Driver Behaviour Models and Autonomous Vehicles

DBM vs AVBM

SAFER study visit to TØI

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SAFER visit to TØI:
Driver Behaviour Models and Autonomous Vehicles

History of Driver Behaviour Models: 1938 – 2013

- «Insiders»: Main contributors to model development:
  - Gibson & Crooks 1938: Field of safe travel (Kurt Lewin….)
  - Taylor 1964: Driving as a self-paced task
  - Näätänen & Summala 1974, 1976 The Zero-Risk Theory
  - Wilde 1982 The Theory of Risk Homeostasis (Economic theory)
  - Fuller 2007, 2011 The Risk Allostasis Model
  - Summala 2007 The Comfort Zone Model
  - Vaa 2007, 2013 The Risk Monitor Model

- «Outsiders»
  - Learning theory Operant conditioning (as a minimum, «It's all about learning…»)
  - Neuroscience Damasio (1994), Bechara et al (1997)
  - Fuller, Summala, Vaa (2007): They all use Damasio and Bechara («a paradigm shift»)

SAFER visit to TØI: DBM vs AVMs

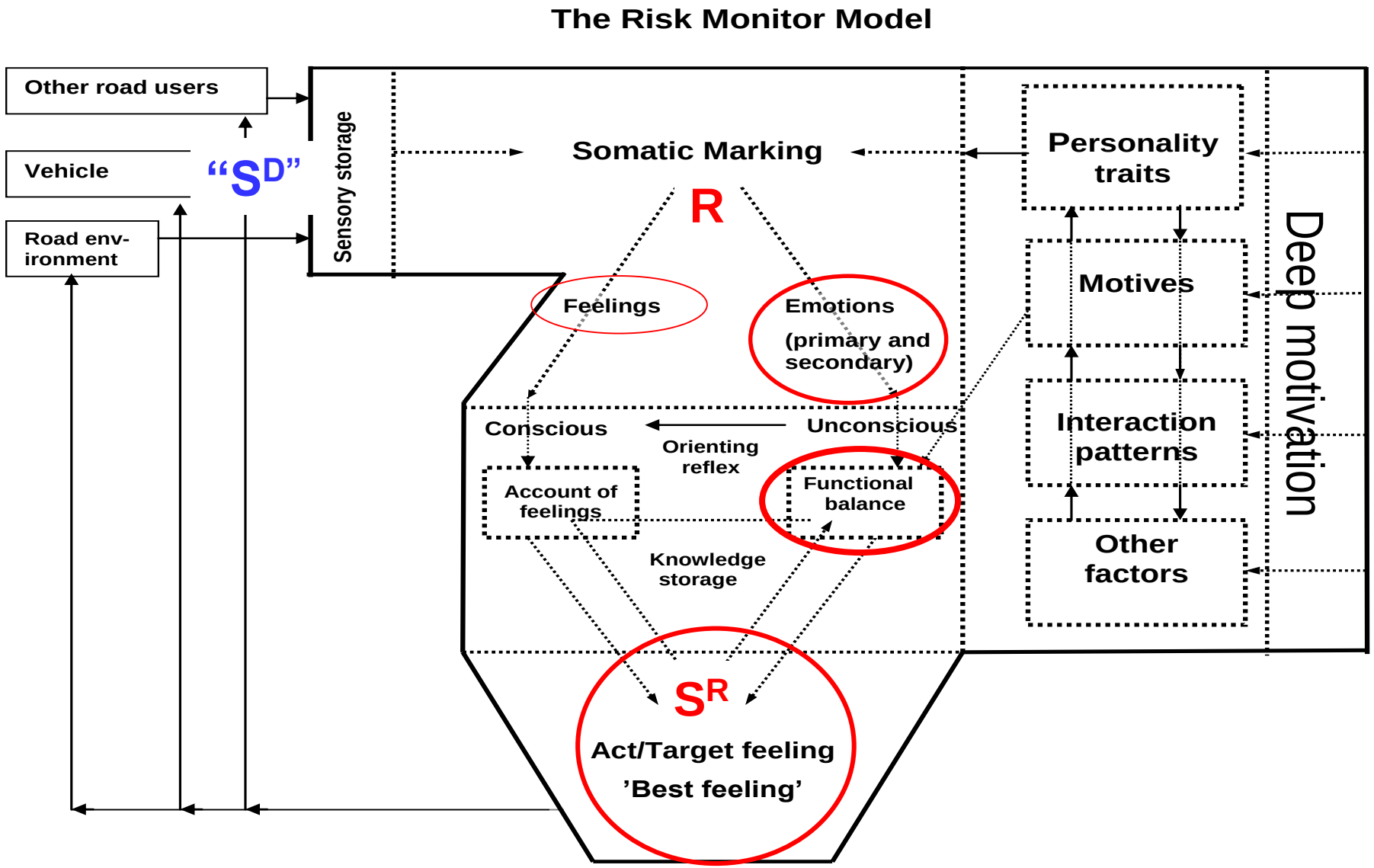
Modelling Driver Behaviour: **The main topic on** the agenda 1982 ➔ *30 yrs on…..*

