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

March 2024

IET Coventry & Warwickshire event
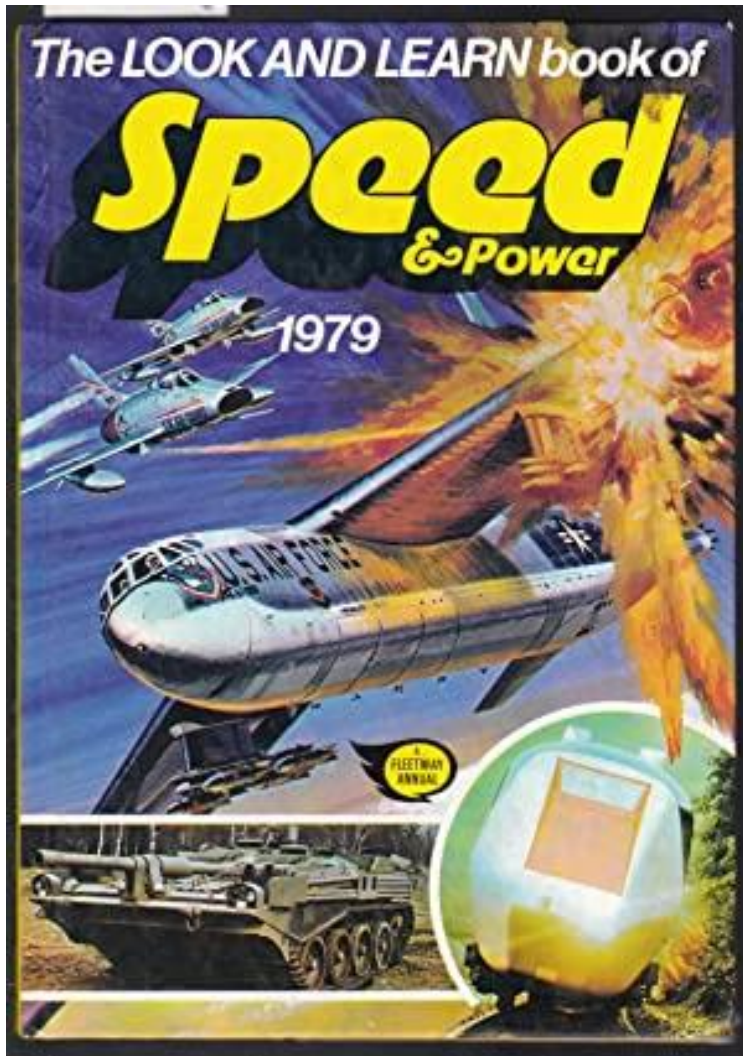
Google Car, 2010

Mini, Cortina and Daimler bus

1979 Look and Learn book of Speed & Power

The LOOK AND LEARN book of

Speed & Power

1979

A FLEETWAY ANNUAL

IT DRIVES ITSELF!

DING! DING! Moving off down a crowded high street, and loaded with dozens of passengers carrying children and heavy shopping, the modern bus heads past the Saturday morning traffic in a specially prepared bus lane. Every few hundred yards it stops, there is the usual interchange of passengers through the air operated doors, and it moves on again.

Quite a normal town centre situation, you may think, but you would be wrong. For, looking at the front of the bus, you will notice that something rather important is missing. The driver! And this could well become a frequent sight in the town centres of tomorrow.

At the Transport and Road Research Laboratory they have been working on a driverless bus system for some time. The bus uses a simple guidance system — basically a cable buried under the road. Using this, the bus will steer or stop and start according to electronic "orders" programmed into the cable.

SENSING DEVICES

This cable can even be laid on the road surface as part of the white line! Special sensing devices underneath the bus would keep it either in the centre, or to one side, of the white line. If any object, or a pedestrian, stepped in the vehicle's path, a form of radar mounted on the front would automatically apply the air brakes. If there was any form of equipment failure on board, the brakes would be activated again.

As you can see, the system has been designed to be completely foolproof, though the main worry would be getting passengers to accept the fact that they are perfectly safe travelling in a bus with no driver!

Even so, buses would be built so that they could be switched over to normal operation at any time. A bus could run automatically through,

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 buses that drive themselves . . .

Above: Guided by a simple underground cable, a driverless bus heads down a busy high street.

Left: It's certainly a strange sight — a crowded bus bowling along with no driver up front! But the passengers don't look too worried. They know about the extensive safety systems that are fitted.

CITY CENTRE 210

PAY AS YOU ENTER
EXACT FARE PLEASE

OFN 130

say, the town centre, and then come under the operation of a driver for the rest of the route through the suburbs.

The Road Research Laboratory's bus has been converted from an ordinary manual bus, and the same could be done for transport companies who just wanted to try out the system. Once it had become accepted, automatic buses could be produced on a massive scale.

Though the cost of building each bus would run into thousands of pounds, after a time this would be saved by not having to pay a driver's wages. The cost of laying the guiding cable would be quite low — about £1 a metre. Probably the most expensive part of the whole bus would be the obstacle direction radar.

One of the few problems at the moment is the fact that automatic buses couldn't detect collisions from cars at the sides. So extensive barriers would have to be built to keep other forms of transport well away.

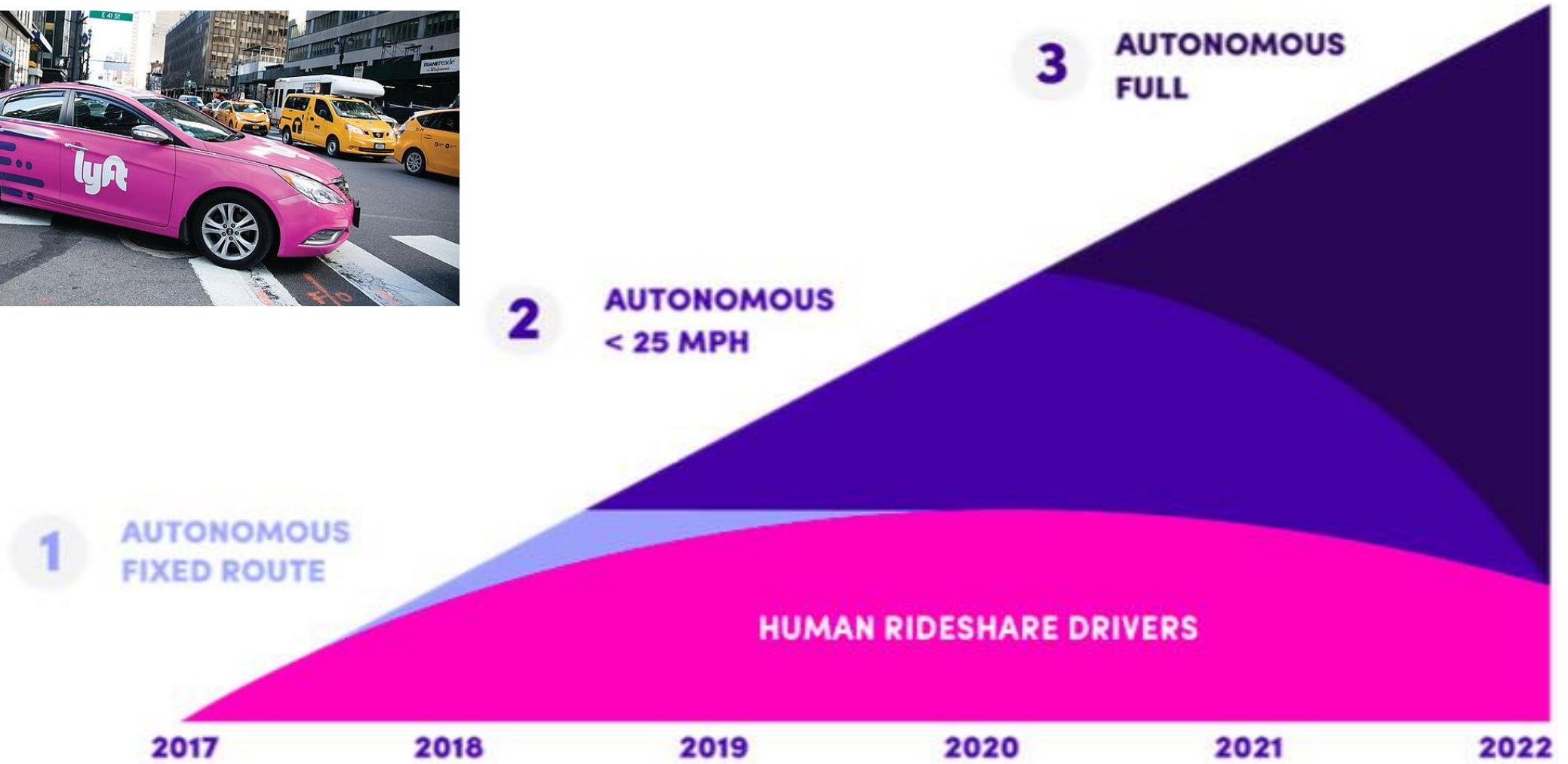At any rate, robot buses are now a reality. Automatic systems could be built into new town centre road schemes.

22

23

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DARPA challenges, 2000s

Robotcar, 2013

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GATEway, 2015

Lyft – autonomous roll out (2016 prediction)

3 AUTONOMOUS FULL

2 AUTONOMOUS < 25 MPH

1 AUTONOMOUS FIXED ROUTE

HUMAN RIDESHARE DRIVERS

2017   2018   2019   2020   2021   2022

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Peak hype?

