Institute for Transport Studies
FACULTY OF ENVIRONMENT

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Human-in-the-Loop Simulation for Human Factors Challenges and Opportunities of Automated Vehicles

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Leader, Human Factors and Safety Group
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Leeds Advanced Driving Simulator (LADS)

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urban DICTIONARY

In Britain…this word generally means a **young male.** However in modern Britain this word has come to mean someone who engages in typical testosterone-driven behaviour such as **drinking, sport and having a laugh with mates**

Driving Simulators for Human Factors Research

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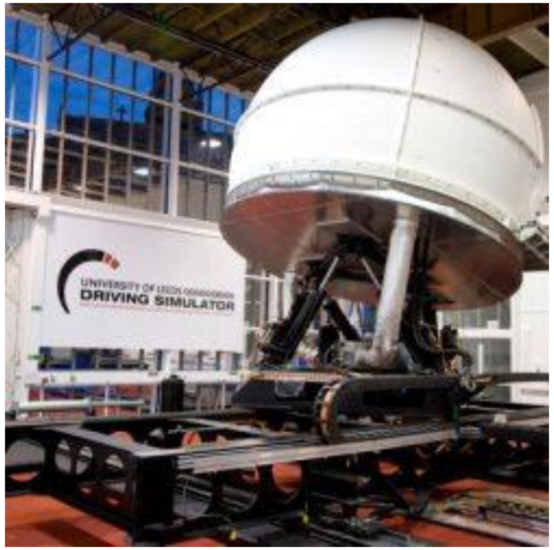
Innovative Reliable Repeatable Controllable Affordable Ethical



University of Leeds Driving Simulator (UoLDS) and Virtuocity

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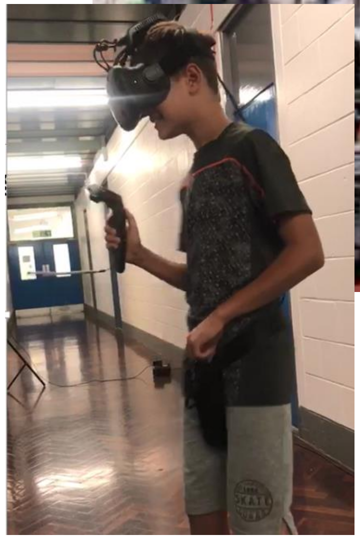
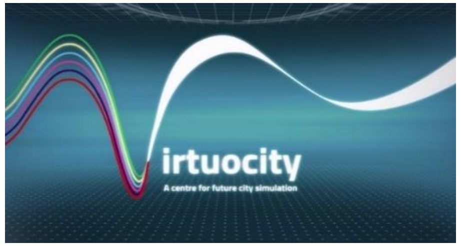
- Driver fatigue
- Driver distraction (EU projects HASTE and AIDE, UK project FORWARN): In-vehicle systems, differences between auditory and visual distraction
- Vehicle automation: effect on drivers (UK project EASY, EU project Citymobil1, AdaptIVe, L3Pilot)
- Vehicle automation: interaction of pedestrians and other road users (Citymobil2, InterACT)





Driver behaviour/road safety research

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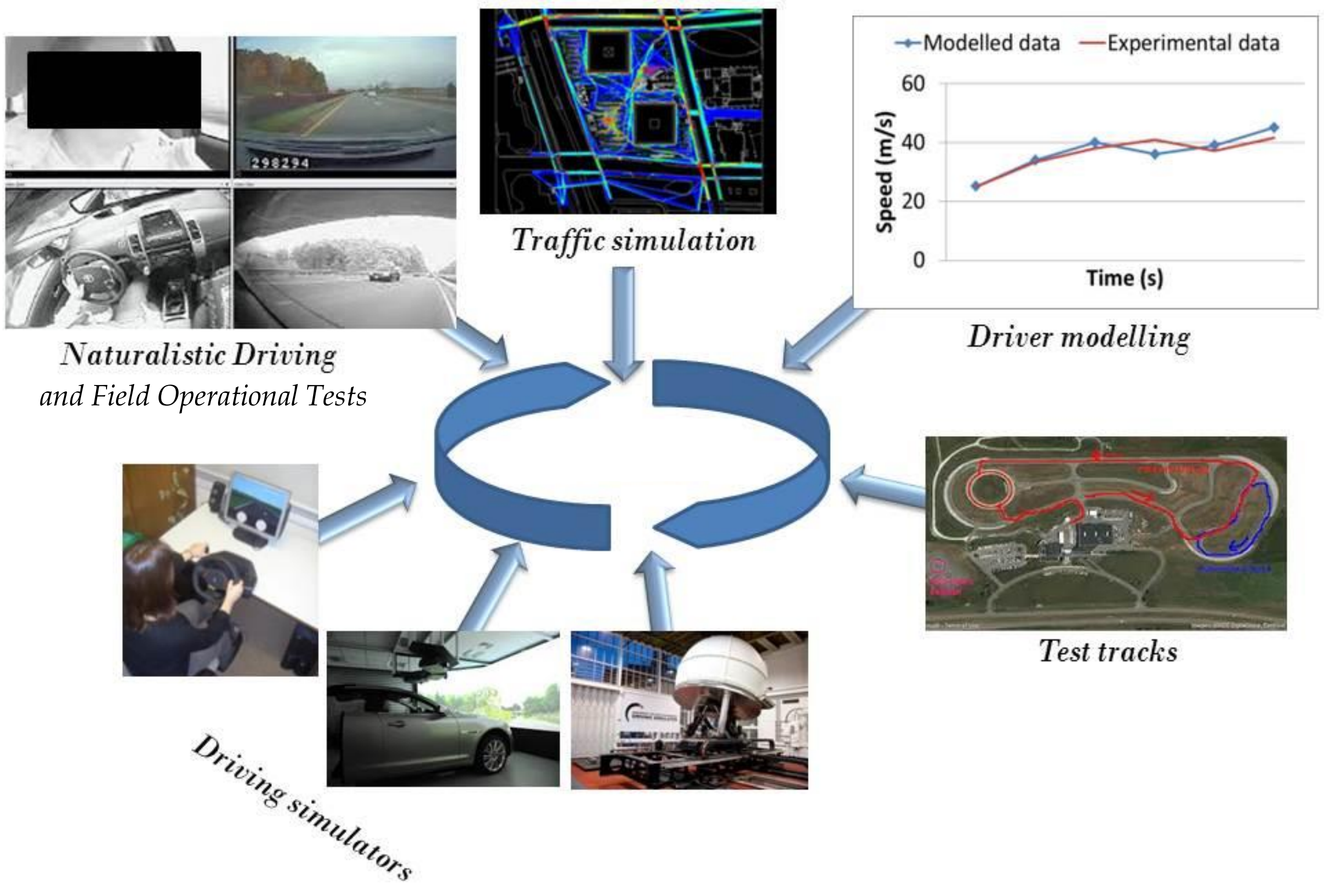

Example of a (semi) successful story

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- Driver distraction leads to crashes
- 20+ years of simulator-based research (plus observational, epidemiological etc.)
  - Poor lateral and longitudinal control (Jamson & Merat, 2005; Kountouriotis & Merat, 2016)
  - Slower reaction time to hazards and lead vehicle braking (Caird et al., 2008; Horrey & Wickens, 2006)
  - Lower situation awareness (Kass et al., 2007)