Theory of Risk Homeostasis (Wilde, 1982) ➔ Risk Compensation**:** «Haunting» road safety research…

Abandoned/added:

Homeostasis(strict)	➔	*Functional balance (some variance)*
(Risk) Compensation	➔	*Behavioural adaptation (evolution)*
Cognition only (conscious)	➔	*Cognition **and** emotion (unconscious)*
Inappropriate understanding of learning	➔	*Operant conditioning (reinforcement)*
«Cognitive homeostasis» (economic theory)	➔	*Feeling of no risk **and** best feeling*
Neuroscience missing	➔	Neuroscience added: ***The*** solution

Risk Monitor Model (RMM): A Model of Driver Behaviour



Driver Behavior Models vs AV Behavior Models: How do they differ?

DBM		AVBM
Learning of schemas	*vs*	*Machine learning - algorithms*
Individual learning curve	*vs*	*Aggregated learning: Distributed to all*
Driver perception	*vs*	*Vehicle perception*
Complete/Global DBMs	*vs*	*“Black box model” – hidden algorithms*
Feeling no risk - “best” feeling	*vs*	*No feelings – no emotions*
Compensation	*vs*	*No feelings means no compensation*

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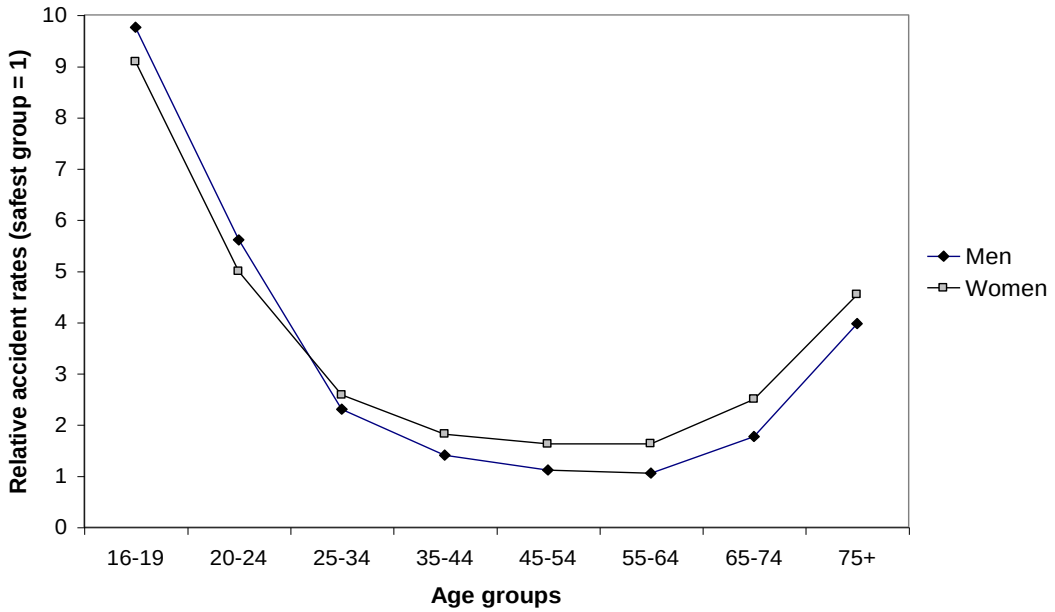
Individual learning curve	*vs*	*Aggregated learning: Distributed to all*
7 years – 100 000		*AV-learning curve ? Increment ?*
		Years ? Km ?