SLATE

News & Politics   Culture   **Technology**   Business   Human Interest   Podcasts

FROM PIPE DREAM TO REALITY

future tense

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

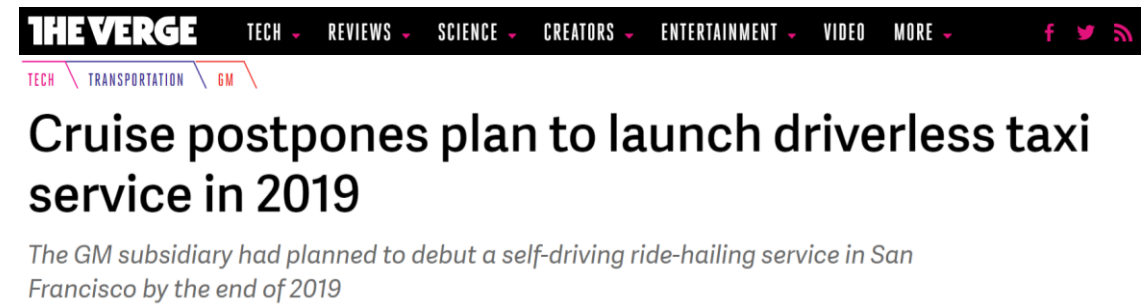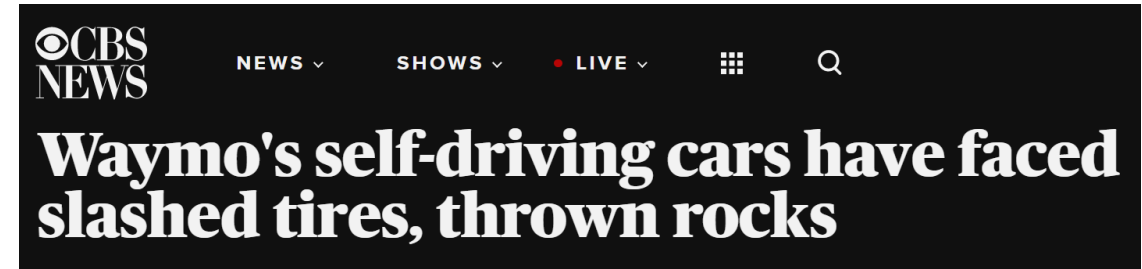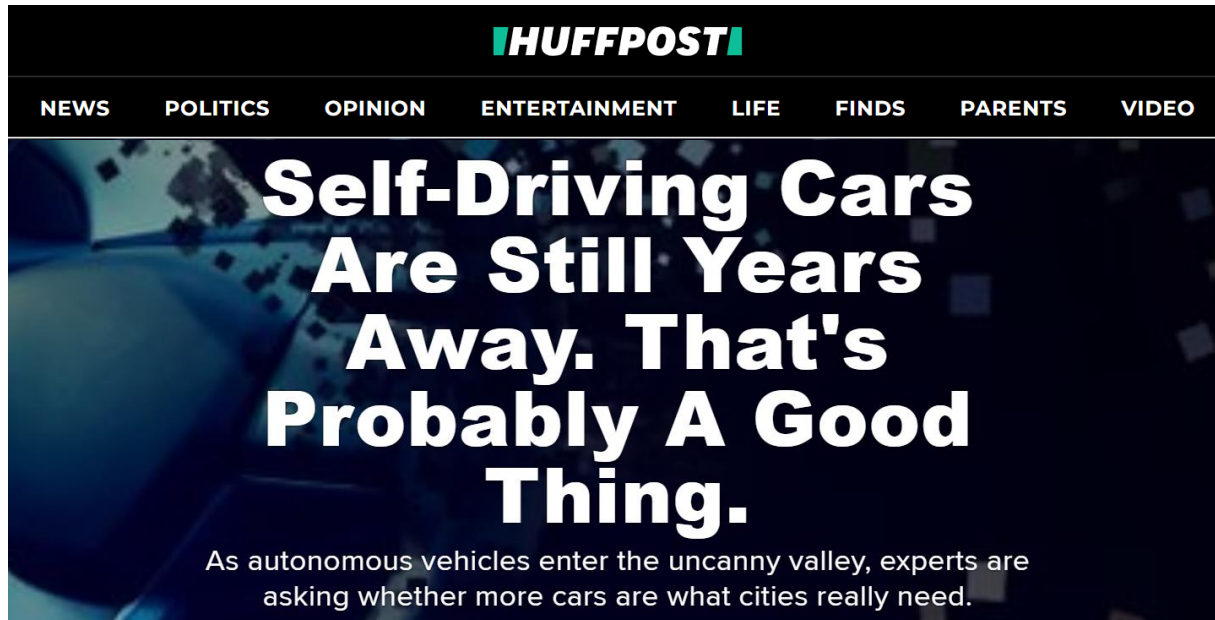https://slate.com/technology/2016/12/self-driving-cars-will-exacerbate-organ-shortages.html
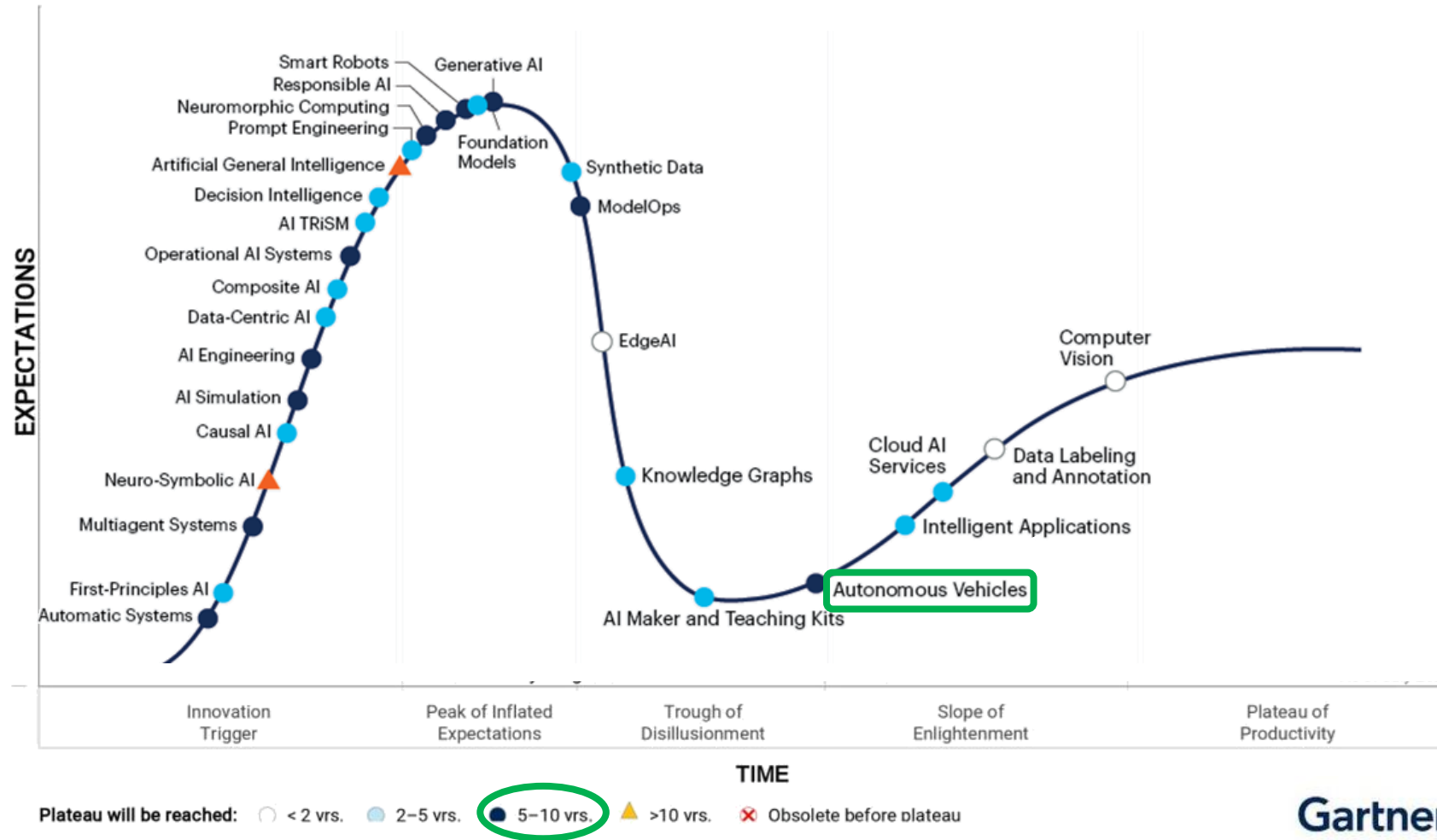
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Media coverage

The Washington Post
Democracy Dies in Darkness

Transportation

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

HUFFPOST

NEWS   POLITICS   OPINION   ENTERTAINMENT   LIFE   FINDS   PARENTS   VIDEO

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.

CBS NEWS   NEWS   SHOWS   LIVE

Waymo's self-driving cars have faced slashed tires, thrown rocks

THE VERGE   TECH   REVIEWS   SCIENCE   CREATORS   ENTERTAINMENT   VIDEO   MORE

TECH   TRANSPORTATION   GM

Cruise postpones plan to launch driverless taxi service in 2019

The GM subsidiary had planned to debut a self-driving ride-hailing service in San Francisco by the end of 2019

The Register®
Biting the hand that feeds IT

Emergent Tech

Autonomous vehicle claims are just a load of hot air... and here's why

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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

