2 Mobile and Ubiquitous User Interfaces

2.1 Mobile Computing

2.2 Design Guidelines for Mobile Devices

2.3 Input and Output on Mobile Devices

2.4 System Architectures for Mobile Devices

2.5 Example Applications

2.6 HCI and Ubiquitous Computing (Automotive UIs)

Slide acknowledgements: Dagmar Kern
Pervasive Computing & User Interface Engineering
University Duisburg-Essen

Trends (1)
mobile communication is ubiquitous

- Terminals for mobile communication have advanced significantly over recent years
- **Infrastructure is ubiquitously deployed**
- Interesting developments happen beyond the classical handsets (when thinking of electricity it is not the advances in light bulbs that changed the world)

- How many handsets will a user have in 10 years?
  - a guess: 2-6 (some mobile phones, car phone, office, …)
- How many communicating appliances and devices in 10-20 years?
  - a guess 20+ (security system, TV, front door, dog collar, wrist watch, camera, headset, coffee machine, alarm clock ...)

Trends (2)
mechanical and electro-mechanical systems
will be computer controlled

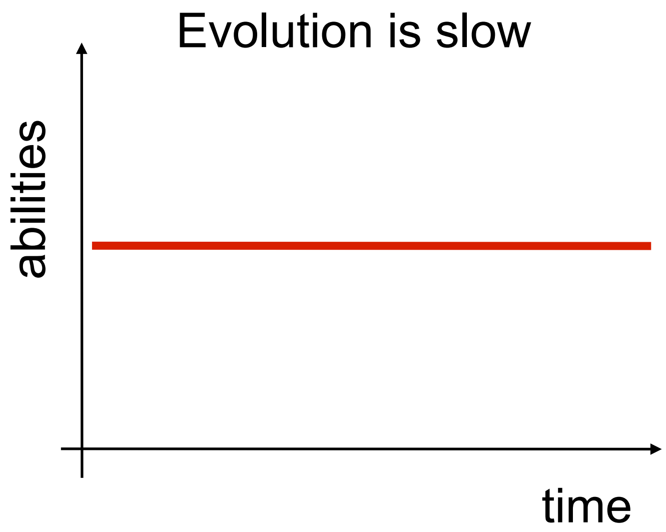
- Mechanical and electro-mechanical systems become computer controlled.
- User interfaces for mechanical and electro-mechanical systems have a tradition of being tangible.
- Many **design restrictions** due to mechanics **are gone** – novel interfaces (for the better or the worse) are possible and emerge.
- **Sensing of actions and reactions from users becomes an interface option**.
- Examples: automotive, industrial machinery, tools, buildings.

Trends (3)
declining willingness for training

- An average person acts today as driver, telephonist, photographer, film-maker, and type setter without much training (many task with just one device – the phone).
- In a fast paced job market training to operate a system is a significant obstacle (and cost factor) for the introduction of new systems.
- Dangerous actions should be prohibited in the first place by the controls available in the user interface.
- User interfaces that have **clear affordances** and draw on the **prior knowledge** of potential users (“intuitive UIs” and “natural interaction”) reduce the need for leaning

Trends (4)
user's abilities

- Abilities of un-augmented users in general do not change a lot over time, e.g.
  - ability to cope with cognitive load
  - willingness to cope with stress
  - time one can concentrate on a particular problem
- Abilities between individual users vary a lot
  - long term, e.g. physical and intellectual abilities
  - short term, e.g. effect of stress or fatigue
- Abilities of one individual user changes over time (e.g. getting old)



Human in the loop
Interactive systems for "augmenting the human intellect" as alternative to automation.

Trends (5)

technology becomes widely available

- Technologies that may be today "specialist devices" become common in a *few* years
- Technologies that are shared now may become personal technologies
- Technologies that are expensive at one point are not even considered as additional cost in the future, e.g.
  - Video camera connected to a computer
  - Biometric authentication
  - Book printing on demand
  - Eye gaze tracking
  - 3D scanning and printing
  - Integrated production systems

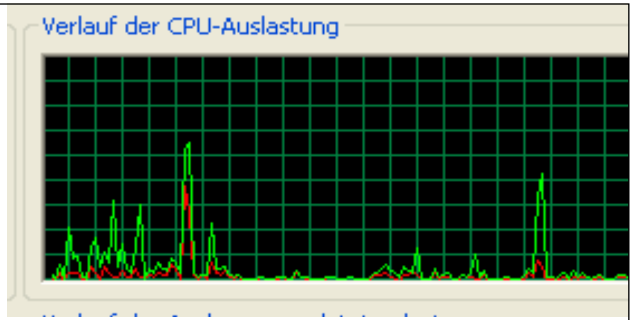
Trends (6)
appliance computing

- Post-PC area
  - Specific tools that are designed to support a specific task
  - Not a all-round tool
  - Different tools for different tasks

- *“[…] the primary motivation behind the information appliance is clear: simplicity.*
- ***Design the tool to fit the task so well that the tool becomes part of the task (Don Norman)***

Trends (7)

computing, storage and communication are not the limit



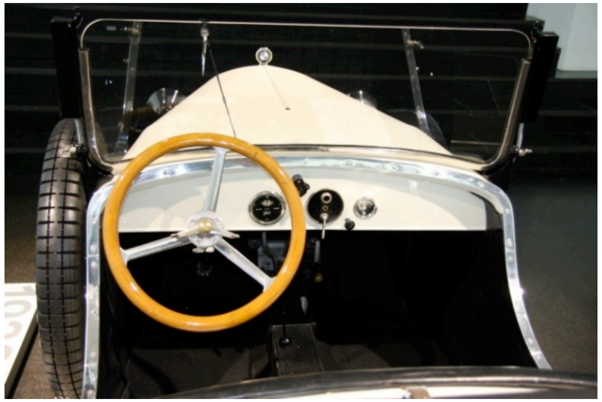
- For personal computing there are few technical limitations
- Processing power is available
  - Already now desktop machines run with minimal processing power
- Massive amounts of storage are readily available
  - Phones with 4GB disk
  - Record everything you ever said on a hard drive
  - Have all movies ever produced in a single device
- Bandwidth (wireless and wired) is huge
  - While you tie your shoe laces you can cache all the latest 20 different news papers
  - While you wait for the bus you can transfer a complete movie

User interfaces and interaction for networked devices that are embedded into the users' lives.

- Anytime and everywhere
- Design restrictions are gone
- Sensing and actuators are part of the UI
- Must be obvious to use (affordances)
- Current cost of technology is not an issue

The interface between the user and the machine is most critical to create effective and efficient systems.

What has become of cars?