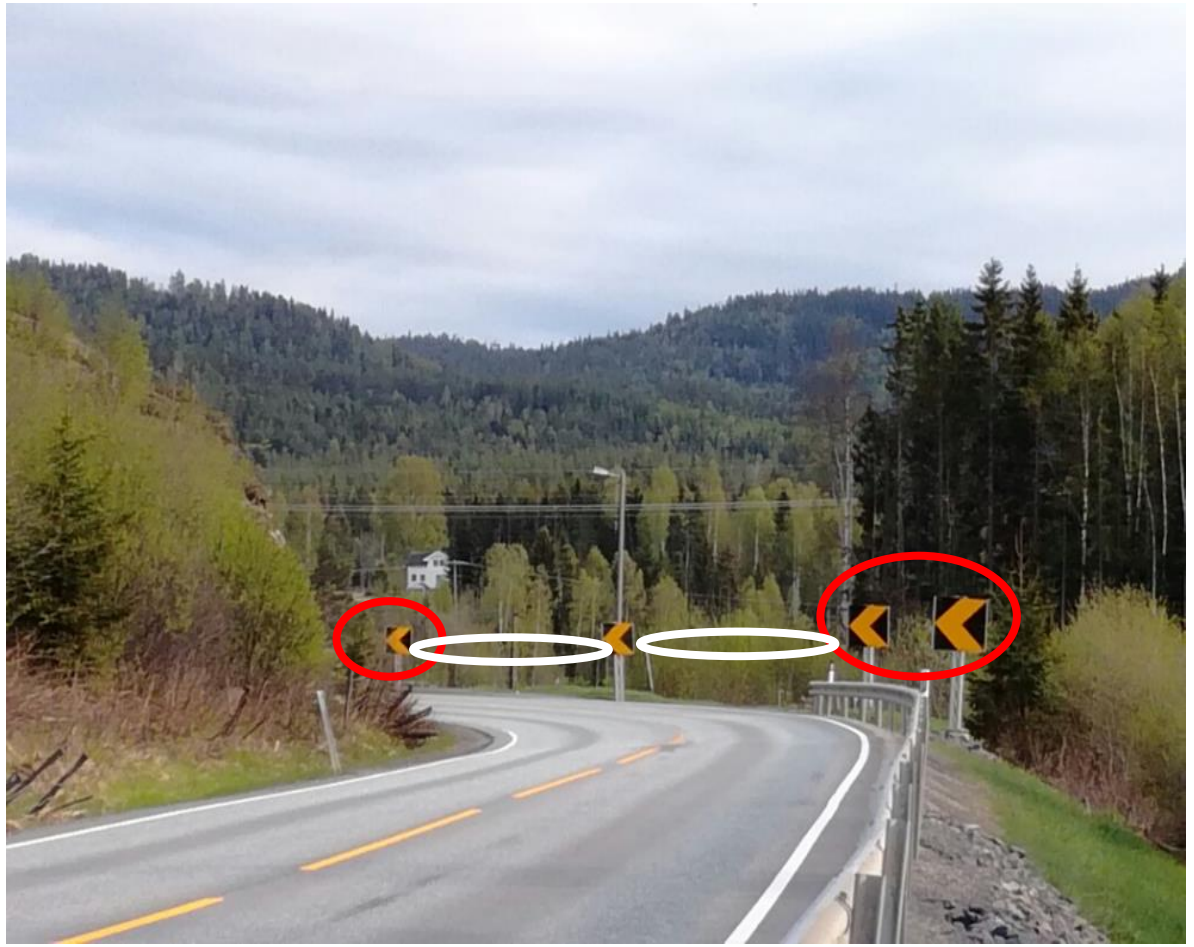


The Tesla rally across US 2015

Tesla «…had a disquiteing tendency to race into curves at breakneck speed»

Schema: «Smallest information entity» -

«Evolution of schemas»: Based on the feeling of risk



The evolution of schemas – based on the feeling of risk

- Mental plans – predominantly unconscious
- Structures for interpreting information
- Serve as guides for action
- Structures for solving (logical) problems
- “Secondary emotions” (Damasio, 1994)

- **IMPLICIT LEARNING (of schemas):**

- **«….takes place largely independent of awareness of both the process of acquisition and the content of the knowledge so acquired»**

Is it safe to drive in traffic ?