DECADE OF ACTION FOR ROAD SAFETY 2011-2020
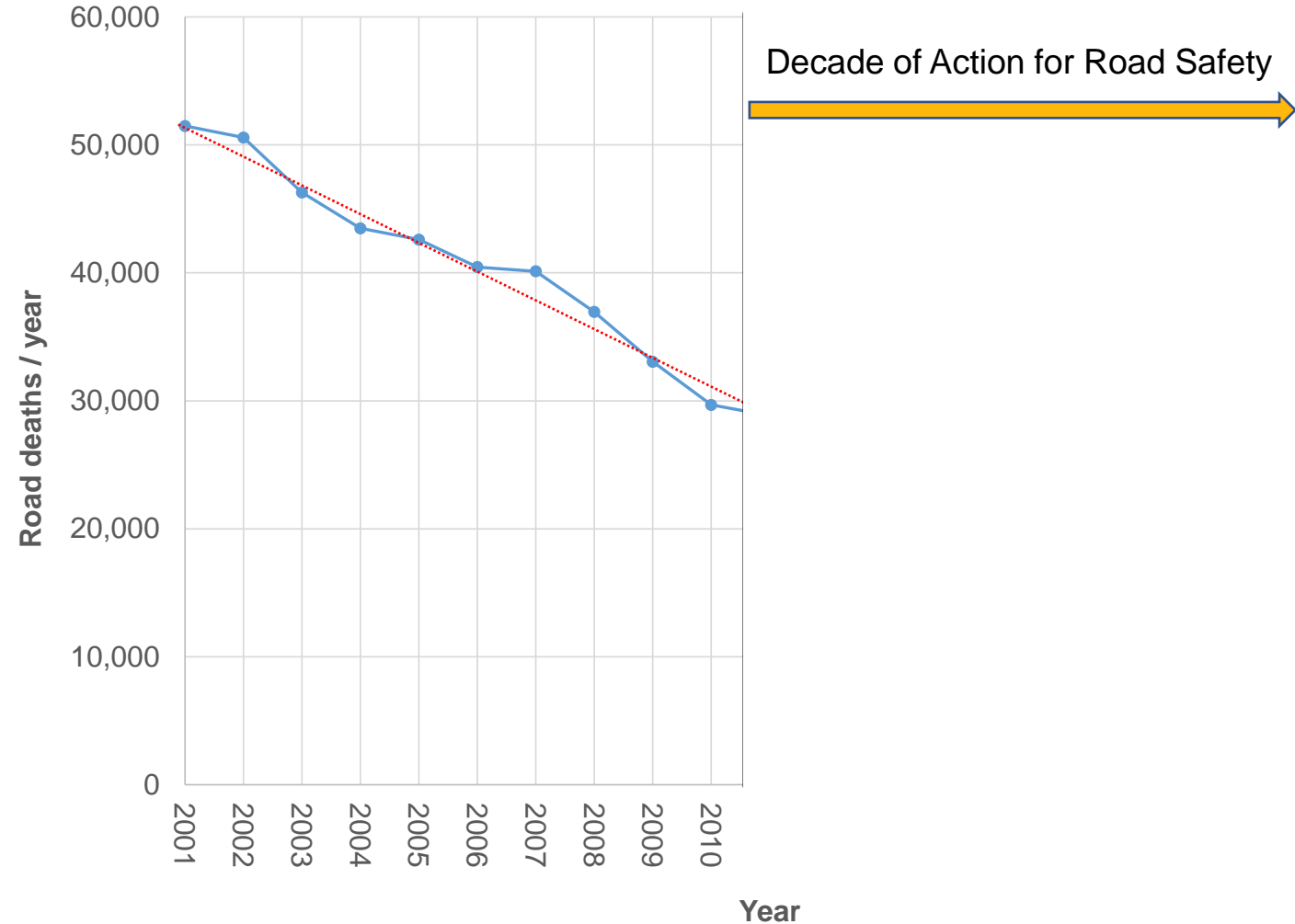
EU-27 Annual road deaths

Decade of Action for Road Safety

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UN Decade of Action for Road Safety 2011-2020

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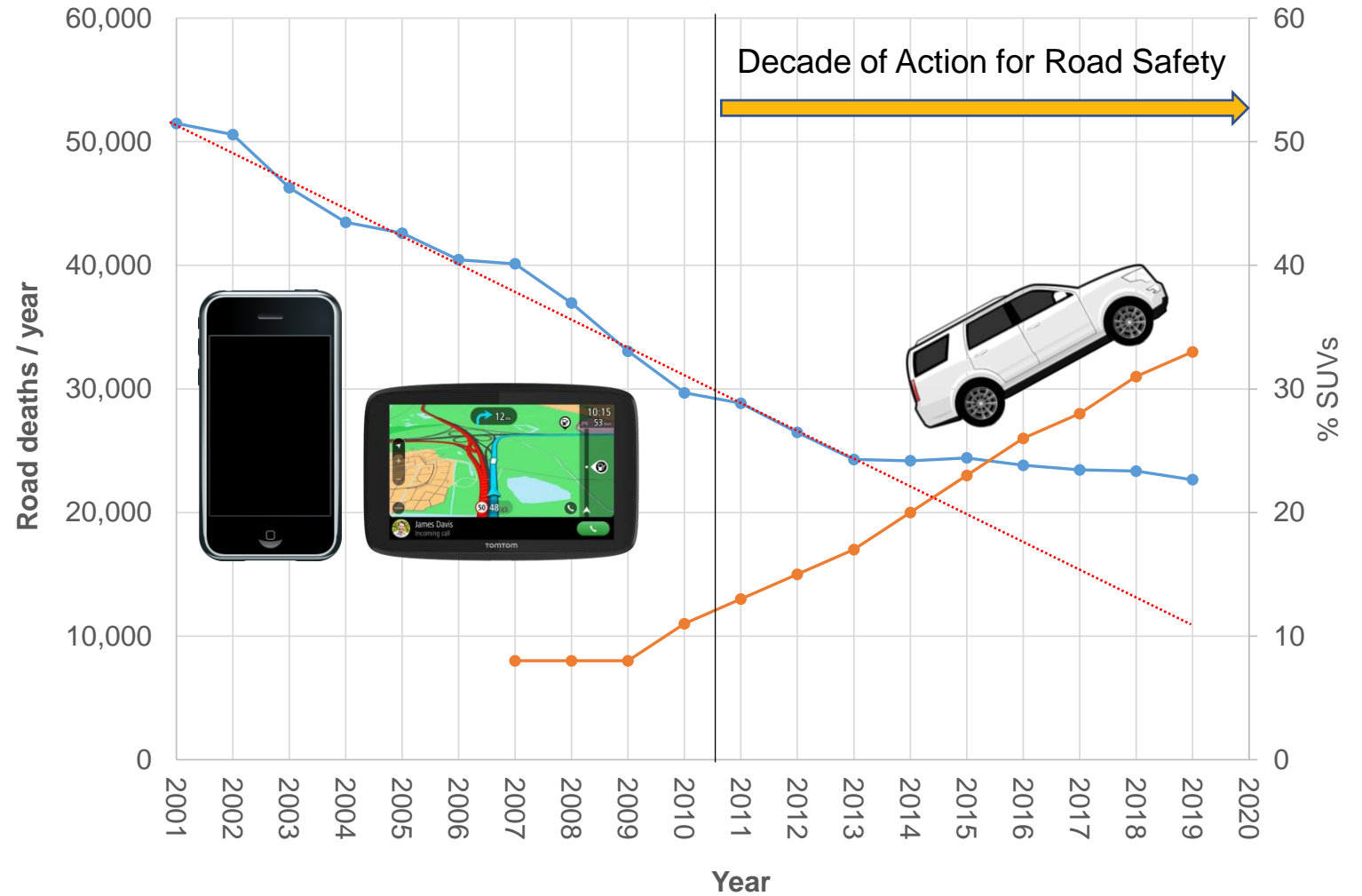for the
Decade of Action for Road
Safety 2011–2020

DECADE OF ACTION FOR ROAD SAFETY 2011-2020

EU-27 Annual road deaths

Decade of Action for Road Safety

Road deaths / year

% SUVs

Year

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How do they compare?

Senses:

- Eyes ~~ouch, ~~ ~~eption~~

Brain:

- Mak~~ng~~ sens~~ sensory~~ ~~mation~~
- Know~~ rules~~ ~~g skill~~
- Und~~erstand~~ ~~he wor~~

Actions:

- Ha~~ teet~~ ~~ions to vehicle controls~~
- Veh~~ rols~~ manipulate vehicle behaviour
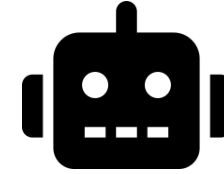
Sensors:

- Camera~~ ~~s, lidars ~~und,~~ mic~~ es etc.~~

Compute:

- Pro~~ g of sens~~
- Knowledge ~~ driving sk~~
- Under~~ g of the w~~
- Rule~~ based and~~ ~~p-learning~~

Actions:

- Com~~ outputs~~ ~~ehicle control inputs~~ via actuators

DISTRACTION
INATTENTION
FATIGUE
INTOXICATION
AGEING
ERROR

PROGRAMMING ERROR
HARDWARE FAILURE
ALGORITHMIC BIAS
UNPREDICTABLE ENVIRONMENT
HUMAN INTERACTIONS

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"Full Self Driving"?

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Joshua Brown / Tesla Autopilot crash, 2016

Grade crest

US Route 27A

SPEED LIMIT 65

N

0   100 ft

74
74
mph

Impact site

NE 140th Court

Fence

Utility pole

Path of onward travel

Final position

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

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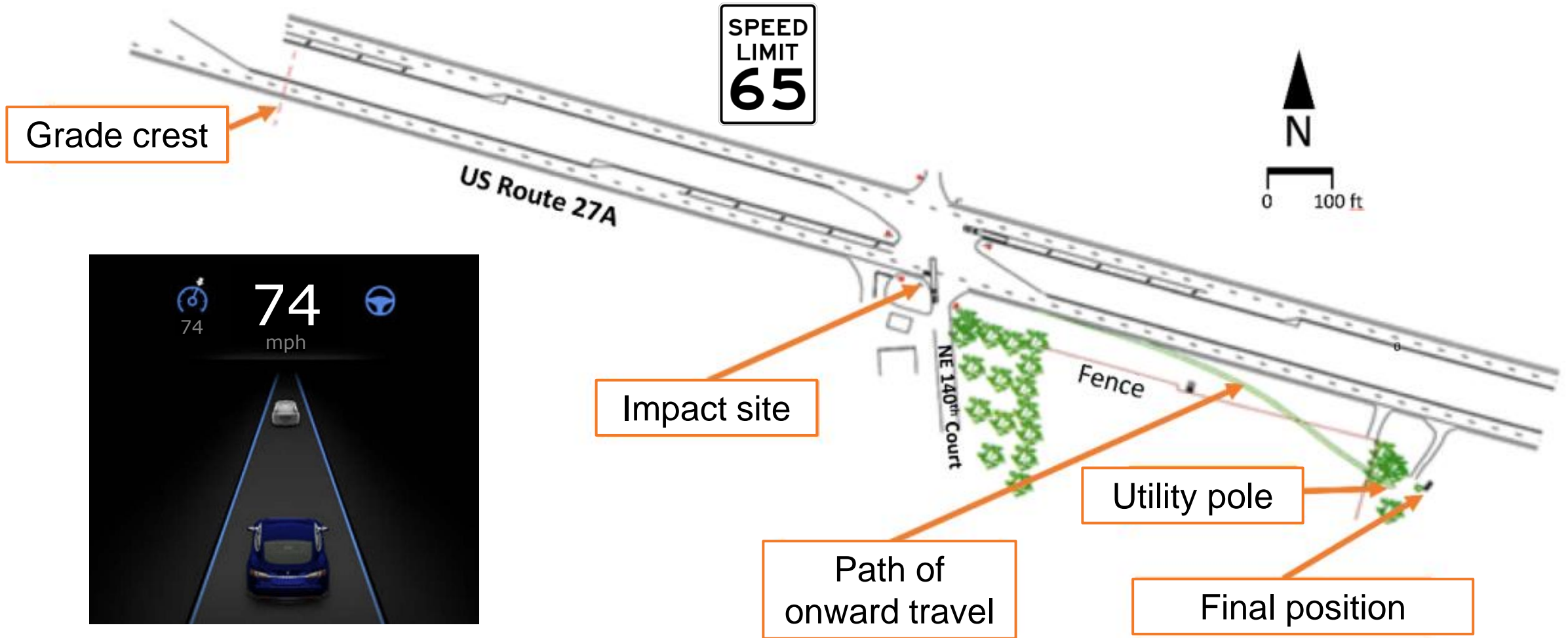
Damage