Not all distractions are equal

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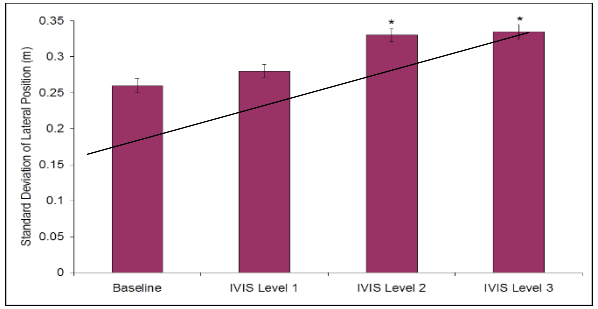
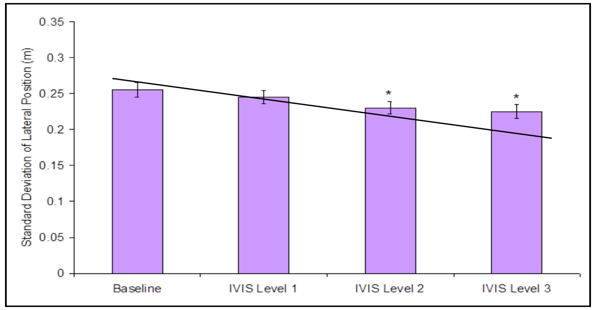
VISUAL

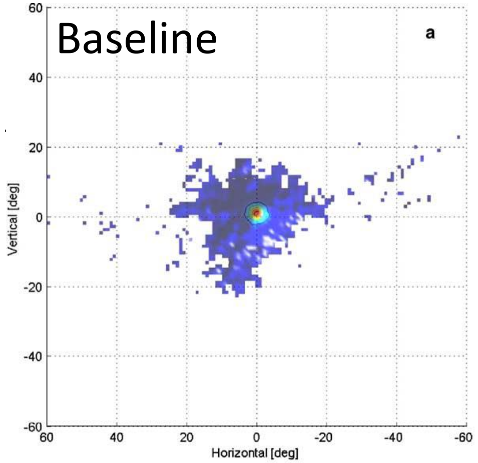
NON-VISUAL



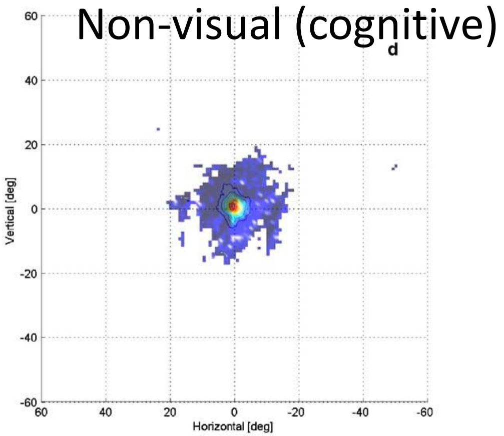


Standard Deviation of Lateral Position

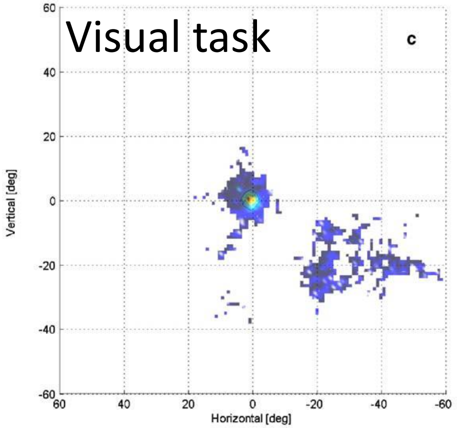
Jamson & Merat, 2005



Visual task baseline Mwy Field



Auditory task SLv3 Mwy Field



Visual task SLv3 Mwy Field

Victor et al, 2005

But then in the real world…

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- Hands-free phone conversations have a “protective” effect.
- Driving during a hands free phone conversation <u>10 times safer</u> than free driving (Victor et al., 2015).

?? Simulator validity, realism, risk perception, etc. ??

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

Good distractions: Testing the effects of listening to an audiobook on driving performance in simple and complex road environments

Robert J. Nowosielski*, Lana M. Trick, Ryan Toxopeus

Department of Psychology University of Guelph, Guelph, Ontario, N1G 2W1, Canada

Effect on policy and behaviour?

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Ban on hands free and hand-held 'phones

- Japan
- United States – No state bans the use of all cell phones for *all* adult drivers of *non-commercial vehicle*
  - California – As of January 1, 2017, it is illegal to hold and use an electronic device while driving. U requires the driver to touch or swipe the screen is a
  - Louisiana has a ban that applies to all drivers c
  - As of January 2012, 30 states plus Washingtor
    - Illinois – The ban applies to drivers *under 1*
    - Kentucky – Allows the use of GPS features
    - Michigan – Does not allow teens with a Gra
      - When using a voice operated system built in
      - When reporting a crime, medical emergency
    - New Jersey – See Kyleigh's Law.
  - Washington State – As of July 23, 2017, anyone ca Islands.[65]
  - 19 states, plus Washington, D.C., ban the use of ce
  - The cities of San Antonio and Austin, Texas have e

- Argentina
- Australia
- Austria
- Bahrain
- Belgium

Maharashtra, Delhi, Andrapradesh.

- Iran
- Ireland
- Isle of Man
- Israel
- Italy

Ban on hand-held only

- Jersey
- Jordan
- Kenya
- Kuwait as of May 1, 2008
- Lithuania

- United States – Only in:[62][79]
  - Alabama – At least in:
    - The city of Montgomery[80]
  - Arkansas – Statewide ban for drivers between 18 and 20, and all drivers in school zones and road construction areas. In addition:
    - The city of Fort Smith has a blanket ban.
  - California
  - Connecticut
  - Delaware[81]
  - District of Columbia
  - Hawaii – No state law, but all counties have enacted distracted driving laws that make hand-held phone use illegal.[82]
  - Illinois
  - Louisiana – Drivers with learner's or intermediate licenses, regardless of age.
  - Maryland
  - Michigan
    - The city of Detroit
    - The city of Troy, Michigan
  - Nevada
  - New Hampshire
  - New Jersey
  - New Mexico – Blanket ban in state vehicles statewide & within the city of Albuquerque city limits.
  - New York
  - Oregon
  - Texas – The cities of San Antonio and Austin have a blanket ban effective January 1, 2015 for all hand-held mobile phones, MP3 players, and GPS navigators not permanently affixed to a motor vehicle (e.g. using a smart phone with a GPS navigator app) – civil fines run up to $500.
  - Vermont
  - Washington
  - West Virginia[83]

Possible solution to distraction?

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My least favourite quote

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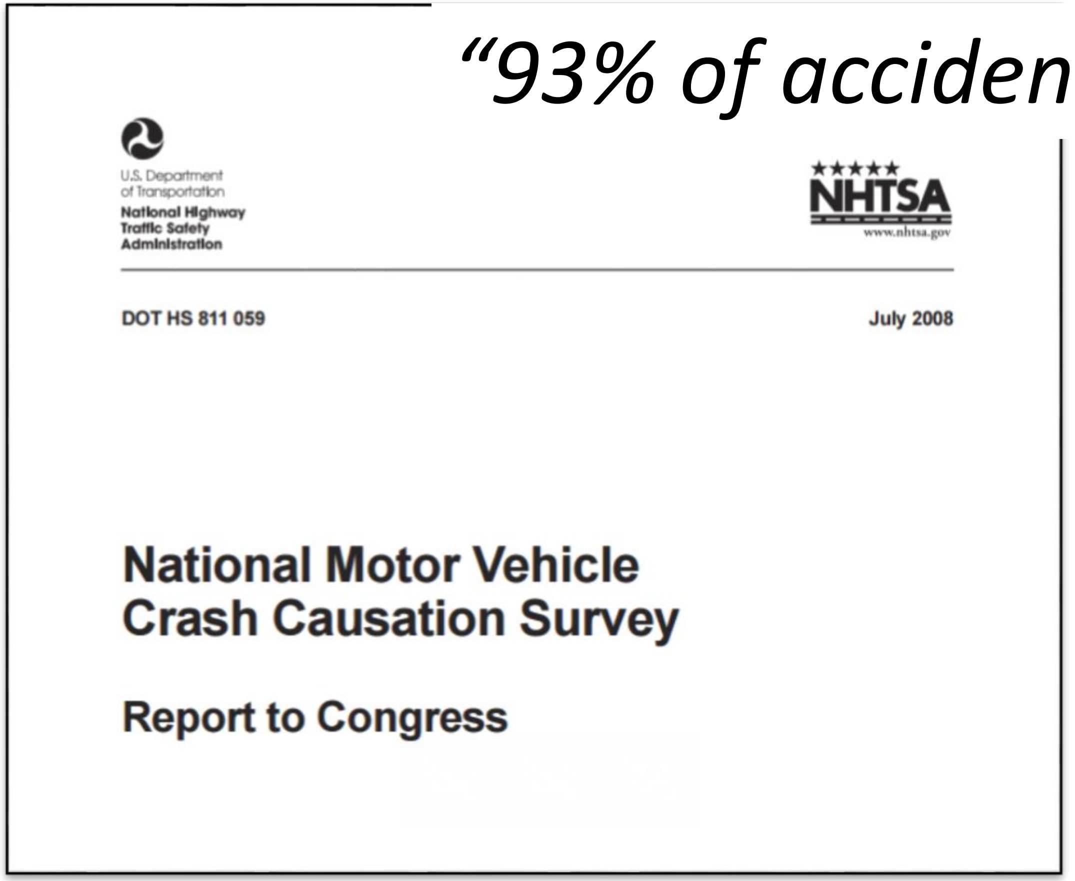
“93% of accidents are caused by human error”


