Automated vehicles and the challenge to deliver safe, clean, accessible mobility

March 2024
Google Car, 2010
Mini, Cortina and Daimler bus
IT DRIVES ITSELF!

With buses becoming more and more important in town travel – and drivers getting less and less easy to recruit – the answer for tomorrow may well be those that drive themselves...

The Look and Learn book of Speed & Power
DARPA challenges, 2000s
GATEway, 2015
Lyft – autonomous roll out (2016 prediction)
Peak hype?

Self-Driving Cars Will Make Organ Shortages Even Worse

We need to prepare for that now.

BY IAN ADAMS AND ANNE HOBSON  DEC 30, 2016 • 5:56 AM

Media coverage

As driverless-car crashes mount, fear of riding in them rises, too

Cruise postpones plan to launch driverless taxi service in 2019

Self-Driving Cars Are Still Years Away. That's Probably A Good Thing.

As autonomous vehicles enter the uncanny valley, experts are asking whether more cars are what cities really need.

Autonomous vehicle claims are just a load of hot air... and here's why
Actual Gartner hype cycle for CAVs (July 2023)
UN Decade of Action for Road Safety 2011-2020

Global Plan for the Decade of Action for Road Safety 2011–2020

EU-27 Annual road deaths

Decade of Action for Road Safety

Road deaths / year

Year
UN Decade of Action for Road Safety 2011-2020

Global Plan for the Decade of Action for Road Safety 2011–2020

EU-27 Annual road deaths

Decade of Action for Road Safety

Road deaths / year

Year

UN Decade of Action for Road Safety 2011-2020
How do they compare?

**Senses:**
- Eyes
- Touch
- Proprioception

**Brain:**
- Making sense of sensory information
- Knowledge of rules, driving skill
- Understanding of the world

**Actions:**
- Hands and feet apply actions to vehicle controls
- Vehicle controls manipulate vehicle behaviour

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**Sensors:**
- Cameras, radars, lidars, ultrasound, microphones etc.

**Compute:**
- Processing of sensor data
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“Full Self Driving”?
Joshua Brown / Tesla Autopilot crash, 2016

NTSB (2017) accident report - NTSB/HAR-17/02 PB2017-102600
Damage

NTSB (2017) accident report - NTSB/HAR-17/02 PB2017-102600
Elaine Herzberg / Uber crash, 2018
UK government expectation – CCAV, 2022

- At least as good as a ‘competent and careful’ driver
- Standard is higher than the average human driver
At least as good as a ‘competent and careful’ driver

Standard is higher than the average human driver

This is ‘too weak and too vague’

The Government should set a clearer, more stretching threshold

Government expectation – HoC Transport Committee, 2023
Recommendation rejected by government

“It is the Government’s view that a competent and careful driver is safer than the average human driver and that a level of safety equivalent to that of a competent and careful driver is an appropriate ambition at this time.”
(a) AVs will achieve a level of safety equivalent to, or higher than, that of careful and competent human drivers, and

(b) road safety in Great Britain will be better as a result of the use of AVs on roads than it would otherwise be.”
Scoping notes – safety principles:

- Safety
- Driving without monitoring / control
- Equality and fairness
- Explainability
- Cyber-resilience

Government legislation – Automated Vehicles Bill, 2024

March 2024
Quick maths – GB (2022) statistics

All traffic:

- Road fatalities = 1,711
- Vehicle miles travelled = 323 billion
- Miles / fatality = \( \sim 189 \text{ million} \) miles / fatality

Includes motorbikes, fatigue, distraction, intoxication etc.
Quick maths – GB (2022) statistics

Cars only

Fatalities involving human error removed:

- Road fatalities = 110
- Vehicle miles travelled = 244 billion
- Miles / fatality = \( \sim 2.2 \text{ billion} \) miles / fatality
The reality of real world testing


- Autonomous vehicles would have to be driven hundreds of millions of miles and sometimes hundreds of billions of miles to demonstrate their reliability in terms of fatalities and injuries.
Quick maths…

100 billion miles with a test fleet of 100 vehicles…

100 vehicles at @ 30mph  =  33,333,333 hours

=  1,388,889 days

=  3,803 years!

We’ll need alternative ways to prove safety!
Automated Road Transport Symposium, San Francisco, 2023

Waymo

Cruise
Automated Road Transport Symposium, San Francisco, 2023

Waymo

Cruise

WeRide

Zoox
Transport authority’s response:

1. Will AVs allow existing streets to move more people?
2. Will AVs reduce lifecycle GHG emissions?
3. Will AVs improve transport choices?
4. Will AVs improve safety, especially for VRUs?
5. Can we co-create performance metrics?
6. Will AV data be shared to back up claims?
“An autonomously driven vehicle from Waymo was traveling on a narrow street with parked cars to the left and right. Due to the parked cars, narrow street and people in the road and near the car, our vehicle was unable to immediately move for a fire truck attempting to enter the street. Our remote assistance teams were working rapidly to develop a new path for the vehicle, when instead after a brief period the fire truck moved along and our vehicle continued on its trip. We maintain great respect for the SFFD and our first responders and appreciate our ongoing relationship with them.” - Waymo

Trouble on the streets of San Francisco?

Cruise driverless car gets stuck in wet concrete in San Francisco as overjoyed construction worker says it 'illustrates how creepy and weird the whole thing is'
Phil Koopman (CMU), September 2023:

• “Every blocked traffic incident is going to add to degrading public opinion and enthusiasm for the technology, regardless of which company is having the problems ... When a large adverse event eventually happens, all that pent up public opinion is going to make it much more difficult for companies to deal with the situation.”