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

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Elaine Herzberg / Uber crash, 2018

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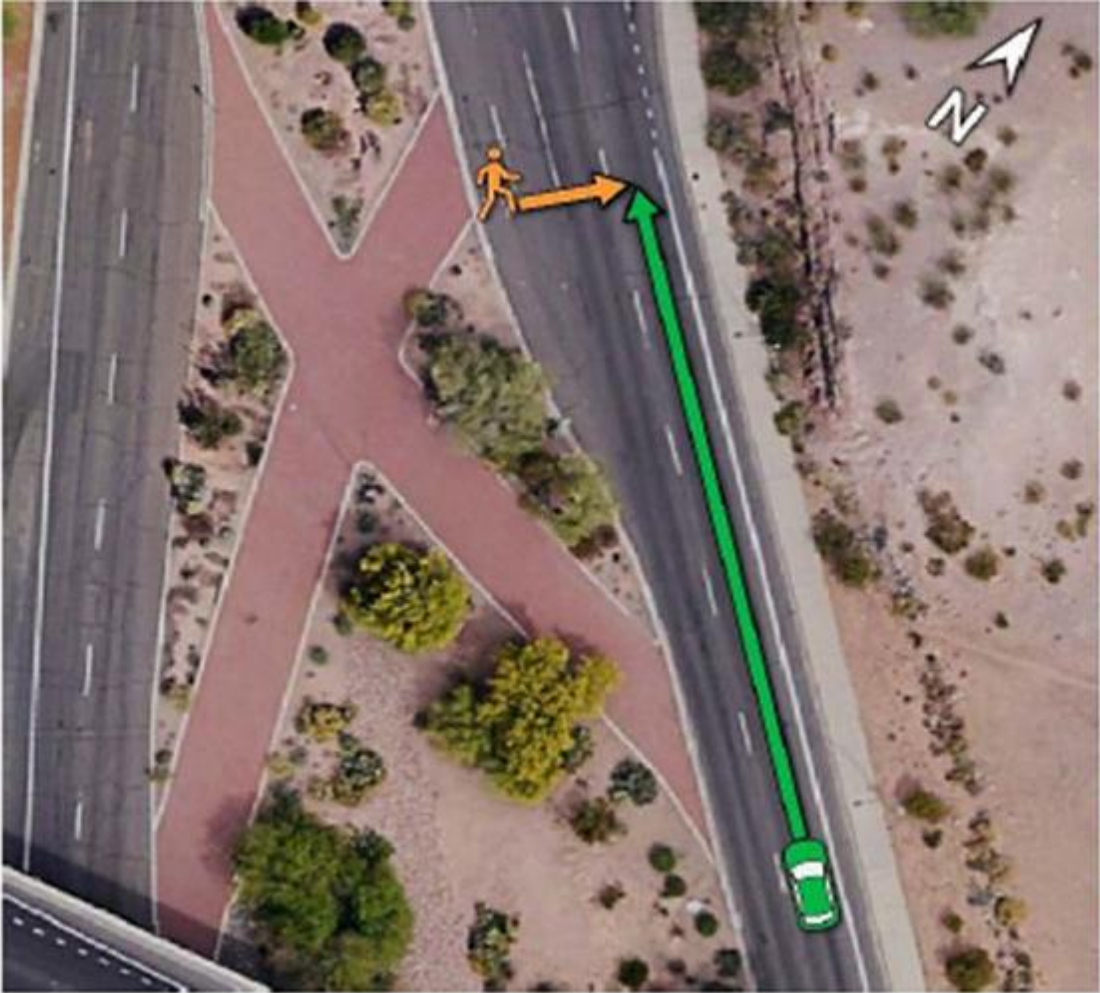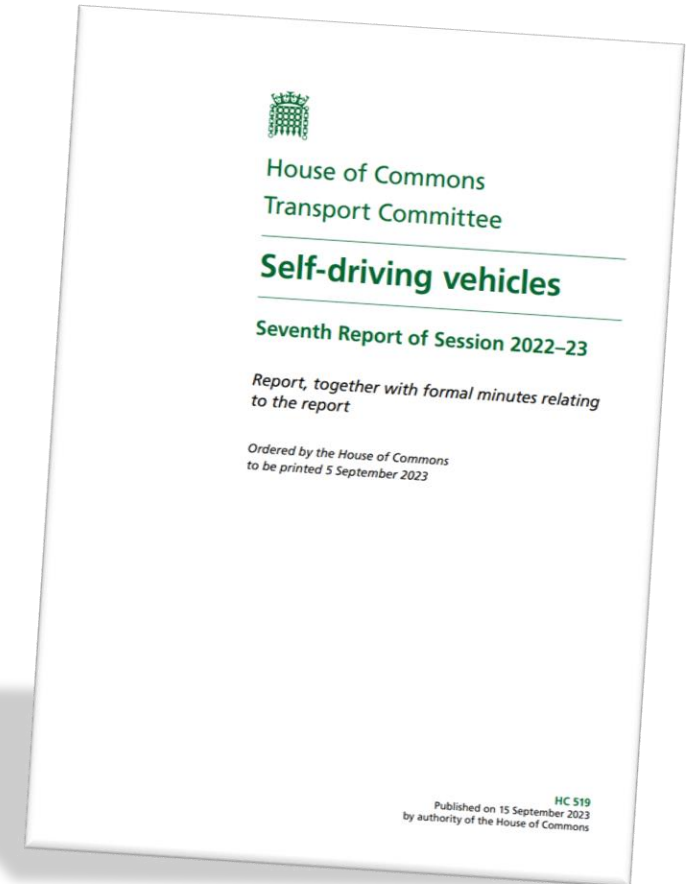
UK government expectation – CCAV, 2022

- At least as good as a '***competent and careful***' driver

- Standard is **higher than the average human driver**

August 2022

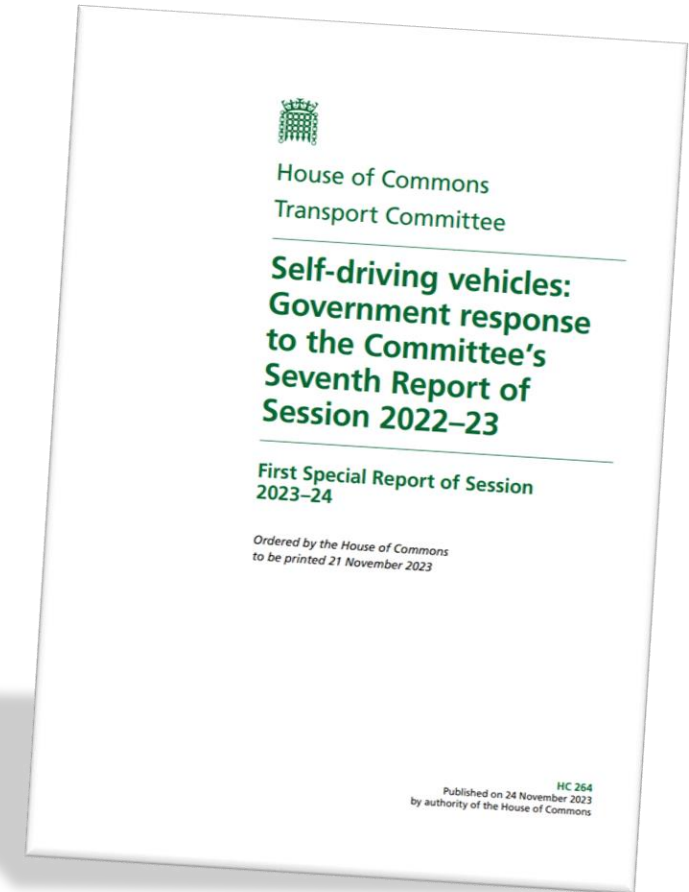# Government expectation – HoC Transport Committee, 2023

- 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**

House of Commons
Transport Committee

Self-driving vehicles

Seventh Report of Session 2022–23

Report, together with formal minutes relating to the report

Ordered by the House of Commons to be printed 5 September 2023

HC 519
Published on 15 September 2023
by authority of the House of Commons

September 2023

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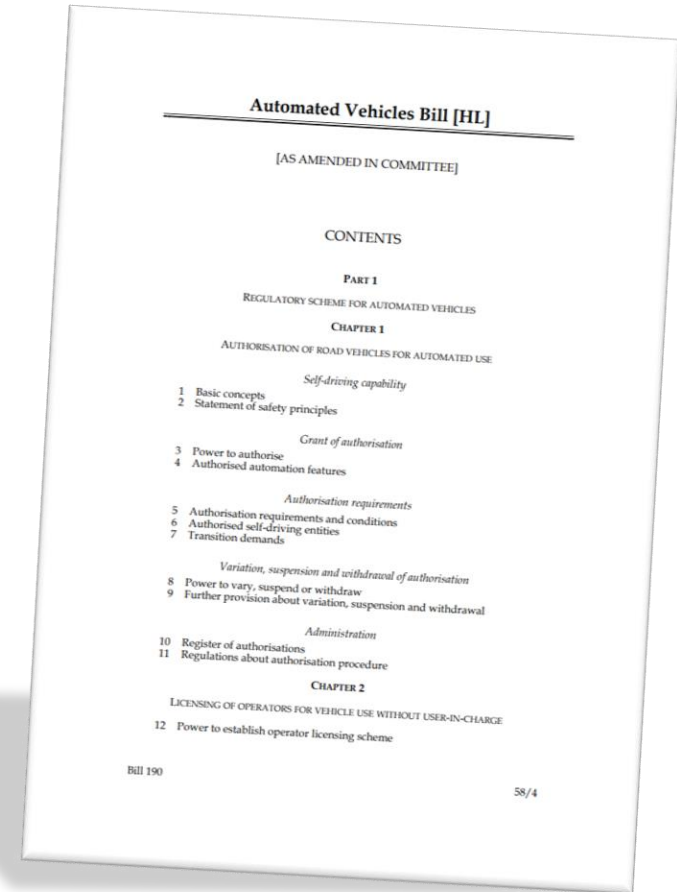# Government expectation – HoC Transport Committee, 2023