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

NHTSA
www.nhtsa.gov

DOT HS 811 059

July 2008

National Motor Vehicle Crash Causation Survey

Report to Congress

Automation doesn’t necessarily eliminate the role of humans or the error…

it just changes it (Lee, 2018)

(and sometimes confuses it!)

Testing and Automated Vehicles

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Why Waiting for Perfect Autonomous Vehicles May Cost Lives | RAND
www.rand.org

Tests uncover issues for advanced features
www.iihs.org

Self-driving cars will kill people and we need to accept that
thenextweb.com

Franken-algorithms: the deadly consequences of unpredictable code | Technology | The
www.theguardian.com

My favourite…

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"If you are not embarrassed by the first version of your product, you've launched it too late"

Reid Hoffman (Co-founder, LinkedIn)

Move Slowly, and Don't Break Things – Future Crunch – Medium
medium.com

Dr Angus Hervey

→Unintended consequences of technology

- →Facial recognition
- →Automatic Number Plate Recognition

→Machine learning and software errors

→Humans

- → distractions/boredom/loss of skill/ incorrect mental model/optimism bias…….

Robust Physical-World Attacks on Deep Learning Models

Kevin Eykholt, Ivan Evtimov, Earlence Fernandes, Bo Li, Amir Rahmati, Chaowei Xiao, Atul Prakash, Tadayoshi Kohno, Dawn Song

(Submitted on 27 Jul 2017 (v1), last revised 10 Apr 2018 (this version, v5))

Lessons from Aviation and Medicine

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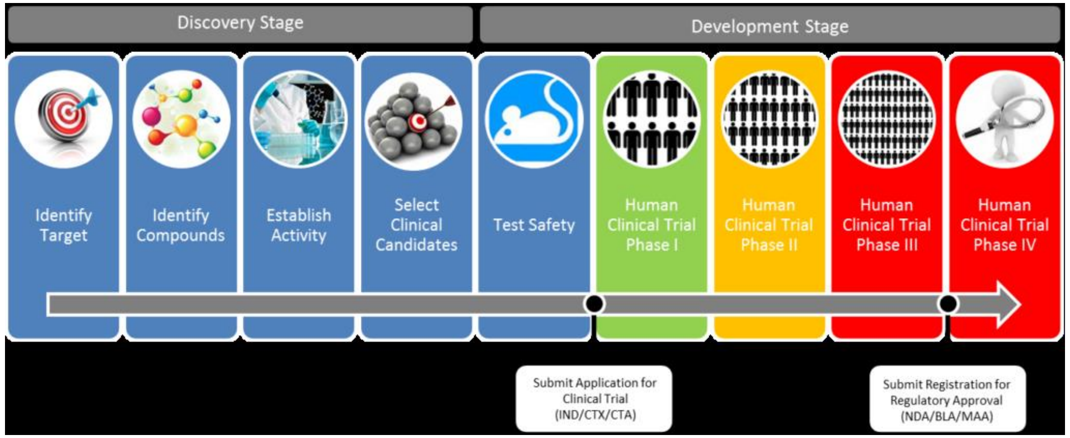
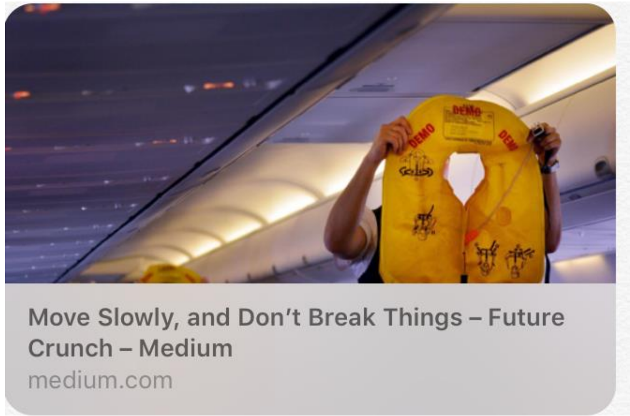


https://scientifist.com/timeline-pharmaceutical-drug-development-idea-market/

~12 years



- A change in culture is needed
- The slow and boring stuff!

From “*move fast and break things*”

→ Ethical. “*first do no harm*”

→ Checklists, training, test test test

Driving simulators are cool again!

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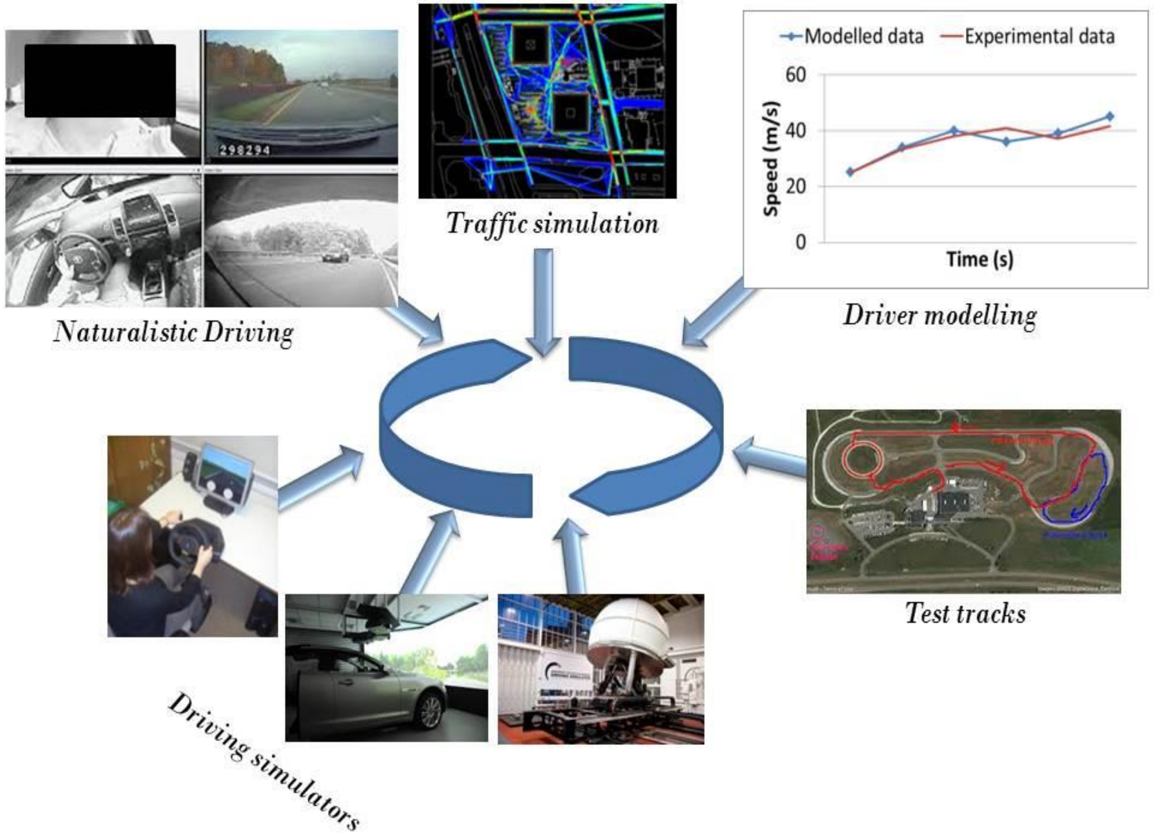

Sample of results from our studies at Leeds

SAE Level 2 Automated Driving

Where do drivers look?