1930

2007

“VW up! … like an iPod touch that you can drive, too.”

What is and what will be?

The Car …

… a means for transport.

… a space for media consumption?

… a personal communication center?

… used as an inter-connected workplace?

http://www.caradvice.com.au

Trends …

… Increase mobility

… Information access always and everywhere

… Assistive functionalities ease the driving task

… Sensing technologies have improved

… Cars become networked

What has not changed?

Primary function as transport vehicle remains central

Primary task (basically driving) has priority

“Fun of use” and “ease of use” are essential

Human user wants to be in control

Driving is often a social situation

Need for safety
(gets even more emphasized)

http://auto.freenet.de

Results in challenges for the UI

More information available

- car data, e.g. sensors, night vision, …
- from the environment, e.g. signs, parking distance, …
- other cars, e.g. weather warnings, collision warnings, …
- from the back-end, e.g. internet, online source, …
- From human to human communication channels, e.g. phone, instant messaging, …

New interaction demands from assistive systems (joint tasks – human and car)

Increased complexity

What is the difference?

Question

Glance time to operate a car radio is approximately 1s

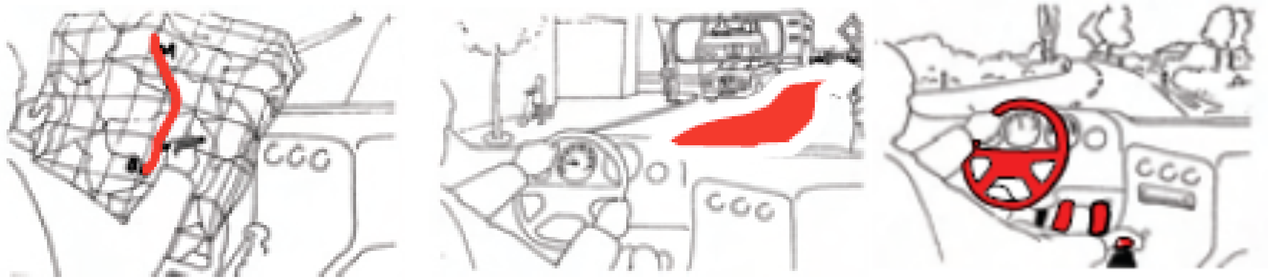
Current speed: 36km/h

How many meters will the driver travel without looking at the street?

Driving Tasks

Primary task: keep the vehicle on track

- Navigation
- Steering
- Stabilization



Secondary task: depending on driving requirements

- Actions (blinking, blowing a horn, ...)
- Reactions (Turn on/off the lights, turn on/off the windscreen wiper,...)

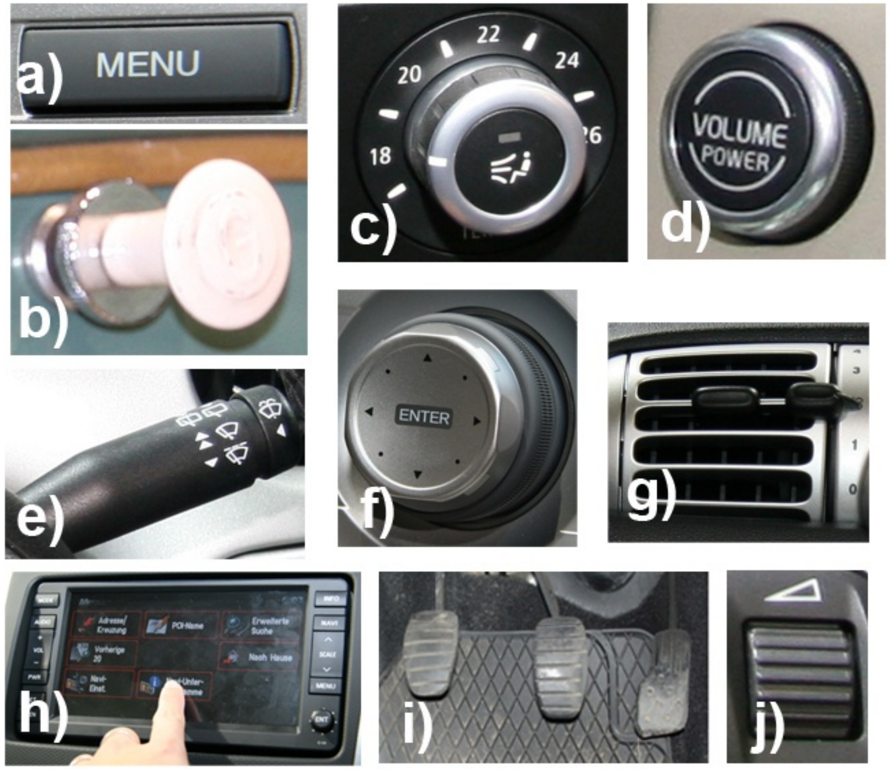
Tertiary task: Tasks independent of driving

- Comfort functions (Air condition, power seats, ...)
- Entertainment (Radio, CD, ...)
- Communication (mobile phone, Internet, ...)

Bubb, Heiner: Systemergonomische Gestaltung. In: Schmidtke, H. (Hrsg.), Ergonomie, 3. Aufl. München, 1993.