• “More transparency and improvement on issues the public cares about are essential ... This technology will not succeed without trust, and it is much easier to lose trust with a single bad event than it is to regain it afterwards.”
Cruise suspends operations after Oct 2nd incident in San Francisco

- Pedestrian knocked into Cruise AV path by hit-and-run driver - dragged 20ft under AV
- CA DMV concerned about withheld data
California regulator looking into Waymo’s collision with a cyclist

Ivan Mehta @indianidle / 10:58 AM GMT • February 8, 2024

A Waymo robotaxi was vandalized and burned in San Francisco

Kirsten Korosec @kirstenkorosec / 5:10 PM GMT • February 12, 2024

Waymo recalls and updates robotaxi software after two cars crashed into the same towed truck

Sean O’Kane @sokane / 10:00 PM GMT • February 13, 2024
Commentary Driving

- Driver sits with expert trainer / assessor
- Reports the critical items / hazards / changes that will influence their driving
- Describes how they will adapt their driving behaviour in response
A possible solution…

Key features of DCD

• Very basic data – no video, lidar etc.
• Only information needed to operate safely – therefore does not compromise IP
• Can compare manufacturer A vs. B or software version 2.3 vs. 2.4 etc.
• Can be used in simulation or real world
• Shared with regulator to confirm safe operation
Principle of DCD

In God we trust... all others must bring data

William Edwards Deming (1900-1993)
European Commission – expert panel on CAV ethics

Connected and Automated Vehicles (CAVs) have the potential to make transport:
SAFER    GREENER    MORE ACCESSIBLE

But new technologies do not just happen: they are imagined by people and developed with purpose. EU values need to be built-in at their core to ensure
ETHICAL USE    POSITIVE IMPACT    ACCEPTANCE    TRUST

Image credit: European Commission

European Commission – expert panel on CAV ethics

1. Ensure that CAVs reduce physical harm to persons.
2. Prevent unsafe use by inherently safe design.
3. Define clear standards for responsible open road testing.
4. Consider revision of traffic rules to promote safety of CAVs and investigate exceptions to non-compliance with existing rules by CAVs.
5. Redress inequalities in vulnerability among road users.
6. Manage dilemmas by principles of risk distribution and shared ethical principles.
7. Safeguard informational privacy and informed consent.
8. Enable user choice, seek informed consent options and develop related best practice industry standards.
9. Develop measures to foster protection of individuals at group level.
10. Develop transparency strategies to inform users and pedestrians about data collection and associated rights.
11. Prevent discriminatory differential service provision.
12. Audit CAV algorithms.
13. Identify and protect CAV relevant high-value datasets as public and open infrastructural resources.
15. Promote data, algorithmic, AI literacy and public participation.
16. Identify the obligations of different agents involved in CAVs.
17. Promote a culture of responsibility with respect to the obligations associated with CAVs.
18. Ensure accountability for the behaviour of CAVs (duty to explain).
19. Promote a fair system for the attribution of moral and legal culpability for the behaviour of CAVs.
20. Create fair and effective mechanisms for granting compensation to victims of crashes or other accidents involving CAVs.

Image credit: European Commission
Recommendation 4

4. Consider revision of traffic rules to promote safety of CAVs and investigate exceptions to non-compliance with existing rules by CAVs.
When to break the rules…

• Rules are a means by which road safety is elevated but non-compliance is sometimes necessary to achieve greater road safety

• How should an CAV manage this?
  • Change the rule?
  • Hand control back to human driver to decide?
  • Not comply but CAV must be able to offer reasoned explanation as to why it was non-compliant
Example 1 – Crossing a red light

- AV must wait at red light
- Green light allows vehicles to turn from side road
- Ambulance cannot pass AV waiting at red light
- AV crosses solid white line with traffic light on red signal to allow ambulance to pass
- Human driven vehicle edges to side of their lane to allow ambulance to pass
- Ambulance can pass through gap
Ethical goal functions

- AI systems cannot independently ‘learn’ to derive ambiguous human values from human behaviour or human feedback nor apply them to new situations
- Even if sufficiently large training datasets were available, CAVs cannot develop underlying ethical principles
- Proposal for **ethical goal functions**
  - How are these developed? By whom?
  - Democratic legitimacy?
Rees Jeffreys Road Fund – Ethical Roads project

• One year
• Two phases
  • Survey
    • 2,000 participants
  • Workshops (×2)
    • 30 participants
• Advisory panel – 3 × meetings
• Outcome – factors contributing to EGFs

Project team

reed mobility
dg: cities
TRL
Smart Mobility Living Lab London
april6
HUMANISING AUTONOMY
reed mobility
Conclusions

• **Legality** and **safety** are vital – all bound up in **trust**
• **Trust** is supported by
  • Not making safety **worse**
  • Availability / sharing of **data**
  • Public sector **regulator**
  • Demonstrably learning from **mistakes**
• **Unanimity on values** is hard to find!
• Good starting point for creating a process to engage public in future mobility technology
BSI Flex 1890

• More than 100 terms
• Clear, industry agreed
• Public consultation
• Six-month cadence
• Not finished!

How to progress?
What do we do next?

• Huge potential to improve safety and efficiency

• No evidence yet to confirm this

• Transparent process for collecting and sharing safety data

• Involvement of society in development of services

• All talking the same language!
Thank you