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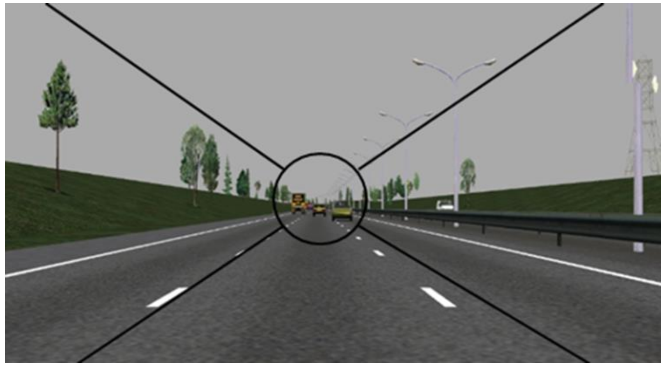
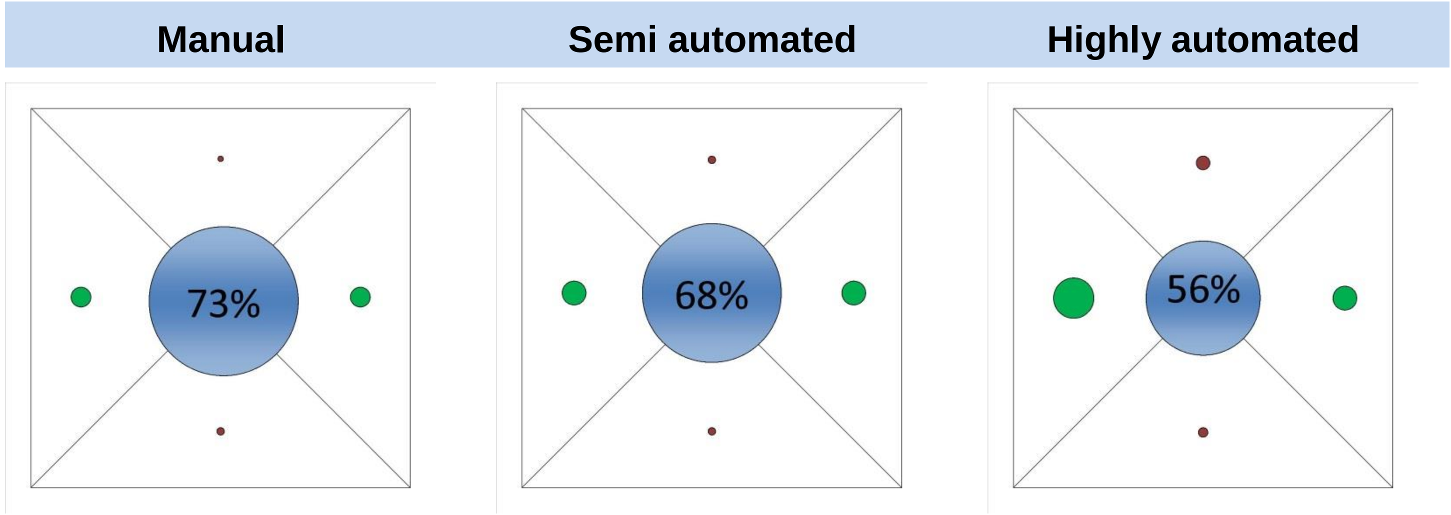


Loss of situation awareness – are “*Out of the loop*”



Merat , et al., 2014b

The “Out-of-the-Loop” Concept in Automated Driving: Proposed definition, measures and implications

Natasha Merat[1*], Bobbie Seppelt[2], Tyron Louw[1], Johan Engström[3], John D. Lee[4], Emma Johansson[5], Charles A. Green[6], Satoshi Katazaki[7], Chris Monk[8], Makoto Itoh[9] Daniel McGehee[10], Takashi Sunda[11], Kiyozumi Unoura[12], Trent Victor[13], Anna Schieben[14] and Andreas Keinath[15]

Simulating the "out of the loop" phenomenon

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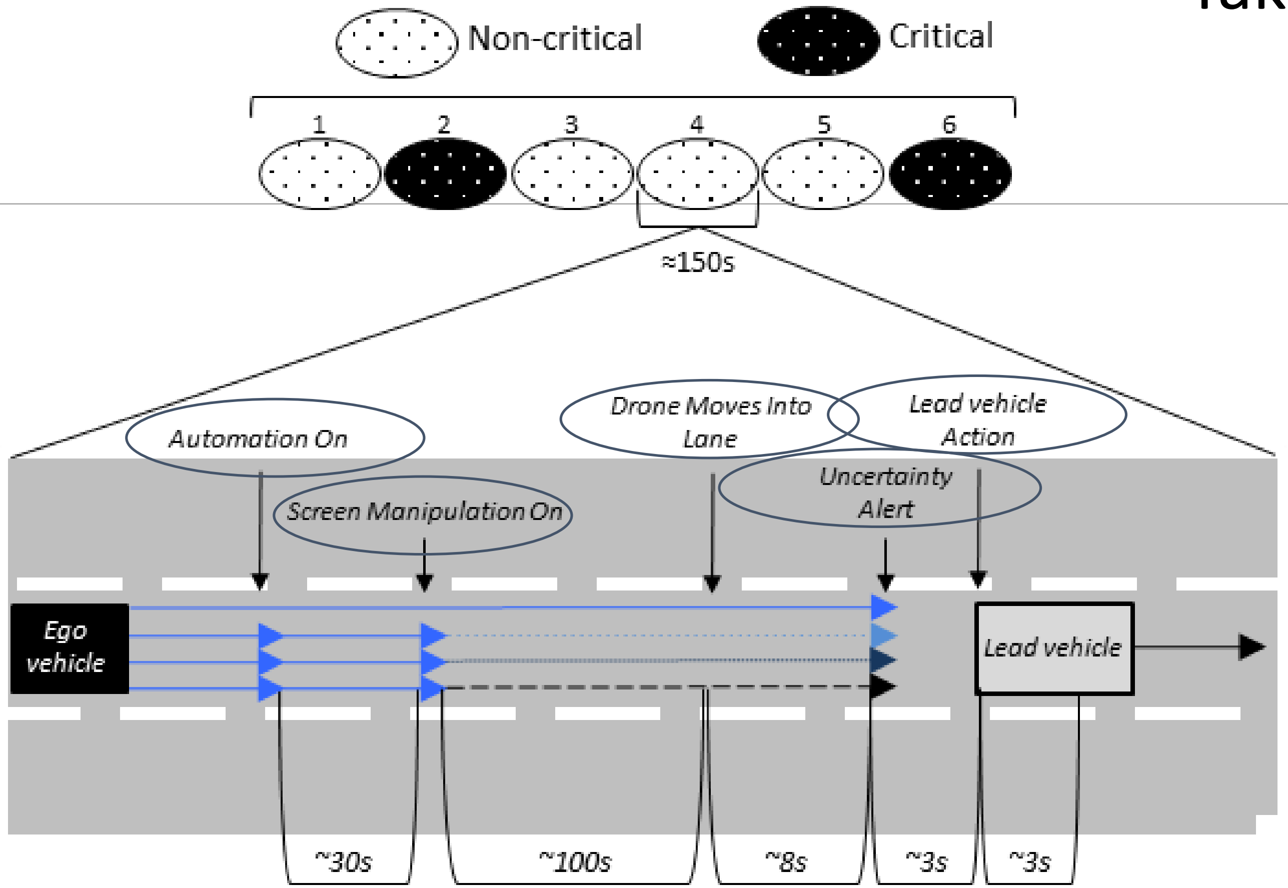
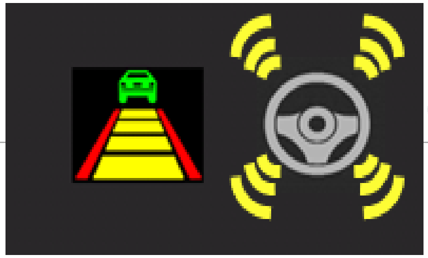
AdaptIVe