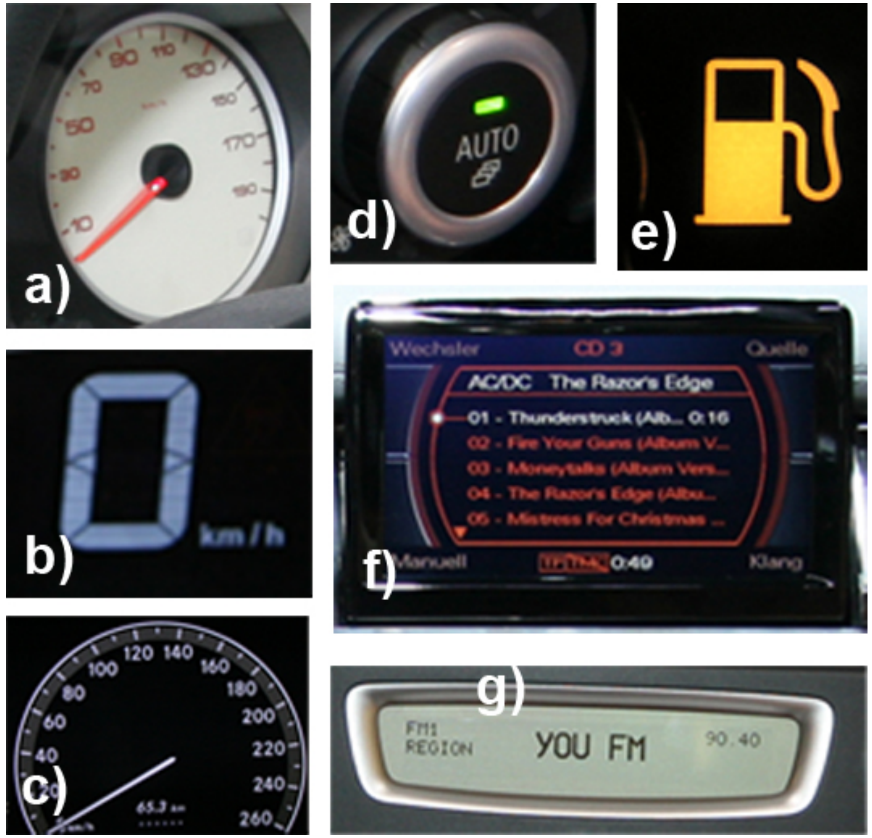
Input modalities

- button
- button (haptic feedback)
- discrete knob
- continuous knob
- lever
- multifunctional knob
- slider
- touch screen
- pedals
- thumbwheel



Output modalities

- analog speedometer
- digital speedometer
- virtual analog speedometer
- indicator lamp
- shaped indicator lamp
- multifunctional display
- digital display