- 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.*"

House of Commons
Transport Committee

Self-driving vehicles:
Government response
to the Committee's
Seventh Report of
Session 2022–23

First Special Report of Session
2023–24

Ordered by the House of Commons
to be printed 21 November 2023

HC 264
Published on 24 November 2023
by authority of the House of Commons

November 2023

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Government legislation – Automated Vehicles Bill, 2024

(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.* "

Automated Vehicles Bill [HL]

[AS AMENDED IN COMMITTEE]

CONTENTS

PART 1
REGULATORY SCHEME FOR AUTOMATED VEHICLES

CHAPTER 1
AUTHORISATION OF ROAD VEHICLES FOR AUTOMATED USE

Self-driving capability

1 Basic concepts
2 Statement of safety principles

Grant of authorisation

3 Power to authorise
4 Authorised automation features

Authorisation requirements

5 Authorisation requirements and conditions
6 Authorised self-driving entities
7 Transition demands

Variation, suspension and withdrawal of authorisation

8 Power to vary, suspend or withdraw
9 Further provision about variation, suspension and withdrawal

Administration

10 Register of authorisations
11 Regulations about authorisation procedure

CHAPTER 2
LICENSING OF OPERATORS FOR VEHICLE USE WITHOUT USER-IN-CHARGE

12 Power to establish operator licensing scheme

Bill 190   58/4

March 2024

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Government legislation – Automated Vehicles Bill, 2024

Scoping notes – safety principles:

- Safety

- Driving without monitoring / control

- Equality and fairness

- Explainability

- Cyber-resilience

March 2024

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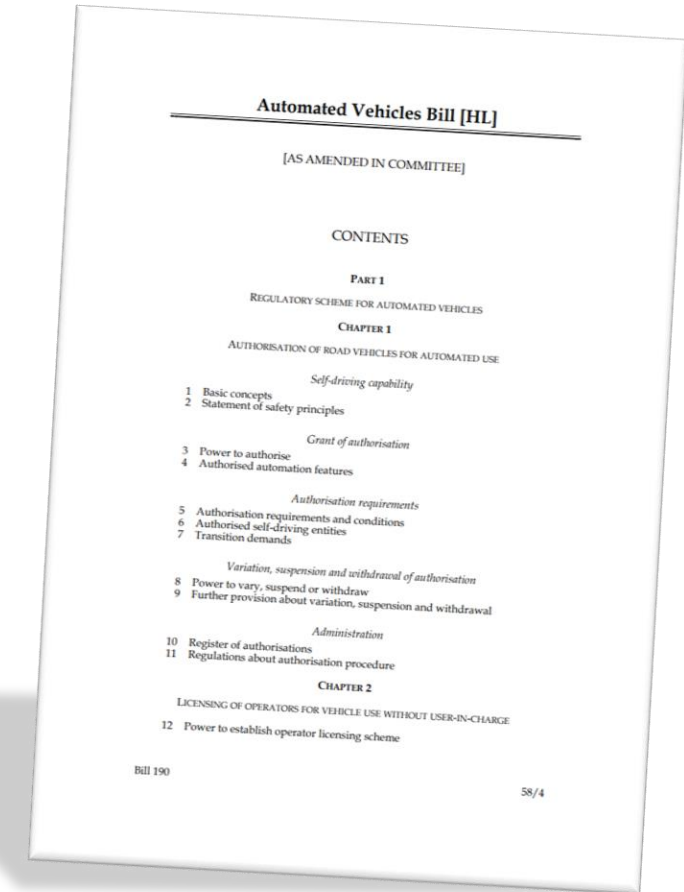
Quick maths – GB (2022) statistics

All traffic:

- Road fatalities $\quad\quad\quad\quad\quad\quad\quad\quad$ = $\quad$ 1,711

- Vehicle miles travelled $\quad\quad\quad$ = $\quad$ 323 billion

- Miles / fatality $\quad\quad\quad\quad\quad\quad\quad$ = $\quad$ ~**189 million** miles / fatality

Includes motorbikes, fatigue, distraction, intoxication etc.

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Quick maths – GB (2022) statistics

Cars only

Fatalities involving human error removed:

- Road fatalities = 110

- Vehicle miles travelled = 244 billion

- Miles / fatality = ~**2.2 billion** miles / fatality

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The reality of real world testing

Kalra, N., & Paddock, S. M. (2016). Driving to safety: How many miles of driving would it take to demonstrate autonomous vehicle reliability?. Transportation Research Part A: Policy and Practice, 94, 182-193.

- Autonomous vehicles would have to be driven <u>hundreds of millions of miles</u> and sometimes <u>hundreds of billions of miles</u> to demonstrate their reliability in terms of fatalities and injuries

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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!

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Automated Road Transport Symposium, San Francisco, 2023

Waymo

Cruise

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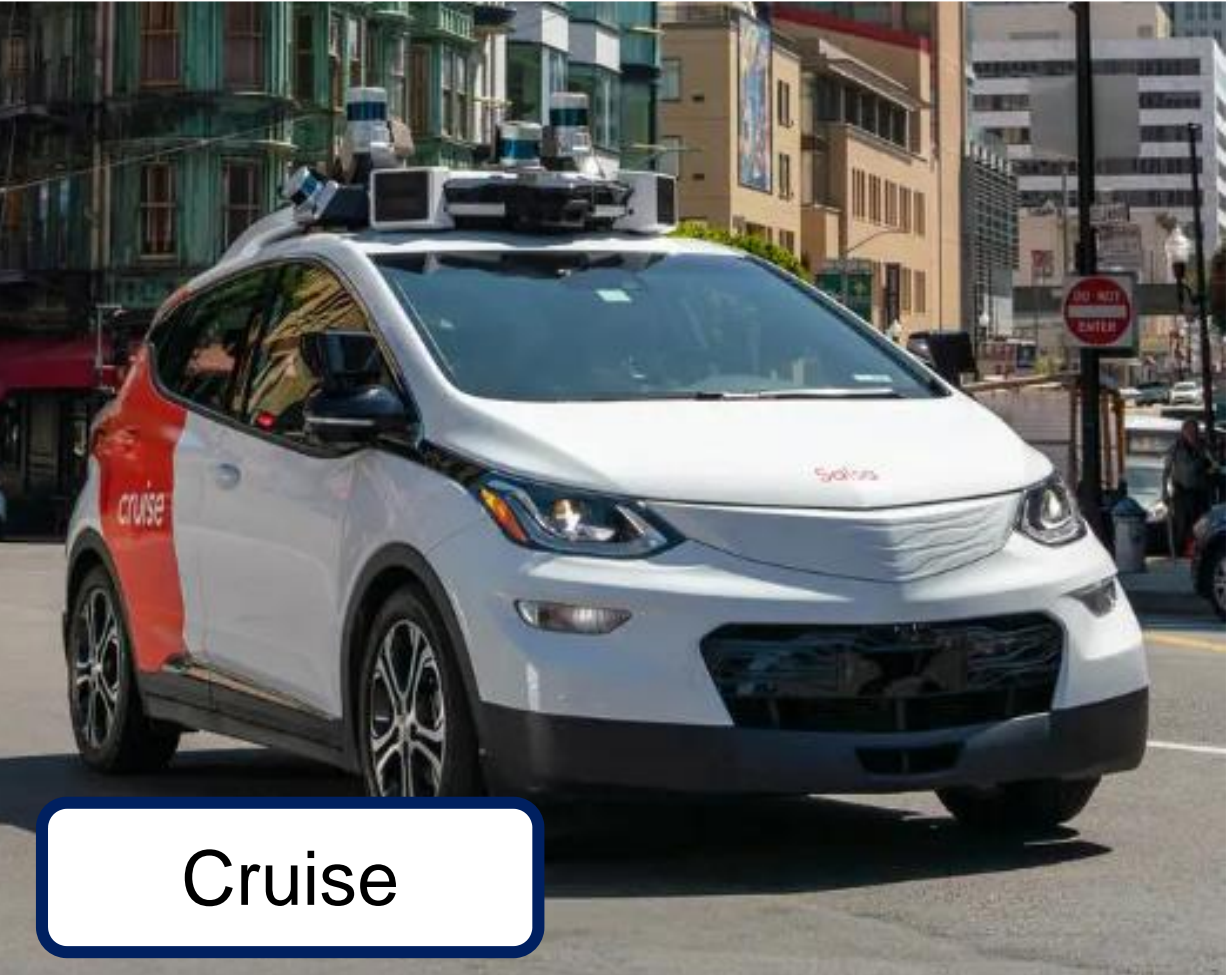
Automated Road Transport Symposium, San Francisco, 2023

WeRide

Zoox

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Automated Road Transport Symposium, San Francisco, 2023

Waymo

Cruise

WeRide

Zoox

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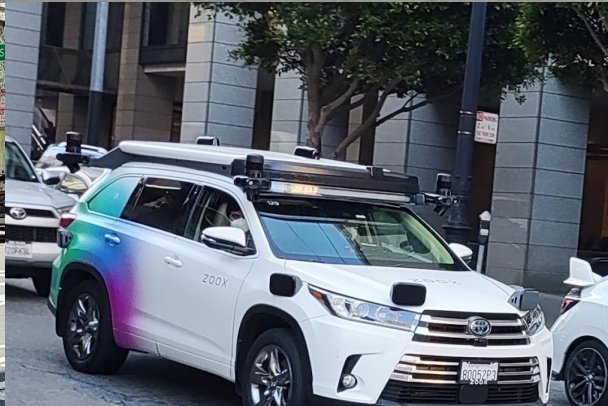
Transport authority's response:

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?