Automated Driving Applications and Technologies for Intelligent Vehicles

Uncertainty Alert, NOT Take Over request

Design



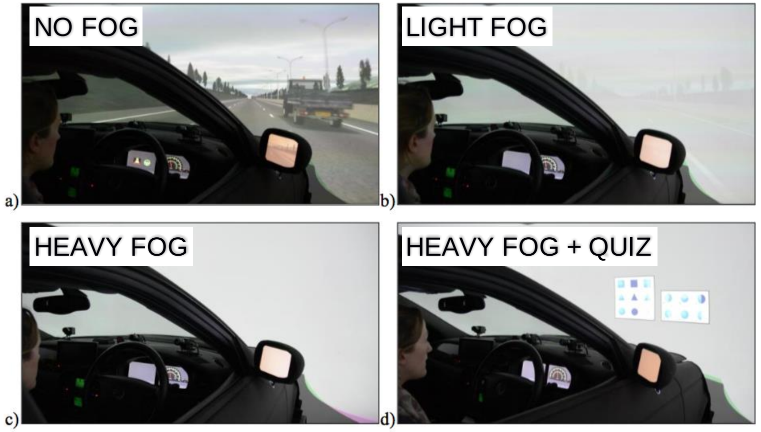


No Fog

Light Fog

Heavy Fog

Heavy Fog + Task



Innovative Reliable Repeatable Controllable Affordable

Automated Driving Applications and Technologies for Intelligent Vehicles

Simulating the "out of the loop" phenomenon

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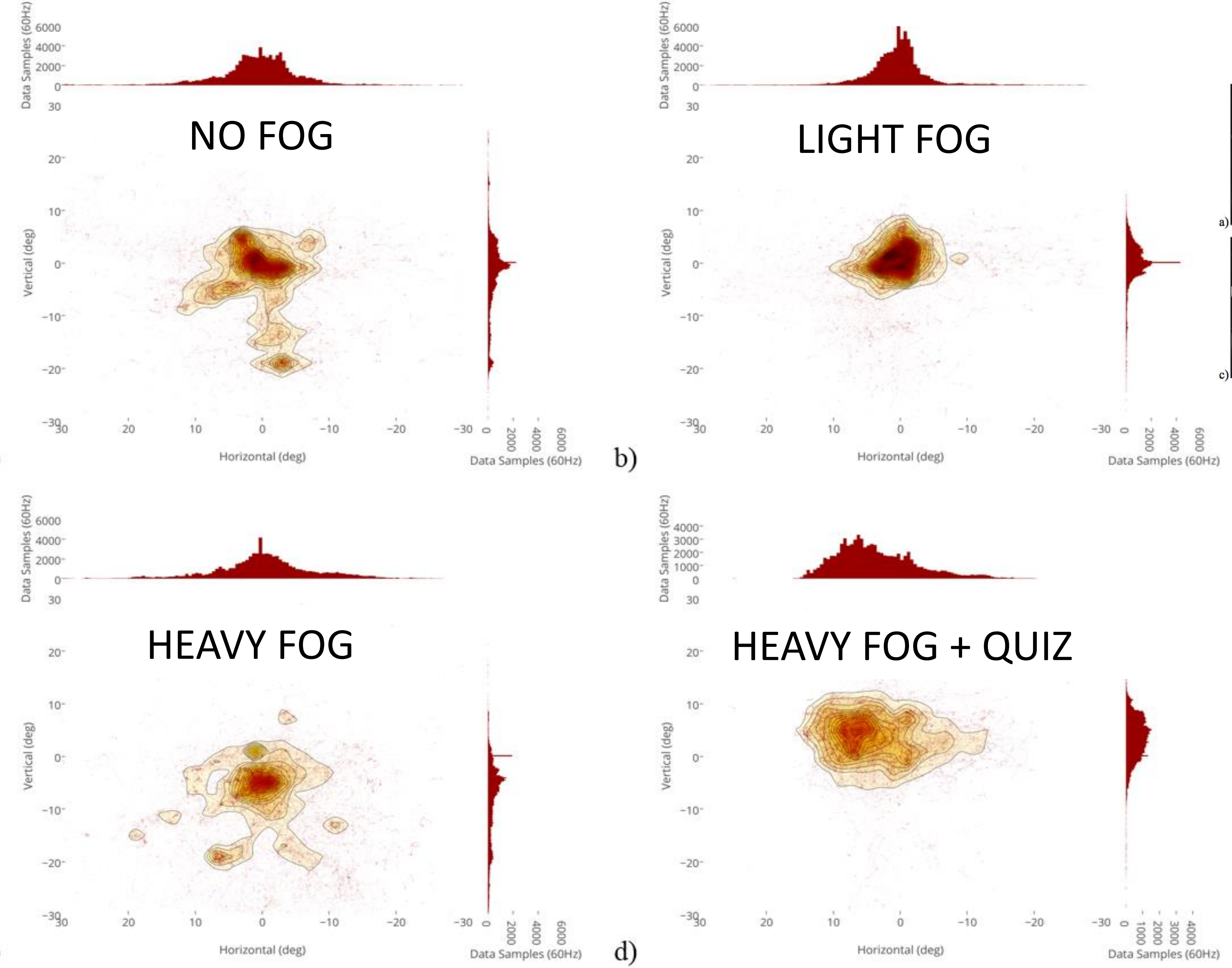
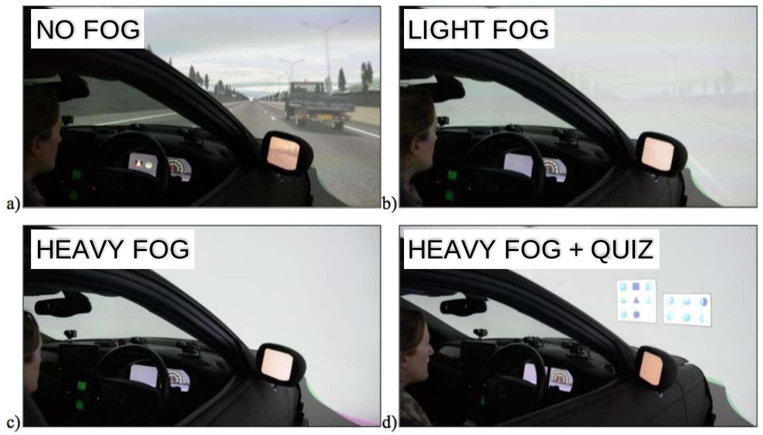
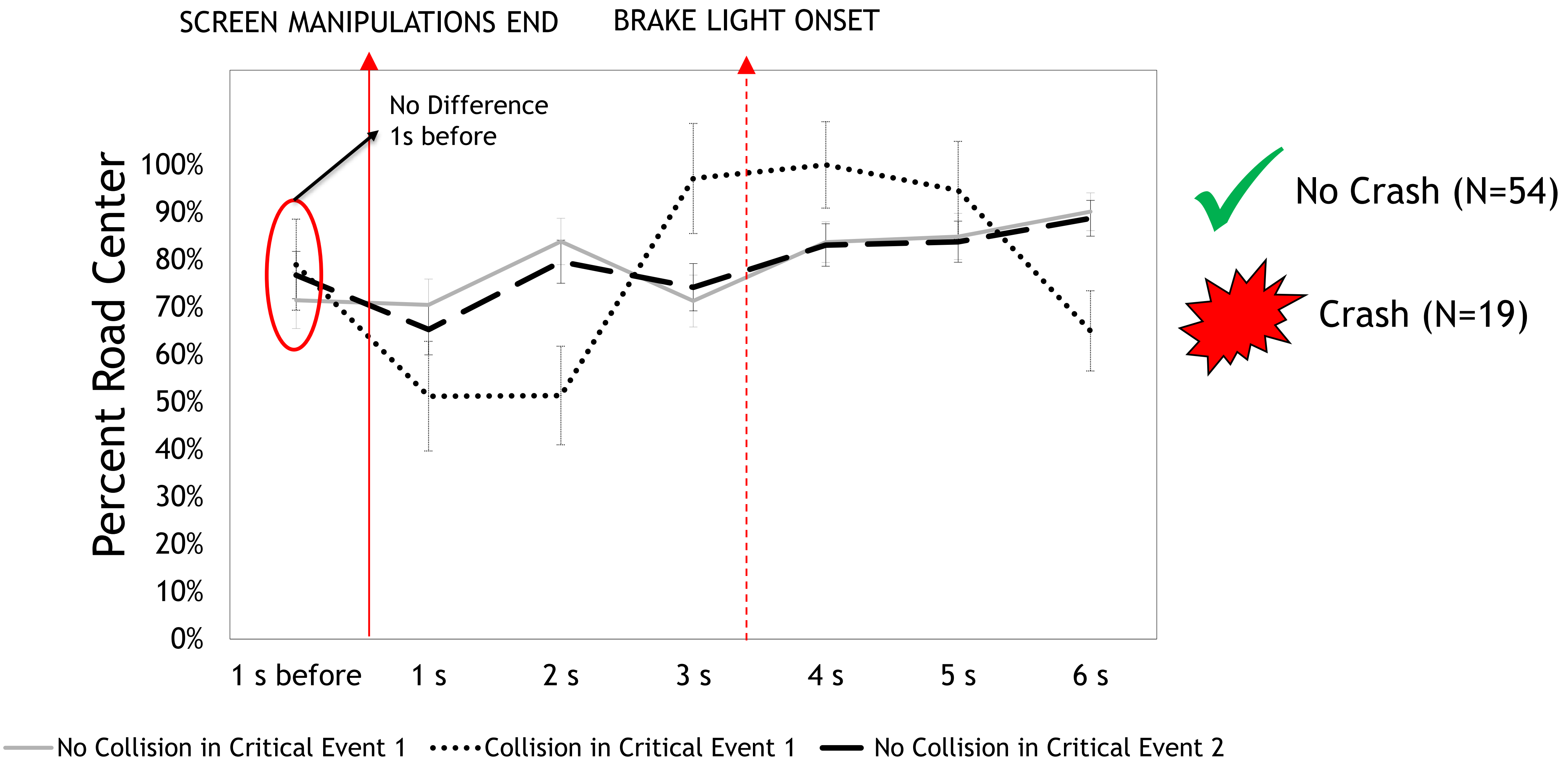
AdaptIVe