Mobile Devices

BMW Group

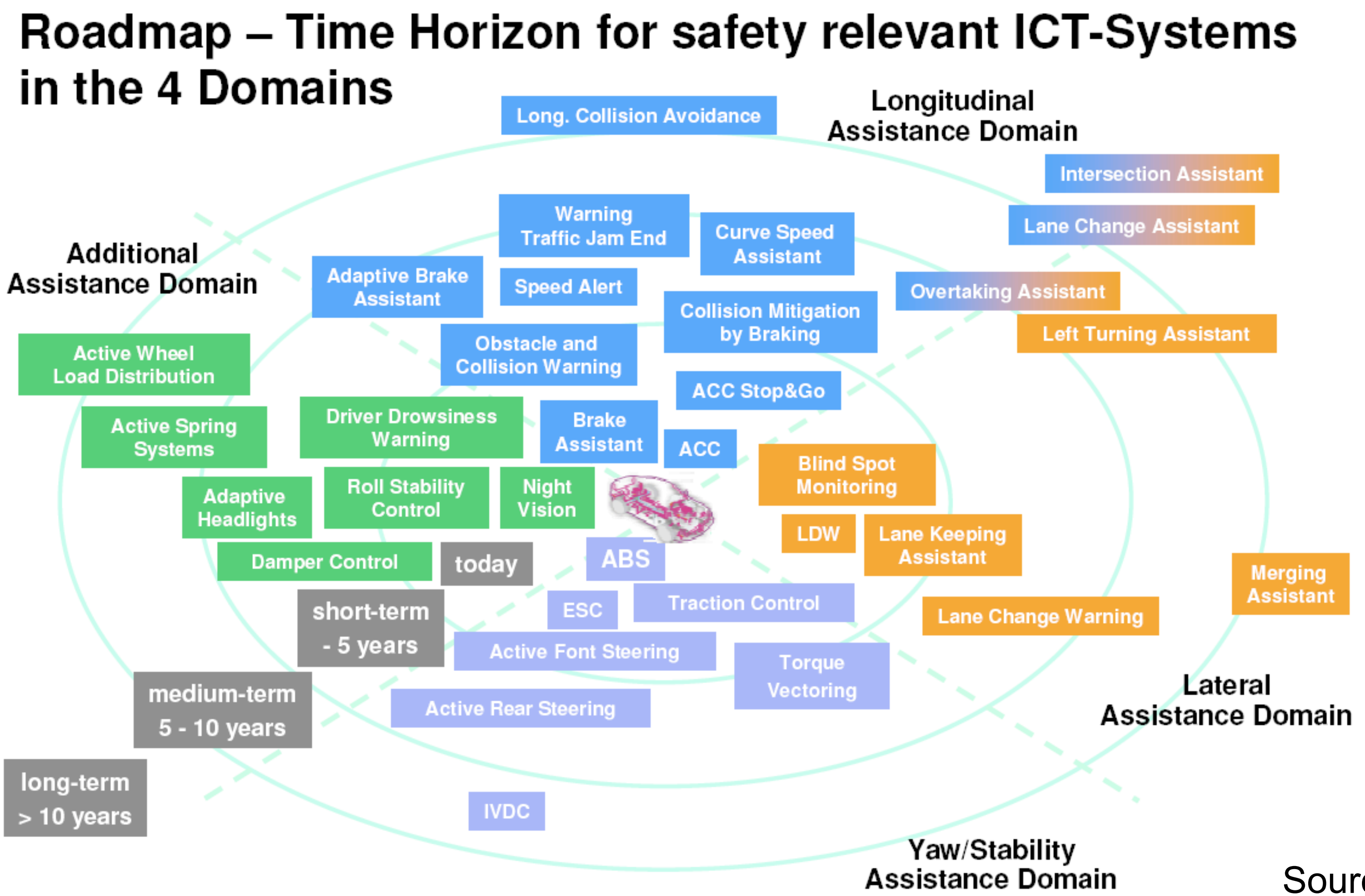
http://www.jemrolfe.co.uk/products.asp

http://www.aufdemmarkt.de/2007/10/22/
tomtom-go-720t-navigation-per-sprache/

Vehicle Systems

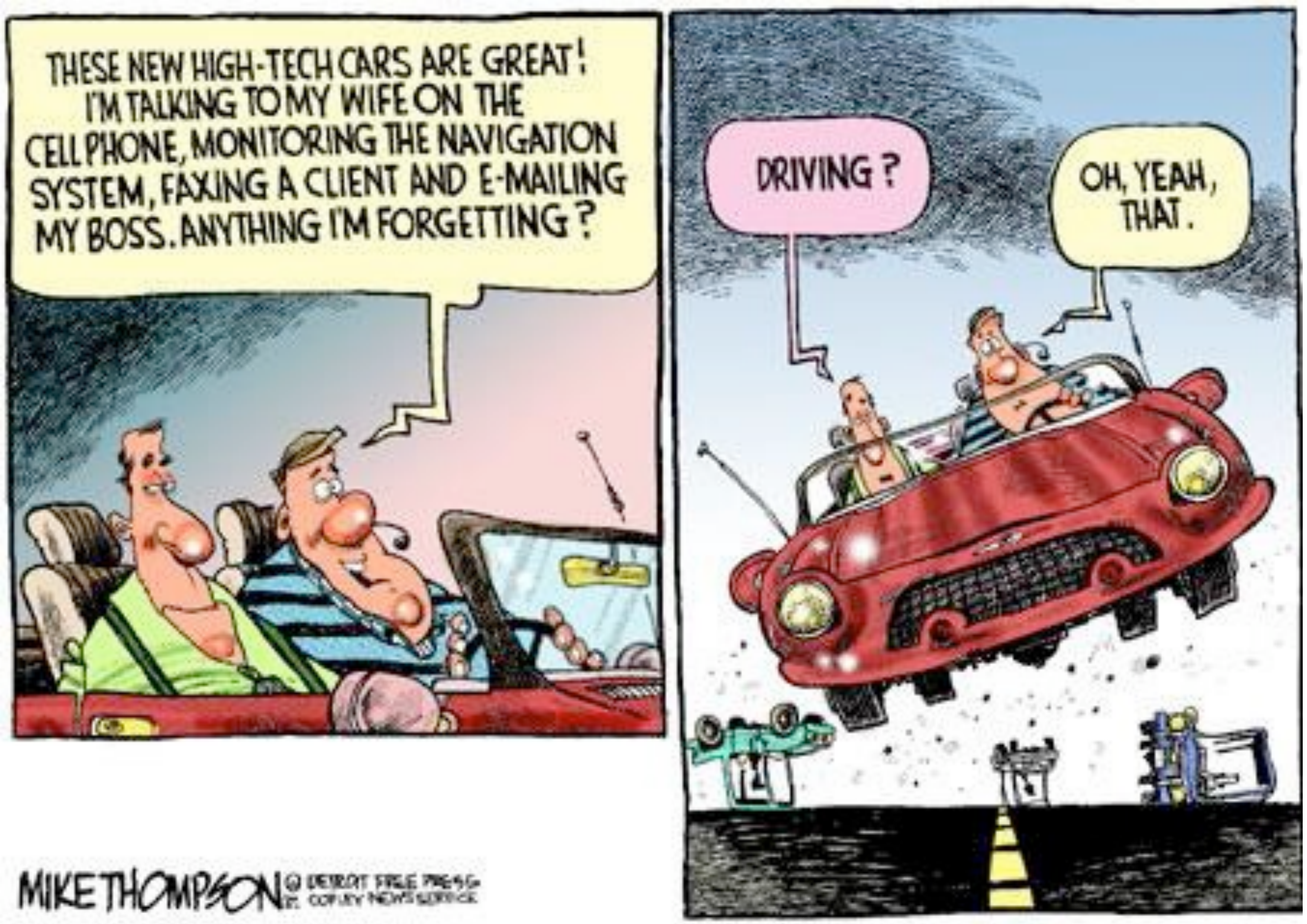
1. Driver Assistance Systems (ADAS): ABS, (adaptive) cruise control, parking assistant, night vision, lane departure warning, etc.
2. Passive safety systems: seat belts, crush zone, roll-over bar, etc.
3. Comfort systems: air conditioning, radio, seat heating, power window regulator, etc.
4. Driver Information Systems (IVIS): Navigation, telecommunication, traffic information, online services, etc.

Driver Assistance Systems
Assistance functions



Source: EU FP7 project eValue 2008

Driver distraction



Driver distraction

"Driver distraction occurs when:

- A driver is delayed in the recognition of information necessary to safely maintain the lateral and longitudinal control of the vehicle (the driving task)
- due to some event, activity, object or person, within or outside the vehicle
- that compels or tends to induce the driver's shifting attention away from fundamental driving tasks
- by compromising the driver's auditory, biomechanical, cognitive or visual faculties, or combinations thereof."

Pettitt, M., Burnett, G., Stevens, A. (2005) Defining driver distraction. Paper to be presented at World Congress on Intelligent Transport Systems, San Francisco, November 2005.
http://www.cs.nott.ac.uk/~geb/ITS%20WC-distraction.pdf

Driver Distraction

Visual Distraction

- Driver's visual field is blocked by objects
- Driver focuses on another visual target, such as an in-car route navigation system
- Loss of visual "attentiveness", "looked, but did not see"

Auditory Distraction

Biomechanical (Physical) Distraction

- Remove one or both hands from the steering wheel

Cognitive Distraction

- E.g. talking on a mobile phone, operate in-vehicle devices (navigation systems, talking to a passenger, …)

Young, K., Regan, M., Hammer, M. (2003). 'Driver Distraction: a review of the literature'. Monash University Accident Research Centre, Report No. 206. Monash University, Victoria, Australia.

Driver Distraction

Technology-based Distraction

- Mobile phones
- Navigation Systems
- In-vehicle Internet and E-Mail Facilities
- Entertainment Systems

Non Technology-based Distraction

- Eating and Drinking
- Smoking
- Passengers

Young, K., Regan, M., Hammer, M. (2003). 'Driver Distraction: a review of the literature'. Monash University Accident Research Centre, Report No. 206. Monash University, Victoria, Australia.