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Trouble on the streets of San Francisco?

KRON 4

BAY AREA

Photo: Waymo vehicle blocks fire truck in San Francisco

by: Tori Gaines
Posted: Apr 25, 2023 / 01:56 PM PDT
Updated: Apr 25, 2023 / 01:56 PM PDT

Waymo vehicle appears to stop in front of fire truck (Photo courtesy of Carrie Haverty)

"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 firetruck 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

https://www.kron4.com/news/bay-area/photo-waymo-vehicle-blocks-fire-truck-in-san-francisco/

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Trouble on the streets of San Francisco?

Mail Online

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'

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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."*

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TechCrunch, October 2023

Cruise pauses all driverless robotaxi operations to 'rebuild public trust'

Kirsten Korosec @kirstenkorosec / 2:32 AM GMT+1 • October 27, 2023

Comment
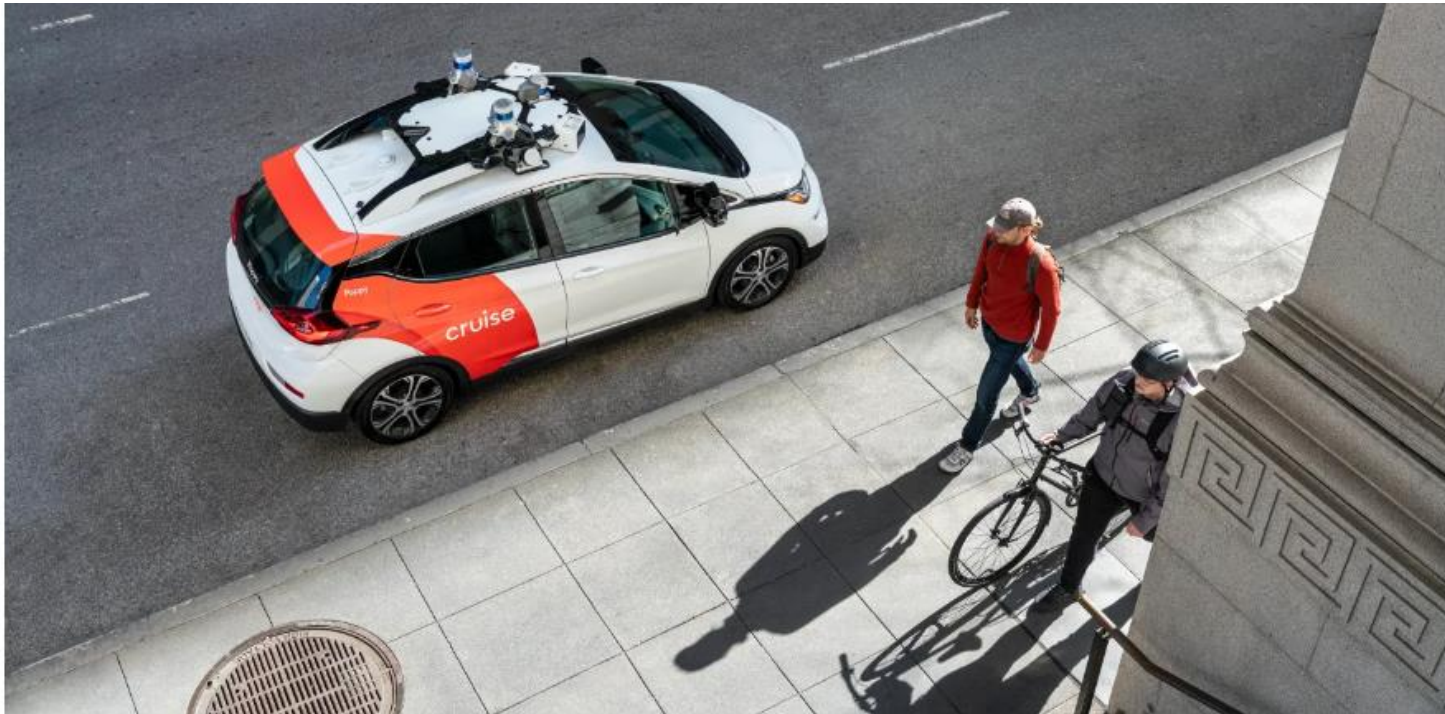
Image Credits: Cruise

- 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

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TechCrunch, February 2024

California regulator looking into Waymo's collision with a cyclist

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

A Waymo robotaxi was vandalized and burned in San Francisco

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

Waymo recalls and updates robotaxi software after two cars crashed into the same towed truck
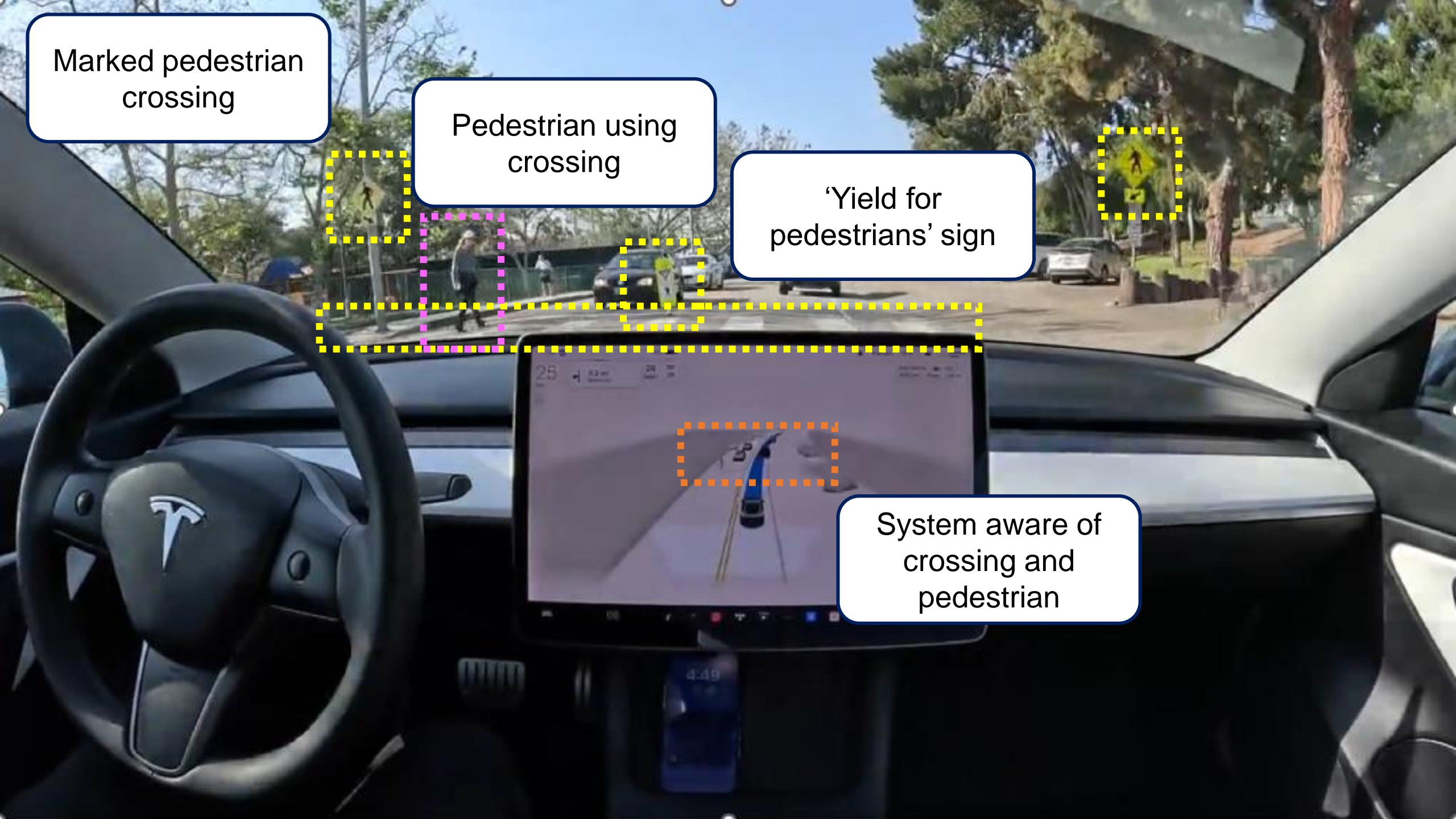
Sean O'Kane @sokane1 / 10:00 PM GMT • February 13, 2024   💬 Comment

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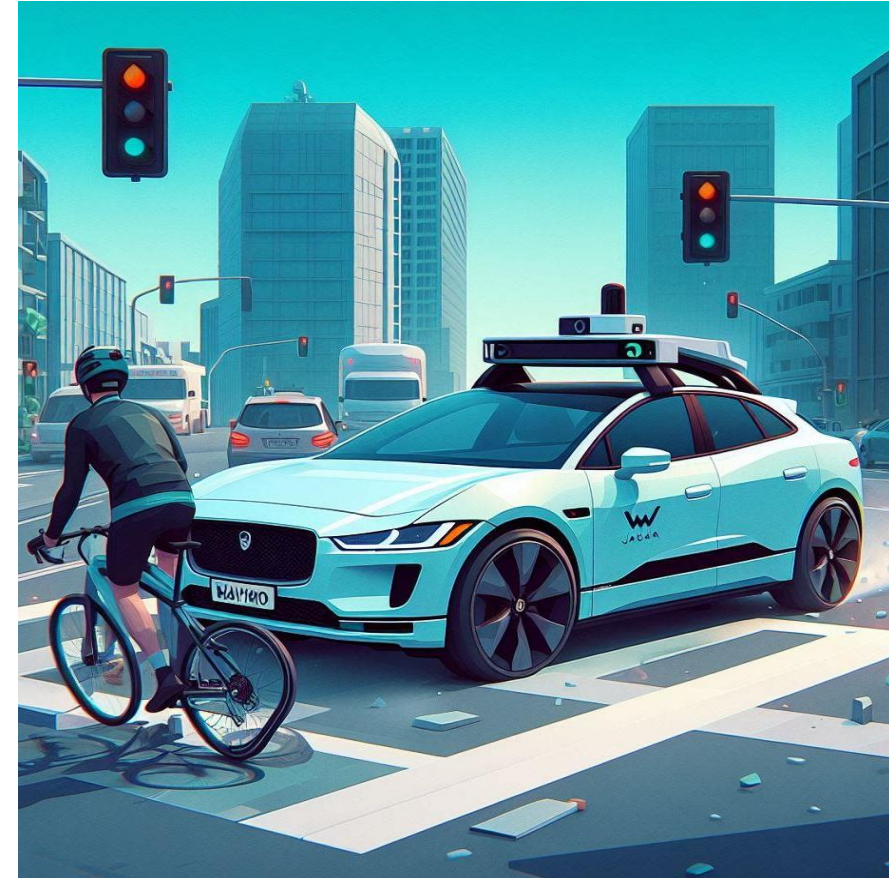
Marked pedestrian crossing