Automated Driving Applications and Technologies for Intelligent Vehicles





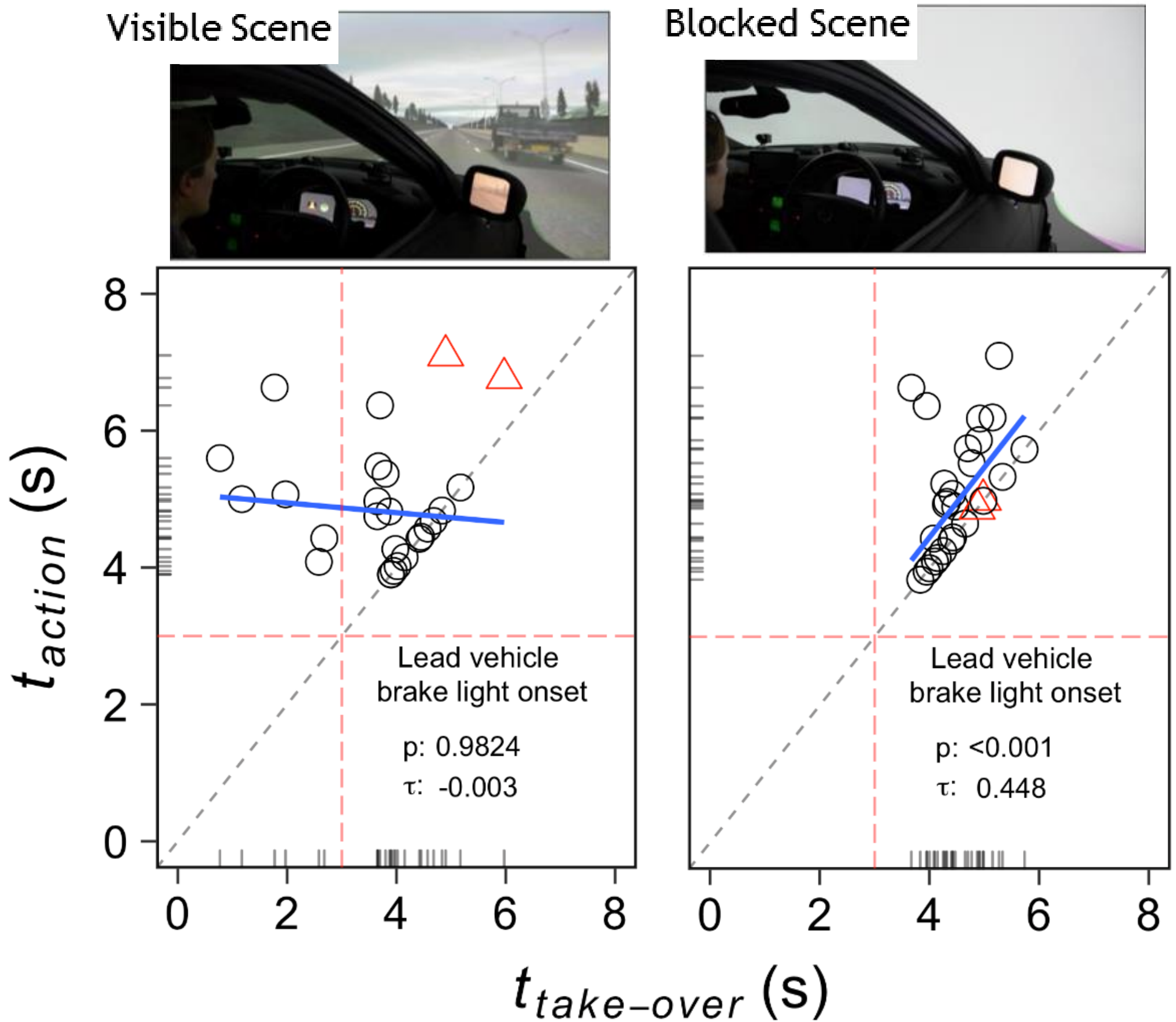
In the three second period after the manipulations ended, there were **no differences** between the OOTL manipulation groups for Horizontal or Vertical Gaze Dispersion



SCREEN MANIPULATIONS END
BRAKE LIGHT ONSET
No Difference
1s before
Percent Road Center
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 s before
1 s
2 s
3 s
4 s
5 s
6 s
No Crash (N=54)
Crash (N=19)
No Collision in Critical Event 1
Collision in Critical Event 1
No Collision in Critical Event 2

Transition time ***not the same*** as safe and effective control

- Transition: Responses/reactions (e.g. touching steering wheel, or braking) in little as 3 seconds



Louw et al., 2017

CityMobil1 project: Do they react in time?