The 100-Car Naturalistic Driving Study

Collecting large-scale naturalistic driving data

No special instructions

No experimenter was present

Data collection instrumentation was obtrusive

Approximately 2.000.000 miles of driving

43.000 hours of data

241 primary and secondary driver participants

12 to 13 month data collection period for each vehicle

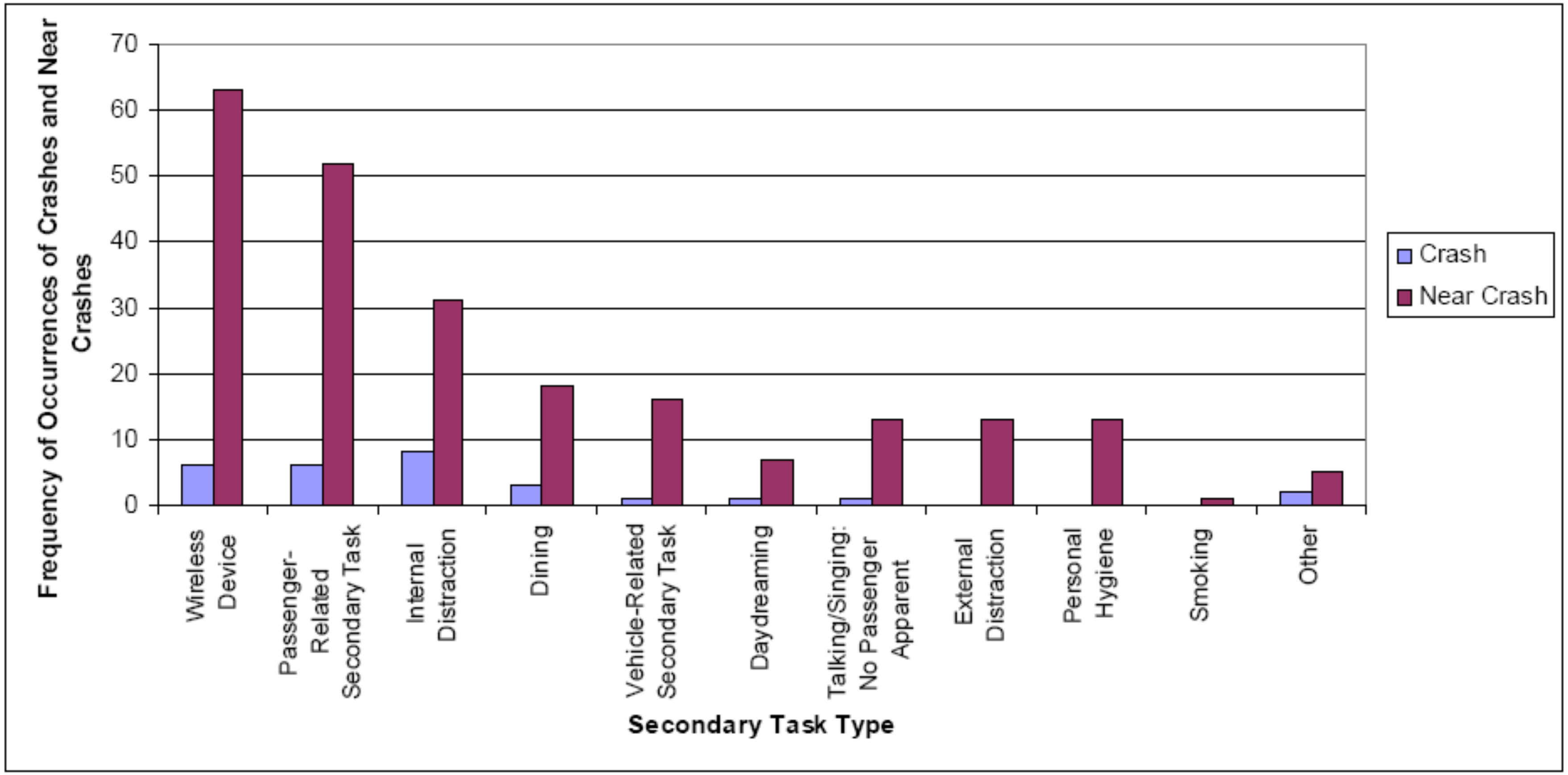
Five channels of video

The 100-Car Naturalistic Driving Study, Phase II – Results of the 100-Car Field Experiment, http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/14302_files/PDFs/14302.pdf

The 100-Car Naturalistic Driving Study

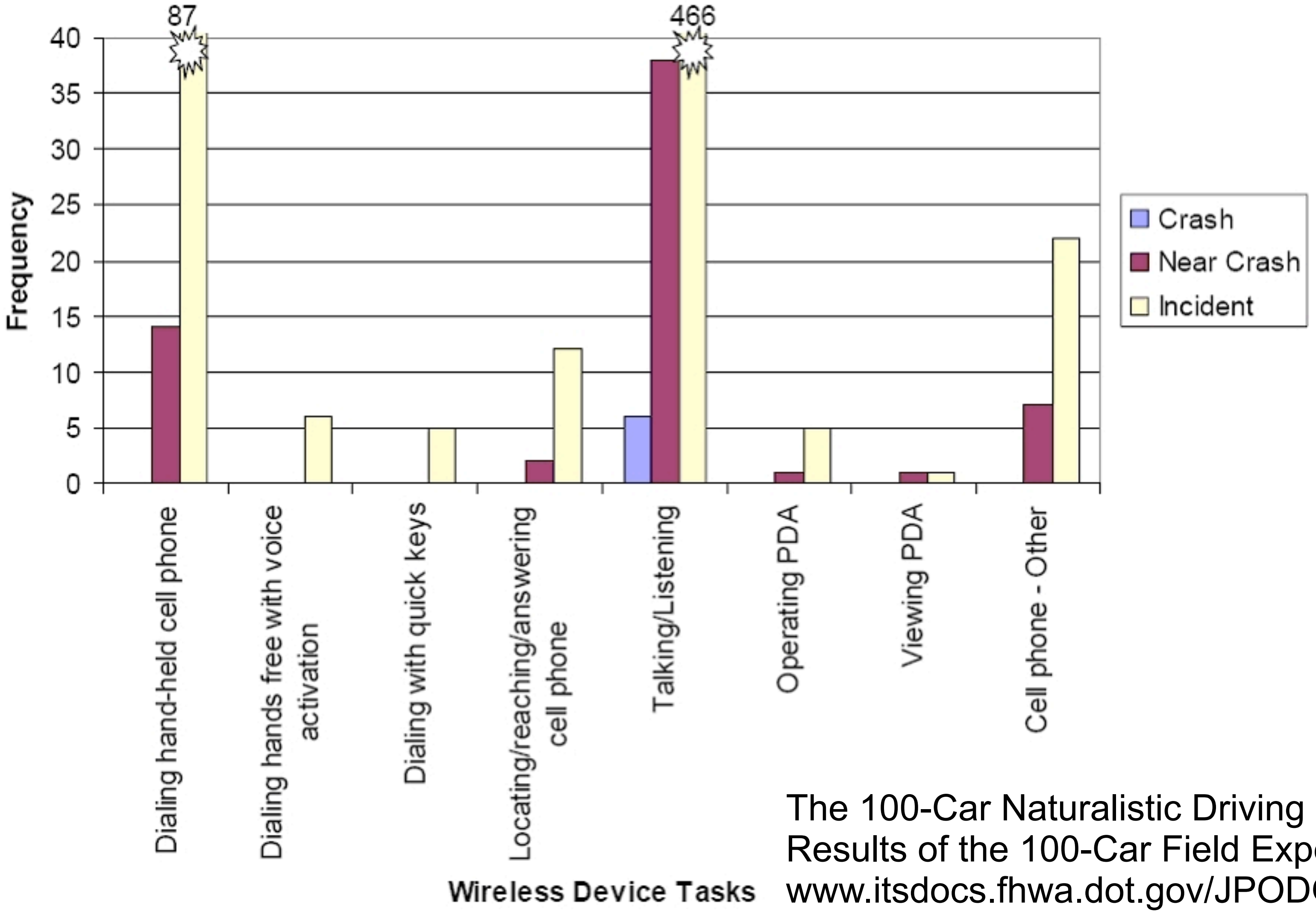
The 100-Car Naturalistic Driving Study, Phase II – Results of the 100-Car Field Experiment, http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/14302_files/PDFs/14302.pdf