Suppose: Driver career from 18 – 83 yoa ≈ 65 yrs - 15 000 km/year

One driver ”on the road”: 65 yrs x 14 000 km ≈ 1 000 000 km

1998:

Approx 0.17 per mill km ≈ 1 accident/6 000 000 km

6 000 000 km : 1 000 000 ≈ 6 drivers

2014:

- Approx 0.07 pr mill km ≈ 1 injury accident per 14 300 000 km (14 drivers)
-
- 1 personal injury accident per 1000 years (80 – 90% minor injury)

- 1 fatal accident pr 37 593 years

- Autonomous vehicles reducing road traffic accidents ?
- 37 593 Teslas driving autonomously (100%) for 1 year…..

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Driver perception:

Continously focused – short distractions average < 700msec ?

Prepared to react to emergencies < 1 sec

AVBM

Vehicle perception

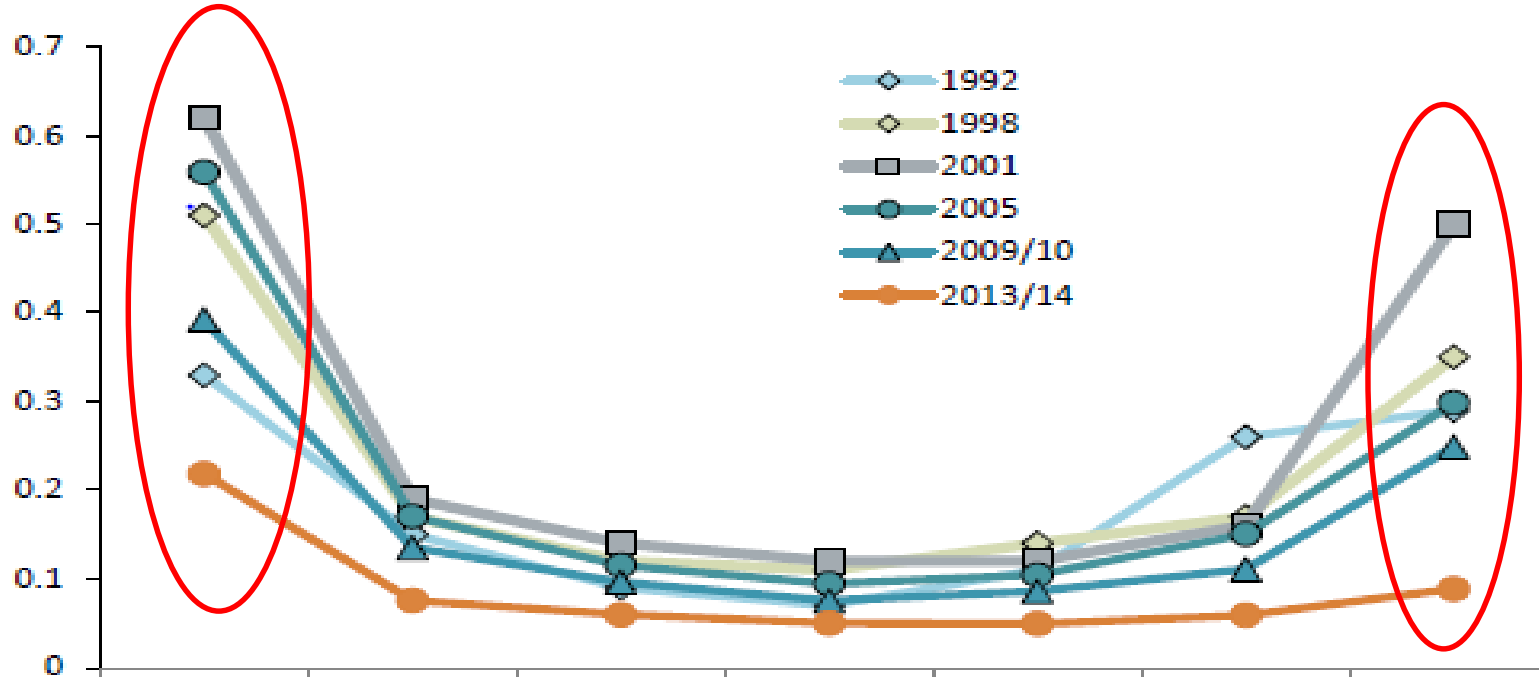
"Black box" algorithms are hidden. Inspection denied