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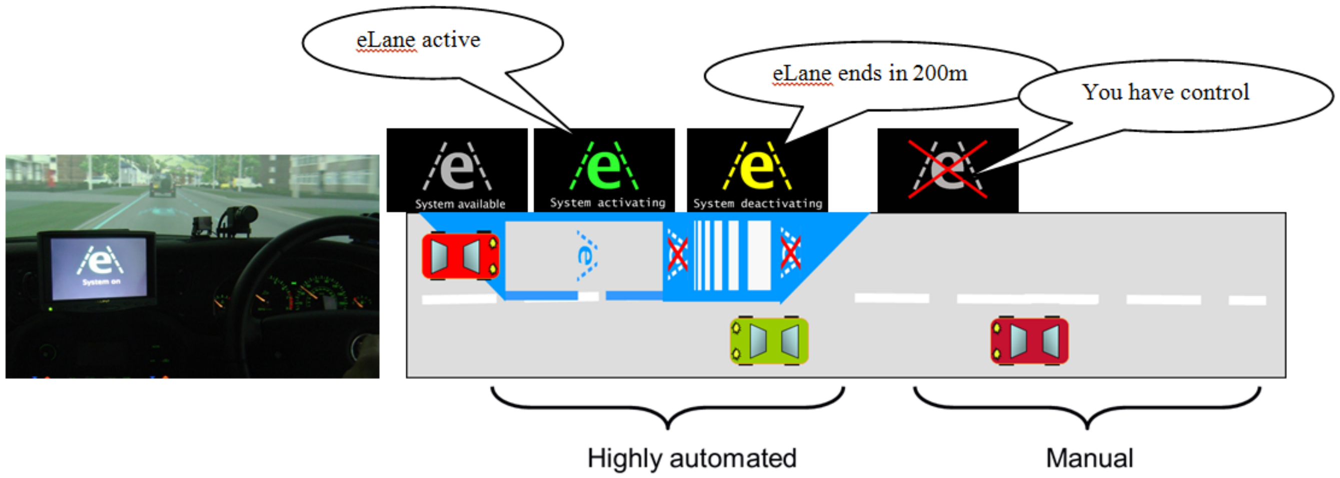
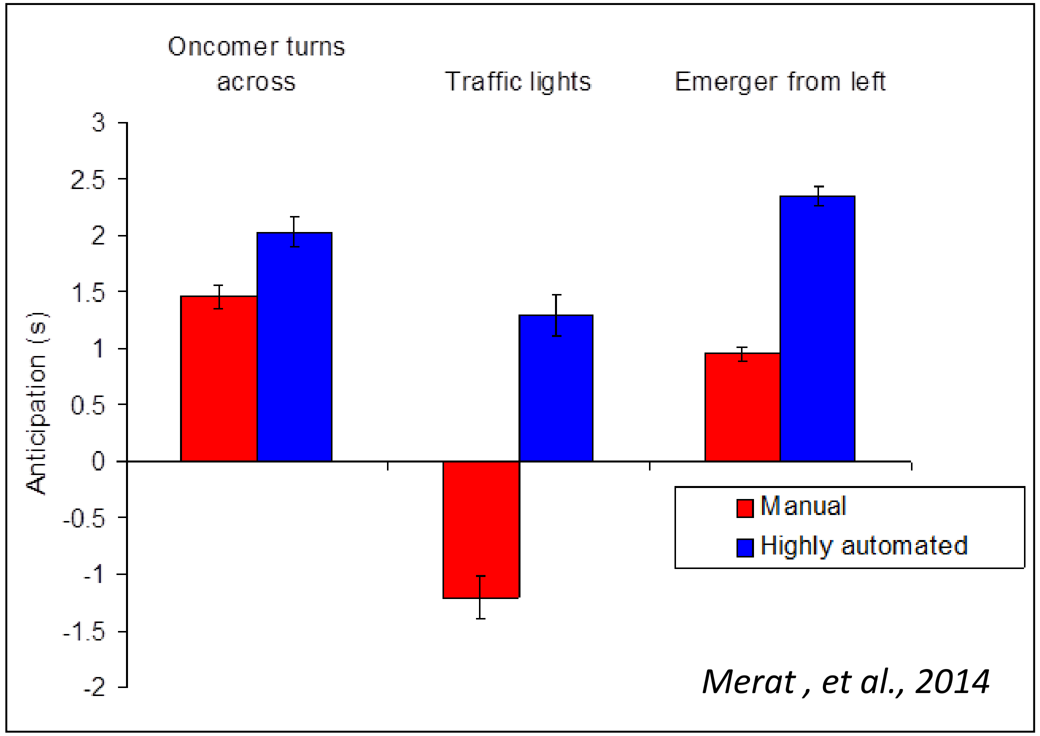


Inaccurate mental model: Who's in charge?



Merat , et al., 2014

"Automation expectation mismatch" – incorrect mental model

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Automation Expectation Mismatch: Incorrect Prediction Despite Eyes on Threat and Hands on Wheel

Trent W. Victor, **Emma Tivesten**, **Pär Gustavsson**, **Joel Johansson**, **Fredrik Sangberg**, and **Mikael Ljung Aust**, Volvo Cars, Gothenburg, Sweden

Objective: The aim of this study was to understand how to secure driver supervision engagement and conflict intervention performance while using highly reliable (but not perfect) automation.

Background: Securing driver engagement—by mitigating irony of automation (i.e., the better the automation, the less attention drivers will pay to traffic and the system, and the less capable they will be to resume control) and by communicating system limitations to avoid mental model misconceptions—is a major challenge in the human factors literature.

Method: One hundred six drivers participated in three test-track experiments in which we studied driver intervention response to conflicts after driving highly reliable but supervised automation. After 30 min, a conflict occurred wherein the lead vehicle cut out of lane to reveal a conflict object in the form of either a stationary car or a garbage bag.

Results: Supervision reminders effectively maintained drivers' eyes on path and hands on wheel. However, neither these reminders nor explicit instructions on system limitations and supervision responsibilities prevented 28% (21/76) of drivers from crashing with their eyes on the conflict object (car or bag).

Conclusion: The results uncover the important role of expectation mismatches, showing that a key component of driver engagement is cognitive (understanding the need for action), rather than purely visual (looking at the threat), or having hands on wheel.

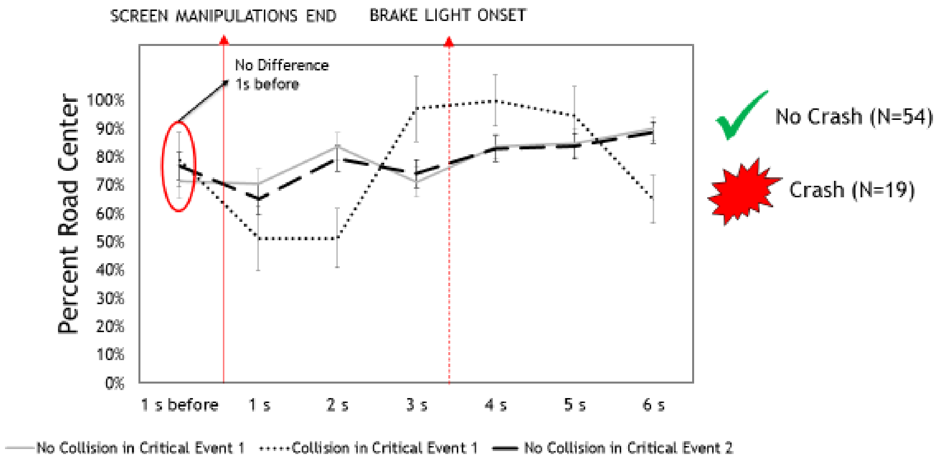
Application: Automation needs to be designed either so that it does not rely on the driver or so that the driver unmistakably understands that it is an assistance system that needs an active driver to lead and share control.