The 100-Car Naturalistic Driving Study



The 100-Car Naturalistic Driving Study, Phase II – Results of the 100-Car Field Experiment, http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/14302_files/PDFs/14302.pdf

The 100-Car Naturalistic Driving Study



The 100-Car Naturalistic Driving Study, Phase II – Results of the 100-Car Field Experiment, http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/14302_files/PDFs/14302.pdf

Designing automotive user interfaces

Designers need to understand

who drives vehicle (users)

what in-vehicle tasks they perform

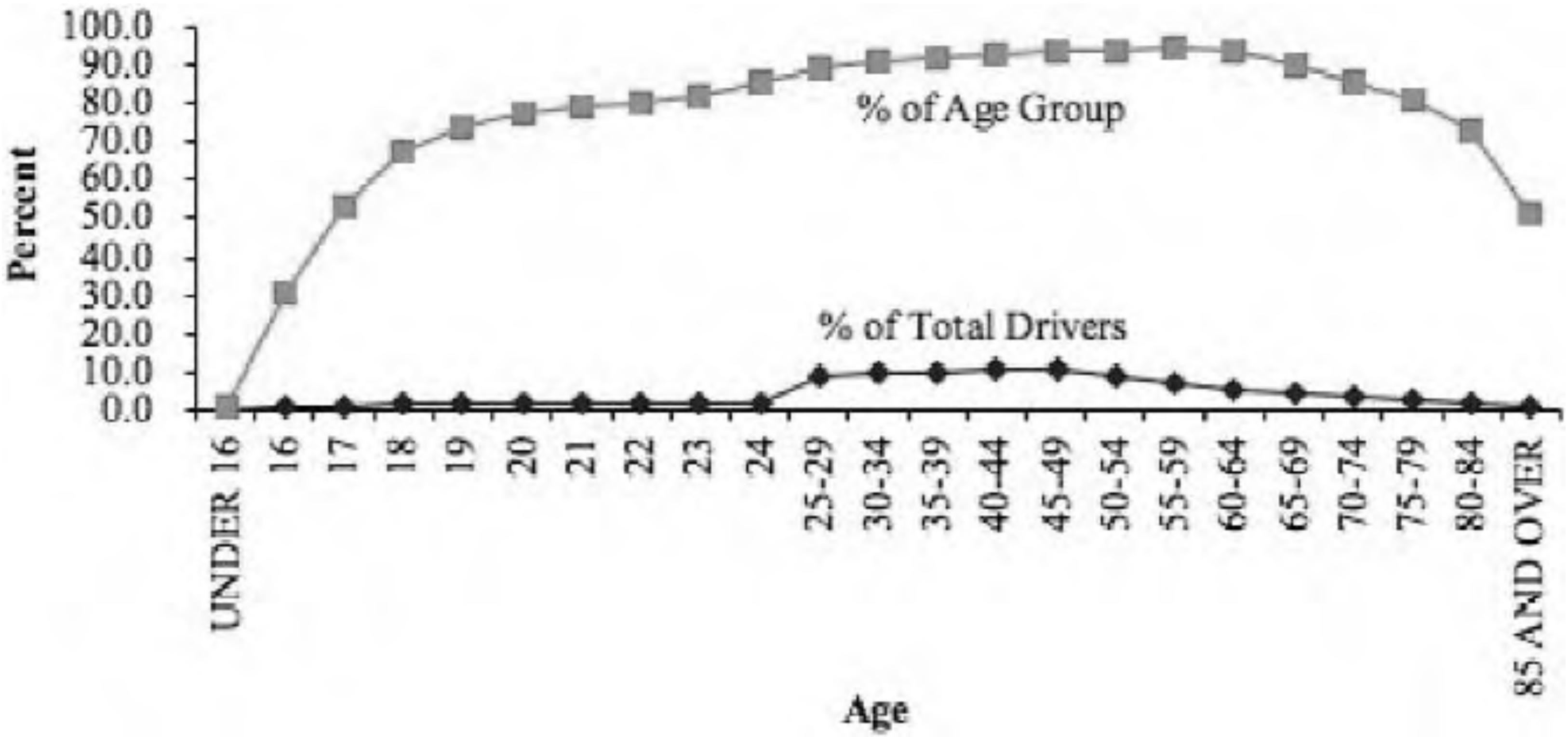
the driving task

task context

the consequence of task failures

Measuring driver and system performance

Who are the users?



Distribution of driver age groups developed from U.S. Department of Transportation data.

Green, P. (2003). Motor vehicle driver interfaces. In J.A. Jacko and A. Sears (Eds.), The Human-Computer Interaction Handbook. Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.

Usability

Guidelines Overview

Japan: JAMA Guidelines

http://www.jama.or.jp/safe/guideline/pdf/jama_guideline_v30_en.pdf

Northamerica: AAM Guidelines

http://iems.net/2005/webzine/newsletter/v10n2/Overseas_report/AAM_Guidelines.pdf

Europa: European Statement of Principles (ESoP)

http://eur-lex.europa.eu/LexUriServ/site/en/oj/2007/l_032/l_03220070206en02000241.pdf

European Statement of Principles on HMI for In-Vehicle Information and Communication Systems (ESoP)

COMMISSION RECOMMENDATION on safe and efficient in-vehicle information and communication systems: Update of the European Statement of Principles on human machine interface

22 December 2006

43 Principles with examples of use

ESoP

1. Overall Design Principles:

a. The system supports the driver and does not give rise to potentially hazardous behaviour by the driver or other road users.

b. The allocation of driver attention while interacting with system displays and controls remains compatible with the attentional demand of the driving situation.

c. The system does not distract or visually entertain the driver.

d. The system does not present information to the driver which results in potentially hazardous behaviour by the driver or other road users.

e. Interfaces and interface with systems intended to be used in combination by the driver while the vehicle is in motion are consistent and compatible.

ESoP

2. Installation Principles:

a. The system should be located and securely fitted in accordance with relevant regulations, standards and manufacturers instructions for installing the system in vehicles.

b. No part of the system should obstruct the driver's view of the road scene.

c. The system should not obstruct vehicle controls and displays required for the primary driving task.

d. Visual displays should be positioned as close as practicable to the driver's normal line of sight.

e. Visual displays should be designed and installed to avoid glare and reflections.