Emergencies SAE level 3: < 30 sec

SAE ?!

AV-accidents as proxy of algorithm limitations ?

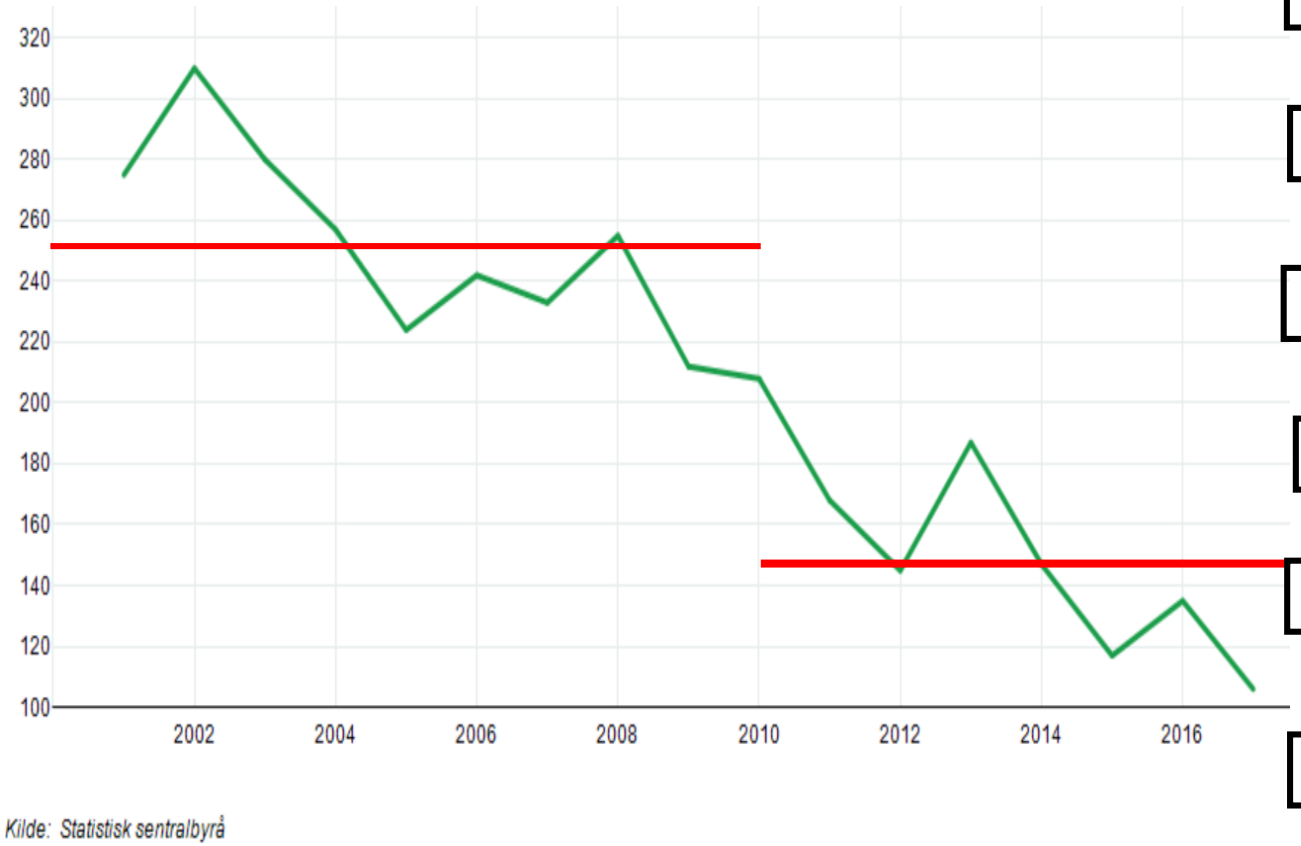
Risk development 1980 -2014 (Bjørnskau 2015)



