provide an accurate picture of events as they would occur in the real world. While lacking experimental control, these studies do provide a unique opportunity to empirically identify and document driver behavior and performance under conditions that represent the full range of circumstances encountered in real world driving. Within the context of cell phones it provides the capability to describe cell phone use in terms of behavior and performance in relation to driver demographics, driving style and traffic events (crashes, near misses, driver error). With appropriate subject selection distributed nationally it would be theoretically possible to get meaningful measures of exposure and relative risk, including the conditions under which these devices are used and comparisons to other distractions. This approach would also capture other portable technologies as well.

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Naturalistic Data Collection

Focus on purchasers of OEM in-vehicle technology

The evolution of technology has focused on integrating a large number of functions within single devices. This trend can be seen in the integration of OEM devices into vehicles that may include audio, navigation and communications systems. Many of these systems have unique voice interfaces that allow control with minimal manual involvement. The manner in which these devices are learned and used is unknown as is their potential to precipitate distraction related crashes. Through a large scale naturalistic study in which purchasers of new vehicles with these systems are offered a monetary incentive (e.g., several thousand dollars off the purchase price) to be a part of the study, it would be possible to collect invaluable information as to the benefits and liabilities of these new devices and interfaces.

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Summary & Conclusions

Unlike most issues in highway safety, those surrounding cell phones represent a unique and daunting challenge. Despite a vast amount of data and research, the most substantive questions regarding the impact of wireless communications on safety remain unanswered. The dynamic nature of the technology and its use, along with the difficulties in collecting complete and accurate crash data, continue to be the greatest challenge. In some notable cases results of studies have been highlighted by the authors as "definitive," and captured by the media and other researchers as having great significance. The material presented here, however, has highlighted a number of shortcomings in the crash data, the research, and the risk analyses. Our analysis, based on the most current data, provides what we believe is a "best" estimate of fatalities and non-fatal crashes and is intended to give the reader a "sense" of the magnitude of the problem. It is further suggested here that realistically, the only mechanism for obtaining the necessary information to properly characterize this problem is through well designed naturalistic driving studies, where the behavior of drivers can be monitored and the consequences of phone use accurately and reliably recorded.

Safety Tips from Transport Canada

Transport Canada Fact Sheet RS200-06 (TP2436E, December 2001) [65, 66]

- "Transport Canada recommends against using cell phones while driving. It is distracting and increases the risk of collision. Your primary concern is the safe operation of the vehicle."

To avoid collisions arising from the use of cell phones:

- Turn the phone off before you start driving. Let callers leave a message.
- If there are passengers in the vehicle, let one of them take or make a call. If you're expecting an important call, let someone else drive.
- If you have to make or receive a call, look for a safe opportunity to pull over and park.

NTSB Safety Recommendations Background

On February 2002, a serious crash involving the loss of five lives took place in Largo, Maryland. The nature of this crash and the events leading up to it were investigated by the National Transportation Safety Board (NTSB) to determine the contributing causes and to make recommendations that would have the potential to mitigate similar crashes in the future. The following slides provide highlights of this event and the NTSB's findings and recommendations. This material in provided because cell phone use was identified as a potential contributing factor.

NTSB Safety Recommendations Report / Hearing

- Single crash that took the lives of 5 persons, including a driver who was using a wireless phone at the moment she lost control of her vehicle.
- Interstate 95/495 (the Capital Beltway) near Largo, Maryland
- The Board found that the probable cause of the crash was the Explorer driver's failure to maintain control of her vehicle in the windy conditions due to a combination of inexperience, unfamiliarity with the vehicle (she had just purchased it that evening), speed and distraction caused by use of a handheld wireless telephone.

NTSB Safety Recommendations

June 3, 2003 Safety Recommendations to NHTSA

1. Develop in conjunction with The Advertising Council, Inc., a media campaign stressing the dangers associated with distracted driving.
2. Develop in conjunction with the American Driver and Traffic Safety Education Association a module for driver education curriculums that emphasizes the risks of engaging in distracting behavior.
3. Determine the magnitude and impact of driver-controlled, in-vehicle distractions, including the use of interactive wireless communication devices on highway safety and report findings to the United States Congress and the States.

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Recommendations: Prologue

The recommendations that follow apply to a diverse group of interests that should carefully consider the implications of the information and analyses in this report, and how the recommendations may be used as a stepping-stone to improving knowledge and safety related to in-vehicle use of wireless devices. These interests include:

Users	Manufacturers
Designers	Service providers
Law enforcement	Media and outreach
State and Local governments	Employers
Special interest groups	Parents
Government agencies	Researchers
Educators	Insurance carriers

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Recommendations: Prologue

While a definitive estimate of the magnitude of the problem is not possible at this time, we believe it is prudent to use existing data and information to generate a best estimate. Using 2002 crash data across an assumed range of relative risk, a best estimate of fatalities, injury crashes, property damage crashes and non-police reported cell phone related crashes was presented earlier to characterize the potential magnitude of the cell phone problem. While these estimates involve a number of assumptions, we believe they are reasonable, given available data and information. The need for the recommendations that follow are based on the magnitude of the problem reflected in these estimates as well as the aggregate of other information provided in the preceding documentation. Because the estimates are relatively large, we believed that in the interest of saving lives and preventing injury, a conservative approach is called for at this time. As additional data, information and analytical approaches become available, these estimates will be adjusted as appropriate.