ESoP

3. Information Presentation Principles:

a. Visually displayed information presented at any one time by the system should be designed such that the driver is able to assimilate the relevant information with a few glances which are brief enough not to adversely affect driving.

b. Internationally and/or nationally agreed standards relating to legibility, audibility, icons, symbols, words, acronyms and/or abbreviations should be used.

c. Information relevant to the driving task should be accurate and provided in a timely manner.

d. Information with higher safety relevance should be given higher priority.

e. System generated sounds, with sound levels that can not be controlled by the driver, should not mask audible warnings from within the vehicle or the outside.

ESoP

4. Interface with Displays and Controls:

a. The driver should always be able to keep at least one hand on the steering wheel while interacting with the system.

b. The system should not require long and uninterruptible sequences of manual-visual interfaces. If the sequence is short, it may be uninterruptible.

c. The driver should be able to resume an interrupted sequence of interfaces with the system at the point of interruption or at another logical point.

d. The driver should be able to control the pace of interface with the system. In particular the system should not require the driver to make time-critical responses when providing inputs to the system.

e. System controls should be designed such that they can be operated without adverse impact on the primary driving controls.

f. The driver should have control of the loudness of auditory information where there is likelihood of distraction.

g. The system's response (e.g. feedback, confirmation) following driver input should be timely and clearly perceptible.

h. Systems providing non-safety related dynamic visual information should be capable of being switched into a mode where that information is not provided to the driver.

ESoP

5. System Behaviour Principles:

a. While the vehicle is in motion, visual information not related to driving that is likely to distract the driver significantly should be automatically disabled, or presented in such a way that the driver cannot see it.

b. The behaviour of the system should not adversely interfere with displays or controls required for the primary driving task and for road safety.

c. System functions not intended to be used by the driver while driving should be made impossible to interact with while the vehicle is in motion, or, as a less preferred option, clear warnings should be provided against the unintended use.

d. Information should be presented to the driver about current status, and any malfunction within the system that is likely to have an impact on safety

ESoP

6. Information about the System:

a. The system should have adequate instructions for the driver covering use and relevant aspects of installation and maintenance.

b. System instructions should be correct and simple.

c. System instructions should be in languages or forms designed to be understood by the intended group of drivers.

d. The instructions should clearly state which functions of the system are intended to be used by the driver while driving and those which are not.

e. Product information should be designed to accurately convey the system functionality.

f. Product information should make it clear if special skills are required to use the system as intended by the manufacturer or if the product is unsuitable for particular users.

g. Representations of system use (e.g. descriptions, photographs and sketches) should neither create unrealistic expectations on the part of potential users nor encourage unsafe use.

ESoP Overall Goals

No potential hazard for the driver

No distraction or visual entertainment

No Information which results to hazardous behaviour

Consistent and compatible HMI

http://www.ktmc.de/pdfs/080603_SafetyDriverDistraction.PDF

Measuring Safety and Usability

PC

- Task completion Time
- Errors
- Rating ease of use

Automotive (additionally)

- Driving performance
- Ratings of workload
- Measures of situation awareness
- Measures of object and event detection
- Physiological measures
- Subjective measures

Driving-Specific Usability Measures

Category	Measure
Lateral	Number of lane departures Mean and standard deviation of lane position Number of larger steering wheel reversals Time to line crossing
Longitudina l	Number of collisions Time of collision Headway (time or distance to lead vehicle) Mean and standard deviation of speed
Visual	Number of glances Mean glance duration Maximum glance duration Total eyes-off-the-road time

Green, P. (2003). Motor vehicle driver interfaces. In J.A. Jacko and A. Sears (Eds.), The Human-Computer Interaction Handbook. Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.

Methods for Evaluating Automotive User Interface

1. Occlusion
2. Peripheral Detection Task
3. Lane Change Task
4. Low-fidelity simulator (lab based)
5. High-fidelity Simulator
6. Field Study

Occlusion

laboratory-based method

focuses on the visual demand of in-vehicle systems

Simulation of successive changes of glances between traffic situation and information systems

Computer-controlled goggles with LCDs as lenses which can open and shut in a precise manner

Speed (TTT, TSOT) and accuracy of subjects task performance (errors)

www.noehumanist.org/documents/presentations_stackeholders_lyon2008/05_HUMANIST-SF2008_Krems.pdf

Burnett, G.E. (2008) Designing and evaluating in-car user-interfaces.