Pedestrian using crossing

'Yield for pedestrians' sign

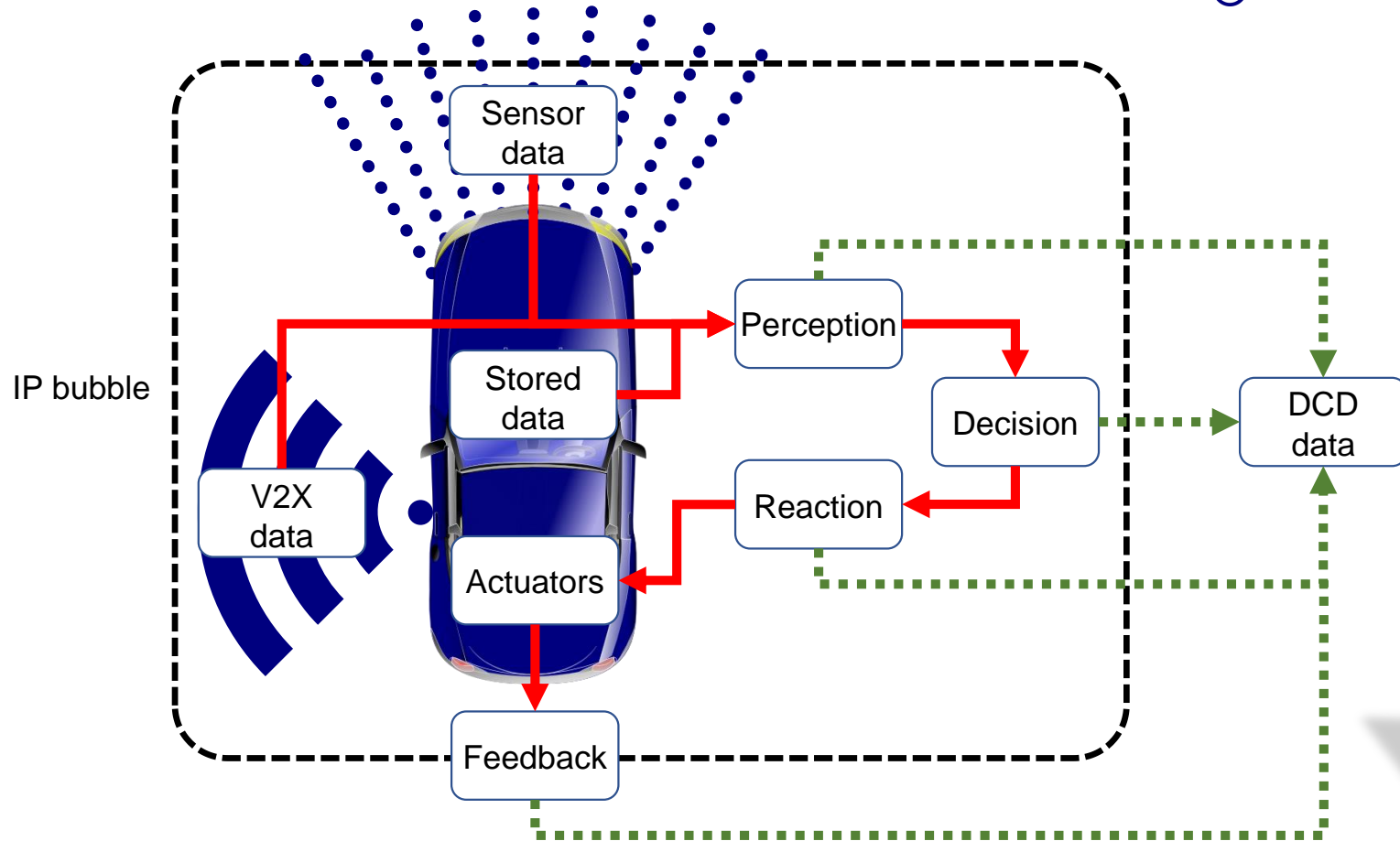System aware of crossing and pedestrian

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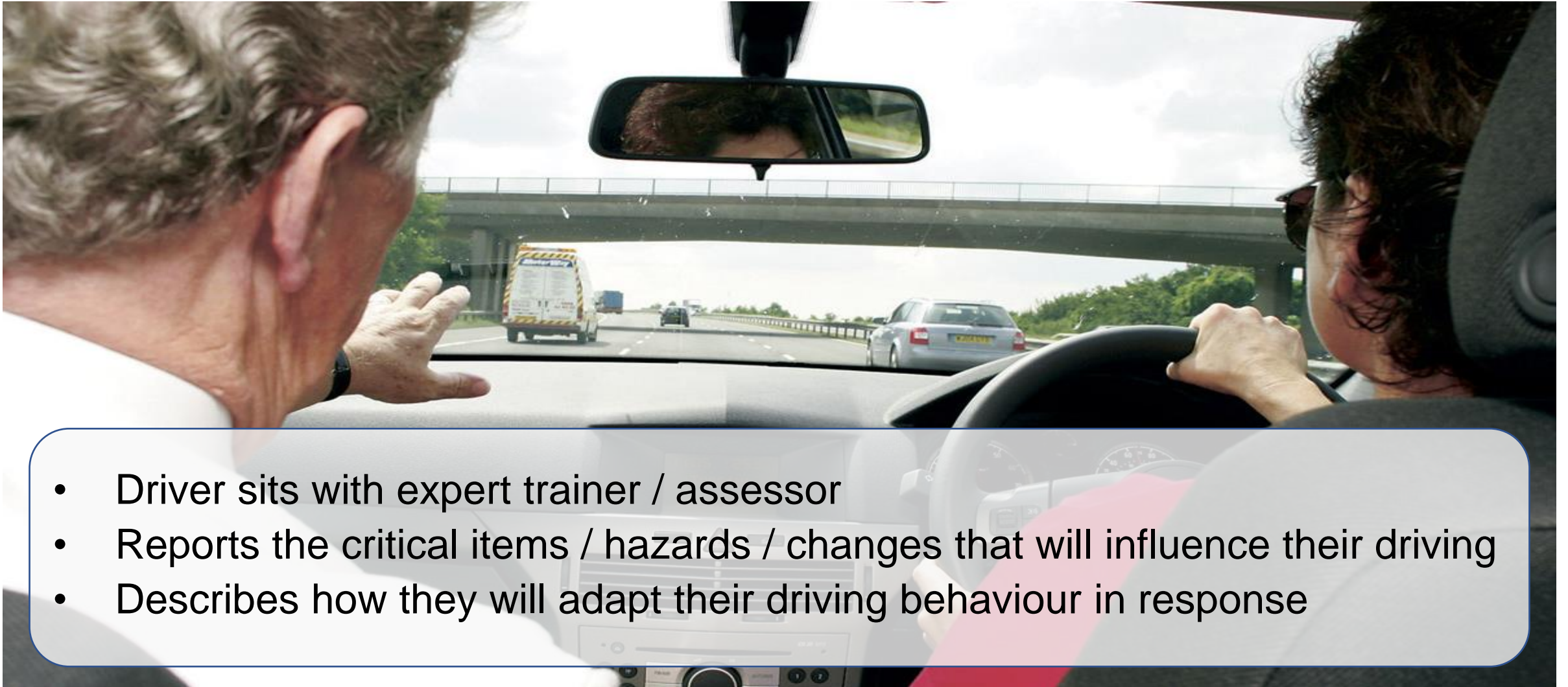
- Driver sits with expert trainer / assessor
- Reports the critical items / hazards / changes that will influence their driving
- Describes how they will adapt their driving behaviour in response

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A possible solution…

IP bubble

Sensor data

Stored data

V2X data

Perception

Decision

Reaction

DCD data

Actuators

Feedback

A review of CAV safety benchmarking and a proposal for a "Digital Commentary Driving" technique

June 2021

bsi.