Recommendations: Wireless Communications Research

Given the likelihood that crash data will be unable to accurately capture distractions as a causal factor, it is recommended that a naturalistic, on-road data collection effort be initiated using instrumented owner vehicles. The effort would focus on cell phones as well as other distracted driving behaviors that can have an adverse influence on driving safety. The study would involve a statistically meaningful number of volunteer drivers, perhaps 10,000 or more, distributed nationally, carefully selected to be representative in all relevant aspects covering demographics, driving history, cell phone type and use, and other characteristics deemed relevant. Driver anonymity, data confidentiality and protection, along with monetary compensation, would be used to encourage participation. Data would be collected over a period of at least one year. For this large subject population it is anticipated that sizable number of crashes would naturally occur. All crashes would be investigated in depth, and all detectable critical incidents and near misses will be recorded as well. It is expected that the aggregate of this data would clarify issues of willingness to engage and exposure, and ultimately lead to a more accurate estimate of the magnitude of the problem.

Recommendations:
Crash Avoidance Research

Recent advances in crash avoidance technologies (e.g., forward collision avoidance) provide a unique opportunity to mitigate crashes involving distraction by sensing conflict situations during periods of inattention and alerting the driver. Other technologies in development are intended to actually sense driver inattention and provide a means of refocusing driver attention to the driving task. These efforts have the potential to mitigate the adverse consequences of inattention due to cell phone use as well as to other distractions. It is unclear at this time how effective these approaches will be, and more research is necessary to establish appropriate trigger algorithms, nuisance criteria and timings, and to determine the effectiveness of these approaches under real world conditions. It is also important to consider how drivers will adapt to these systems over time (i.e., behavioral adaptation) to ensure that use of these systems does not decrease safety by reducing vigilance or by allowing drivers to use these systems to drive the margin between safe and unsafe.

Recommendations:
Users

The driver's primary responsibility is to operate the vehicle safely. This requires undivided attention and focus on the driving task.

Using wireless communications devices while driving can be distracting and increase the risk of crash and injury. Therefore, NHTSA recommends that drivers not use these devices while driving, except in emergency. This recommendation applies to both hand-held and hands-free devices.

Recommendations: Users

- **Drivers who use wireless communication devices should not use them while driving. Instead, drivers should do at least one of the following:**
  - **Stop the vehicle in a safe location that is off the road, well away from traffic, before they receive or place their calls.**
  - **Allow a passenger to receive or place calls.**
  - **Use the phone's voice mailbox feature if so equipped, and return the call when not driving.**
- **All drivers should follow these guidelines, and employers are urged to adopt policies implementing them.**

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Recommendations: Outreach

Whereas efforts to educate and inform the public about the risks of distraction and cell phone use by drivers have been highlighted by the NTSB and the industry, past experience with education and public information programs has indicated that these efforts are likely to influence only limited segments of the population. It is nonetheless important to sensitize the general public to the issue of driver distraction. Because of the dynamic nature of cell phone technology and use in particular, we believe that distraction due to cell phones must be emphasized in any outreach programs. It is therefore recommended that:

- A series of policy-based PSAs be developed, consistent with the NTSB's recommendations, and implemented to focus on the risks of distraction in general, with an emphasis on cell phones in particular.
- Because younger drivers appear to be most vulnerable to distraction and tend to use available technologies with less awareness of the potential dangers involved, a lecture series geared to high school students should be developed and included in school curricula to sensitize students to the issue of distraction in general and cell phones in particular.
- Employers should be encouraged to establish a formal policy with regard to distraction in general and the use of work-related technologies, including cell phones, while driving and be sensitized to issues of liability.

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Recommendations:
Legislation

Decisions as to the need for legislation limiting the use of cell phones from a moving vehicle are a state or local issue and should be based on the determination by authorities that a sufficient problem exists in their jurisdiction to warrant action. Where such action takes place, however, it is recommended that provisions be made for an evaluation of the impact of such action in terms of use and crashes, particularly given the uncertainty of how the use of hands-free devices will influence overall safety.

In view of the greater risks associated with new or novice drivers it is also recommended that consideration be given to specifically prohibiting these drivers from using cell phones while driving, perhaps as a part of graduated licensing programs or through some period of time based on driving experience.

Information Needs From Industry

In developing the various analyses and information for this report it was necessary to derive estimates from limited or incomplete information about the use of wireless devices in general and from moving vehicles, in particular. Availability of this information in the United States is further limited by the difficulty in obtaining phone records that would facilitate associating a crash with phone use, a problem not encountered in Canada, as reflected in the epidemiological studies referenced. In some cases relevant information is embedded in CTIA reports available at great cost. In the interest of providing research with the best available information to address the issues at hand, it would be helpful for these data to be made generally available so that research can more accurately reflect the true status of cell phone use. Recognizing that it may not be possible to provide all the desired data, the following page identifies a list of information that would be helpful.

Desired Data from Industry

- **Call Frequency and Duration data**
  - Time of day distributions
  - Regional distributions
  - Roaming vs. non-roaming
  - 911 calls
- **Estimates of mobile vs. landline phone use**
- **Equipment Sales / Use data**
  - Hand-held
  - Hands-free
    - Headsets, Ear buds, Speakerphone systems, etc.
- **Customer Satisfaction / Survey Data**
  - Hands-free vs. Hand-held

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Applicability

The findings, analyses and recommendations of this effort may have applicability to other issues associated with in-vehicle distraction in general, and the use of advanced in-vehicle technologies, in particular. With current trends for integrating device functionality and expanding the capabilities of advanced in-vehicle technologies, including wireless communications, it would appear that there is reason for concern. As more complex systems are placed in use, it is unknown at this time how, when and where these devices will be used by drivers. Similarly, many distractions other than those involving advanced technologies are also relevant to the research and recommendations presented, particularly from the standpoint of understanding the role they play in crashes, and how best to communicate the risks involved and address the behaviors.

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This Driver Lost Control While Using Phone and Struck a Stopped Construction Vehicle

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