INTRODUCTION

The potential of automation to revolutionize vehicle safety is widely recognized, given that as many as 94% of crashes have been attributed to driver-related critical reasons, such as recognition errors, decision errors, and performance errors (National Highway Traffic Safety Administration, 2015). At the same time, if we look at exposure, crashes in manual driving are very rare events (Lindman, Isaksson-Hellman, & Strandroth, 2017; Nidhi & Paddock, 2016). The level of human crash avoidance performance that must be surpassed by automation to achieve the vision of zero fatalities and serious injuries is very high (Eugensson, Ivarsson, Lie, & Tingvall, 2011; Johansson, 2009), for example, 39.1 million kilometers per crash with severe or fatal injury in passenger cars considering all traffic environments (126 million kilometers for motorways only) in Sweden (Lindman et al., 2017).

Furthermore, extensive experience with human factors in automation over the past 50 years indicates that human factors issues are a key hurdle to overcome (Bainbridge, 1983; Billings, 1988; Endsley & Kiris, 1995; Lee, Wickens, Liu, & Boyle, 2017; Parasuraman & Riley, 1997; Sarter & Woods, 1995; Sheridan, 1992; Wiener & Curry, 1980).

The current status is thus a kind of catch-22, or "crash-22," whereby automation may prevent



Using driving simulators to create better AV controllers

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- Geo-specific database incorporating Aimsun
- Different levels of risk
- Different ages, different personalities
- What are the similarities/ differences between sim and test track?

HUMAN DRIVE

AV research using pedestrian simulator

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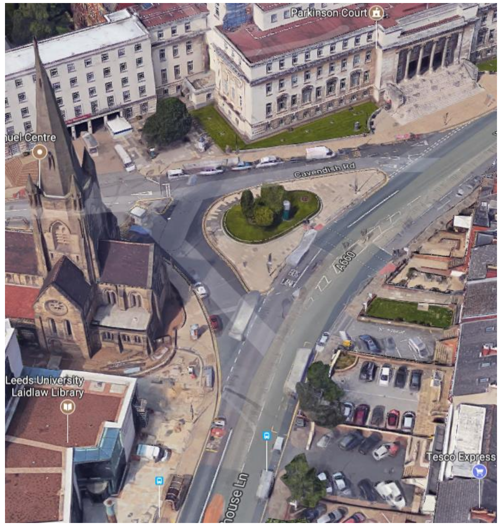
interACT
Designing cooperative interaction of automated vehicles with other road users in mixed traffic environments



- Questionnaire (N = 664)
- Would like some kind of communication (external HMI)
- Understanding AV's intentions (and vice versa)
- Most important: *has it detected me?*

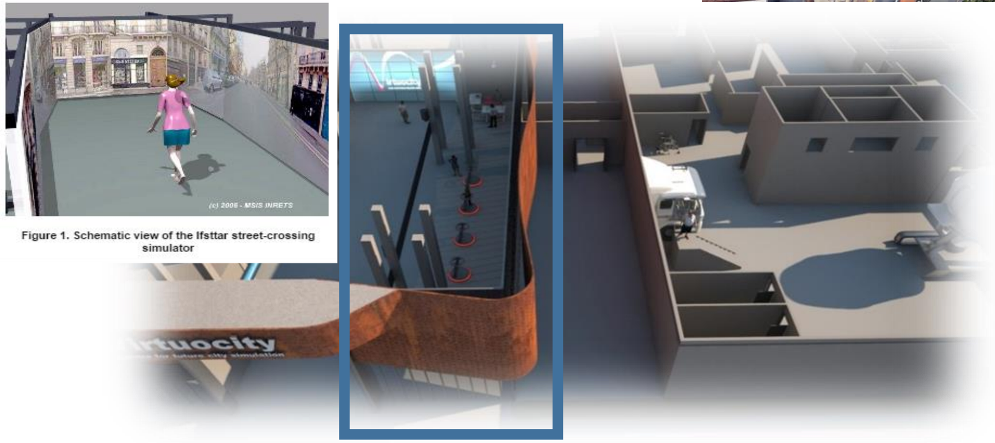


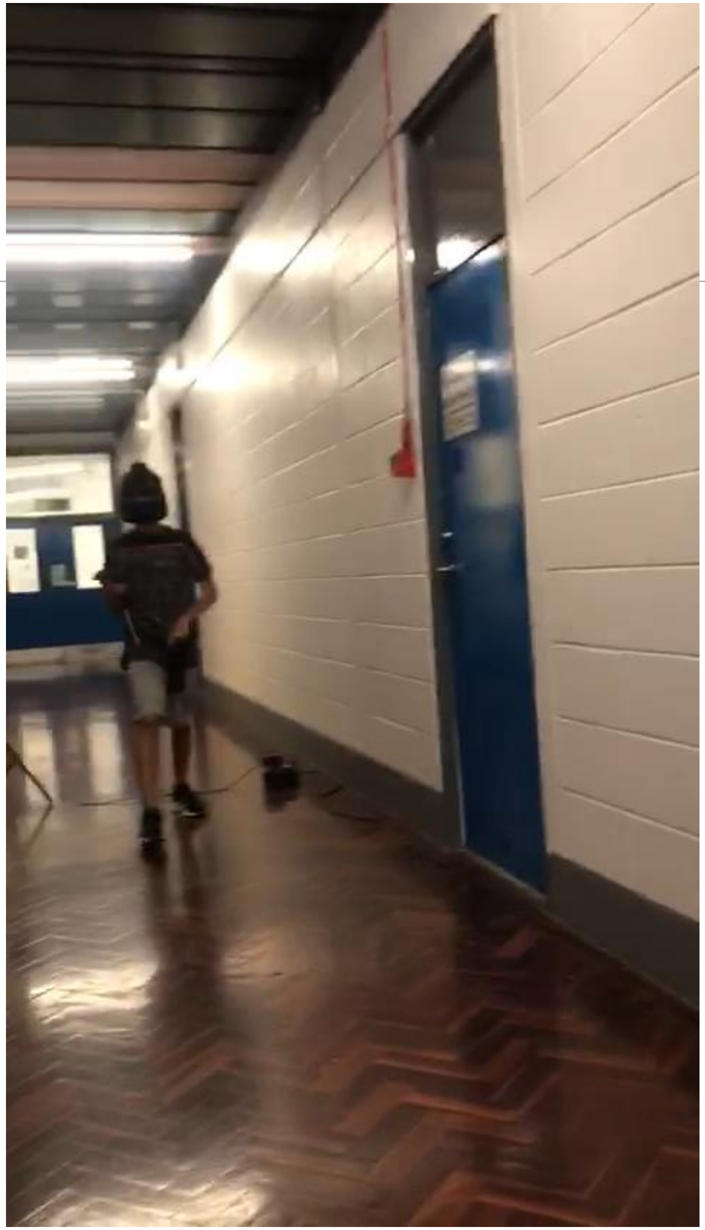
Figure 1. Schematic view of the Ifsttar street-crossing simulator

CityMobil2
CITIES DEMONSTRATING AUTOMATED ROAD PASSENGER TRANSPORT

Merat et al., 2018

“Limitations” of simulators

- Simulator sickness – road environment plays a big role
- How much on urban roads? (e.g. Papadimtriou et al. 2015: 45 studies on distraction, mostly rural/motorway
- Simulator fidelity/ecological validity etc. – risk perception, reality, immersion?



Forthcoming challenges:

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- How do we measure human performance when the machine is in charge?
- Scenario development that goes beyond simple reaction time tasks
- Longitudinal studies – designing for incidents we do not know about
- Moving away from obsession with time for "transition of control"
- Human factors aspects related to the "safety driver"
- Human factors of "teleoperation"
- Understanding the consequence of being "Out of the loop" and how HMI can help
- <u>Don't forget the excluded</u>

Acknowledgements

European Commission

EPSRC
Engineering and Physical Sciences Research Council

Centre for Connected & Autonomous Vehicles
Innovate UK

Thank you for your attention!

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