Centre for Connected & Autonomous Vehicles

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

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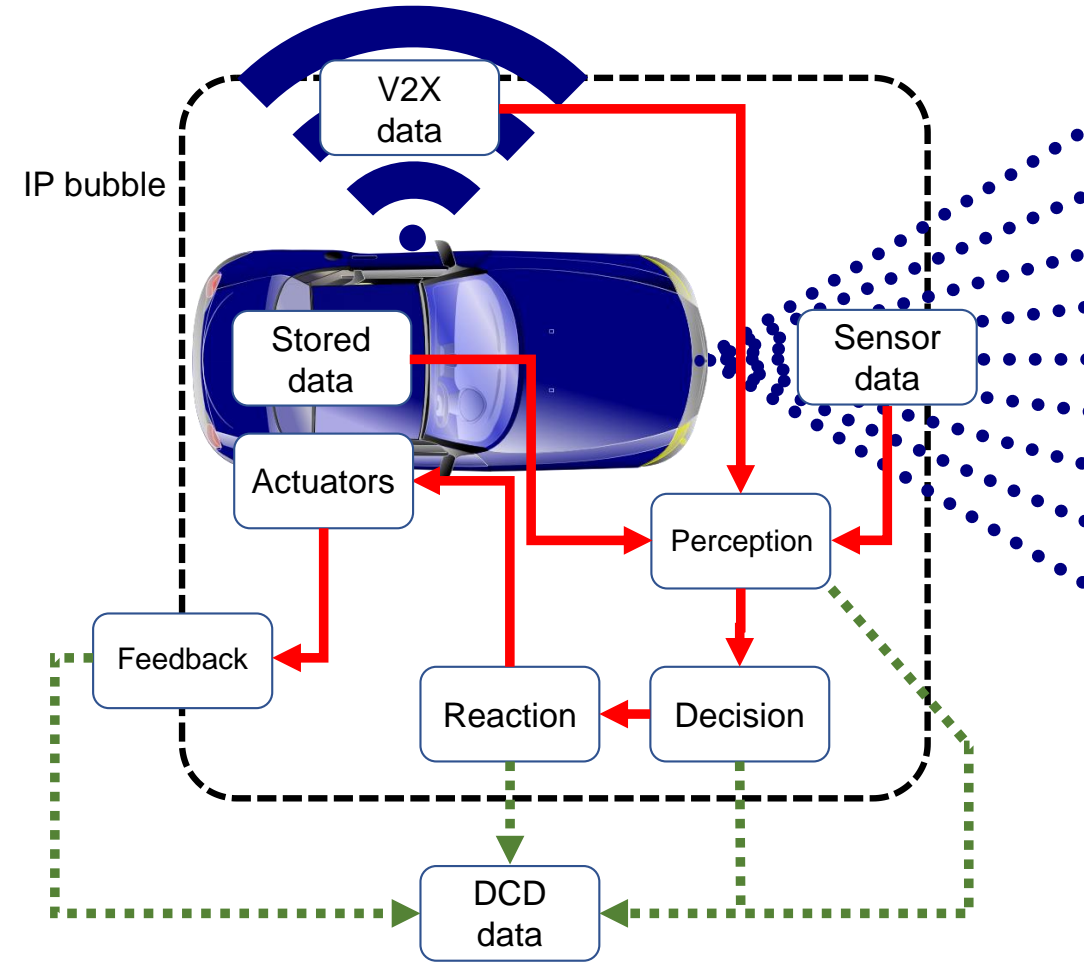
Principle of DCD
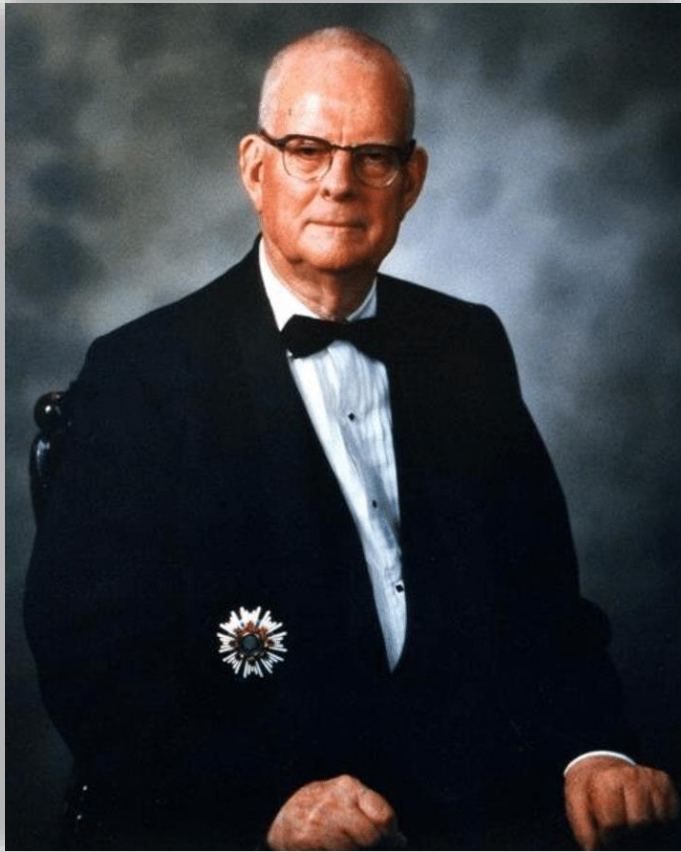
In God we trust…
all others must bring data

William Edwards Deming (1900-1993)

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European Commission – expert panel on CAV ethics

Image credit: European Commission

European Commission – expert panel on CAV ethics

Safety

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.

Transparency

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.

Transparency

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.
14. Reduce opacity in algorithmic decisions.
15. Promote data, algorithmic, AI literacy and public participation.

Responsibility

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.

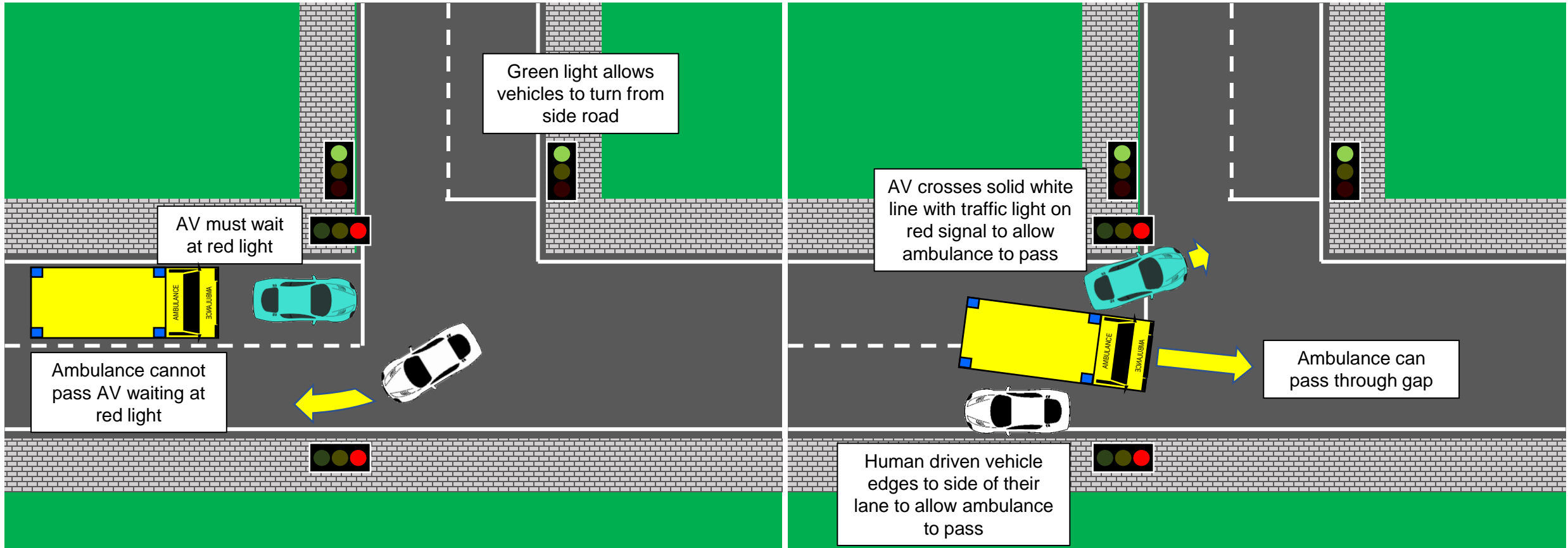Image credit: European Commission

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Recommendation 4

Consider revision of traffic rules to promote safety of CAVs and investigate exceptions to non-compliance with existing rules by CAVs.

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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

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Example 1 – Crossing a red light

Green light allows vehicles to turn from side road

AV must wait at red light

Ambulance cannot pass AV waiting at red light

AV crosses solid white line with traffic light on red signal to allow ambulance to pass

Ambulance can pass through gap

Human driven vehicle edges to side of their lane to allow ambulance to pass

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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?

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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

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d☌:cities

T?RL   Smart Mobility Living Lab London

april6

HUMANISING AUTONOMY

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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

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BSI Flex 1890

- More than 100 terms

- Clear, industry agreed

- Public consultation

- Six-month cadence

- Not finished!
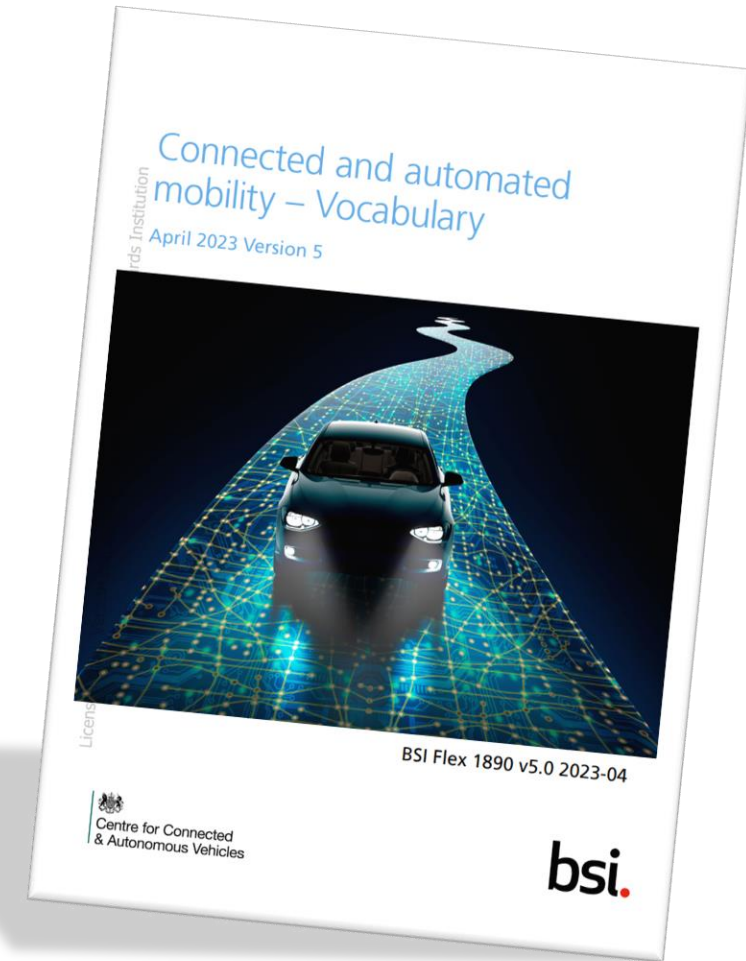
https://camstandardshub.bsigroup.com/bsi-flex-1890-v5/vocabulary/

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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!

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Dr Nick Reed
Founder

nick@reed-mobility.co.uk

www.reed-mobility.co.uk

@reedmobility

Thank you

March 2024

IET Coventry & Warwickshire event