Peripheral Detection Task PDT

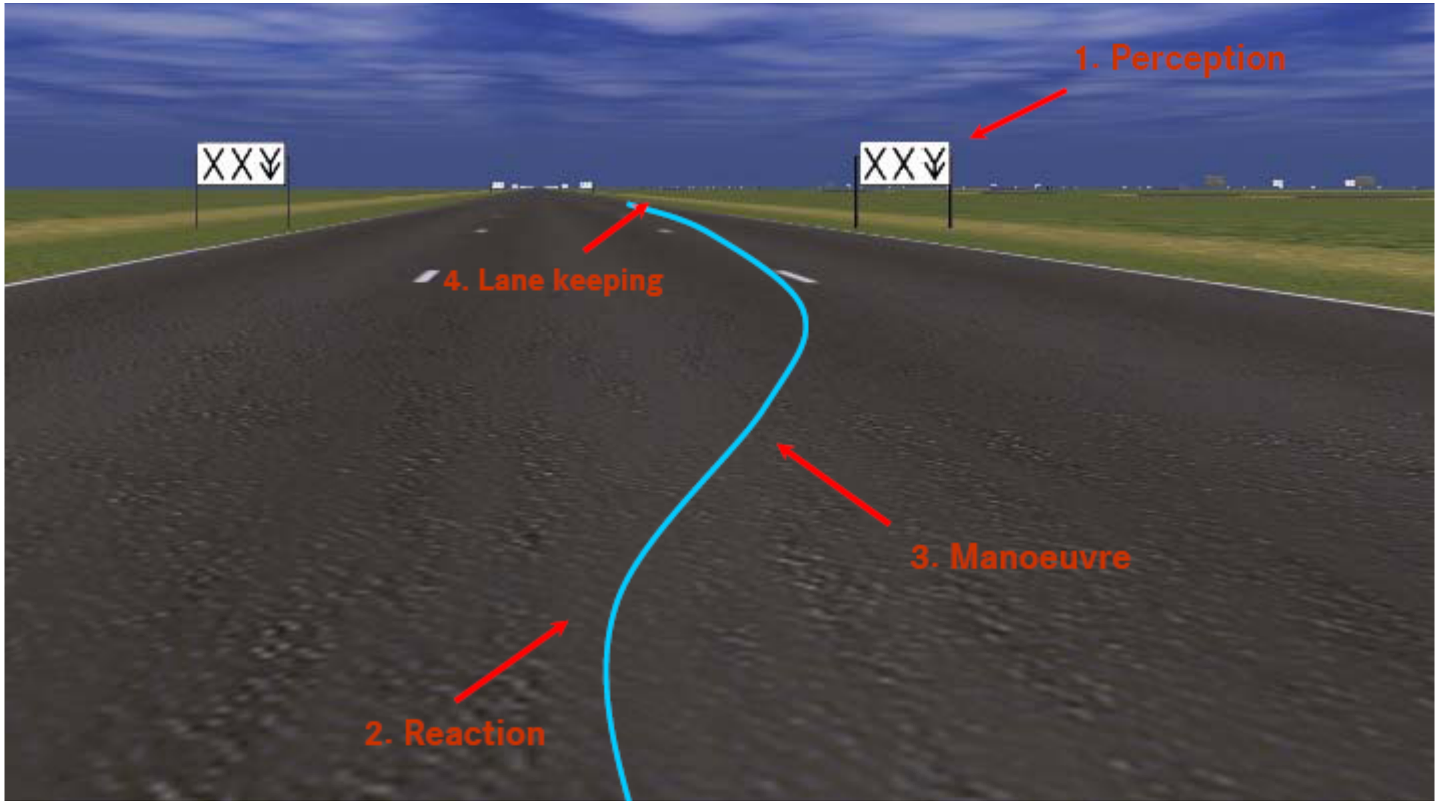
Task: detection of peripheral stimuli

Simulation of visual workload when simultaneously driving and interacting with IVIS

www.noehumanist.org/documents/presentations_stackeholders_lyon2008/05_HUMANIST-SF2008_Krems.pdf

Lane Change Test (LCT)

PC-based driving simulation

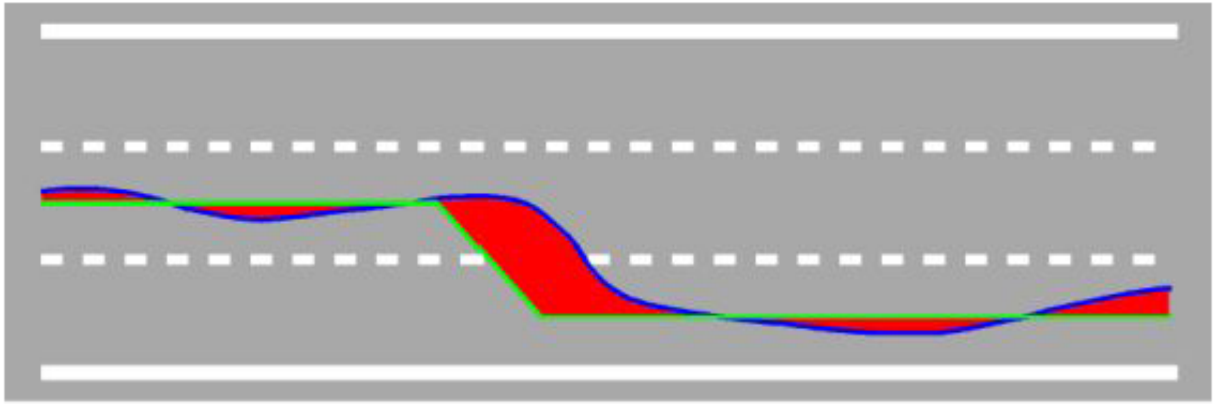


http://ppc.uiowa.edu/drivermetricsworkshop/documents/LCToverviewMattes.pdf

Lane Change Test (LCT)

Analysis

Area indicates driving quality.



The area is sensitive to

- Perception (missed sign)
- Reaction
- Manoeuvre
- Lane keeping

This comparison of the behavioral data to the normative model provides one single index of performance which allows automatic and objective analysis.

http://ppc.uiowa.edu/drivermetricsworkshop/documents/LCToverviewMattes.pdf

Low fidelity Driving Simulator

CARS-“Configurable Automotive Research Simulator”

Open source

Low cost (regarding hardware requirements)

Adjustable

Three components

- Map editor
- Simulator
- Analysis tool

High-fidelity Driving Simulator

Very expensive

Sometimes the only possible way for studies (danger)

Experimental control

Large number of driving performances

Simulator sickness

Validity not easy to assess

www.noehumanist.org/documents/presentations_stackeholders_lyon2008/05_HUMANIST-SF2008_Krems.pdf

Field Test

Need instrumented car

Expensive

Ethical limitations (e.g. fatigue warning)

Many factors uncontrolled (e.g. traffic situation)

High validity

www.noehumanist.org/documents/presentations_stackeholders_lyon2008/05_HUMANIST-SF2008_Krems.pdf

MINI center globe UI
3D display concept for cars

http://www.dontmiss.fr/img200810/Mini.jpg

http://gigazine.jp/img/2008/10/08/future_dashboard/custom_
1223312335024_Mini_Crossover_Concept_m.jpg

http://www.youtube.com/watch?v=aSWr_Craqos

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Young, K., Regan, M., Hammer, M. (2003). 'Driver Distraction: a review of the literature'. Monash University Accident Research Centre, Report No. 206. Monash University, Victoria, Australia

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JAMA: http://www.jama.or.jp/safe/guideline/pdf/jama_guideline_v30_en.pdf

AAM: http://iems.net/2005/webzine/newsletter/v10n2/Overseas_report/AAM_Guidelines.pdf

EPoS: http://eur-lex.europa.eu/LexUriServ/site/en/oj/2007/l_032/l_03220070206en02000241.pdf

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Josef Krems, Methodologies, http://www.noehumanist.org/documents/presentations_stackeholders_lyon2008/05_HUMANIST-SF2008_Krems.pdf

ISO 16673:2007 Road vehicles -- Ergonomic aspects of transport information and control systems -- Occlusion method to assess visual demand due to the use of in-vehicle systems

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Green, P. (2003). Motor vehicle driver interfaces. In J.A. Jacko and A. Sears (Eds.), The Human-Computer Interaction Handbook. Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.

Dagmar Kern, Paul Marshall, Eva Hornecker, Yvonne Rogers and Albrecht Schmidt: Enhancing Navigation Information with Tactile Output Embedded into the Steering Wheel.
In: Proceedings of the Seventh International Conference on Pervasive Computing, Pervasive'09. Springer Berlin / Heidelberg Nara, Japan 2009, S. 42-58.

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Tai, G., Kern, D., Schmidt, A. Bridging the Communication Gap: A Driver-Passenger Video Link, Mensch und Computer 2009, Berlin