	18-24	25-34	35-44	45-54	55-64	65-74	75 +
1992	0.33	0.15	0.09	0.07	0.11	0.26	0.29
1998	0.51	0.17	0.12	0.11	0.14	0.17	0.35
2001	0.62	0.19	0.14	0.12	0.12	0.16	0.5
2005	0.56	0.17	0.12	0.09	0.10	0.15	0.30
2009/10	0.39	0.14	0.10	0.08	0.09	0.11	0.25
2013/14	0.22	0.08	0.06	0.05	0.05	0.06	0.09

Figure 5.5 Car drivers killed or injured per million person kilometres distributed by age in 1992, 1998, 2001, 2005, 2009/10 and 2013/14.

Killed in road traffic accidents Norway 2001-2017



Average 2001-2017: 205

Average 2001-2010: 250

Average 2011-2017: 144

Maximum 1970: 560

2017 ≈ Level of 1947

2018 = 108

Automated Vehicle Behaviour Models (AVBM)

- After more than 1 million miles:16 of 17 accidents with Google's self-driving cars were blamed on human error caused by other drivers

- The problem in 16 accidents «…caused by other drivers» seemed to occur at junctions when the traffic signal switched to amber
- Google-cars stopped on amber light and were hit by a car from behind

- Most drivers don't stop on amber light, they cross.....(Bjørnskau,1994)

- Obviously, the Google-engineers were not aware they
- had to change algorithms at signalled junctions

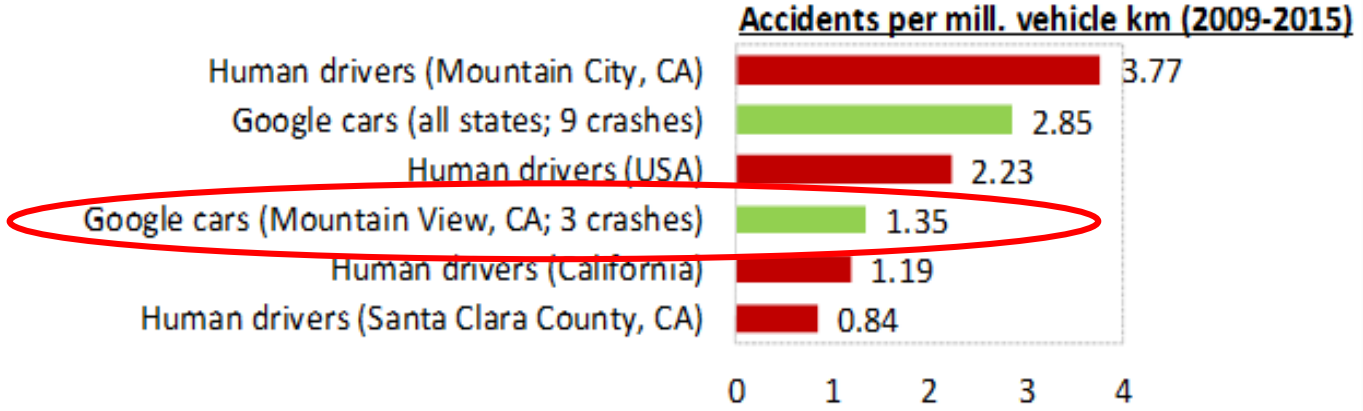
- In compliance with posted speed limits ? Traffic law?
- Drivers are not 100 % compliant… the UBER-accident:
- The other car violated a yielding sign

Recognising a Google car…..?

The longest series of data is obtained from Mountain View, a city in Santa Clara County in California and covers the period 2009-2015.

Mountain View:

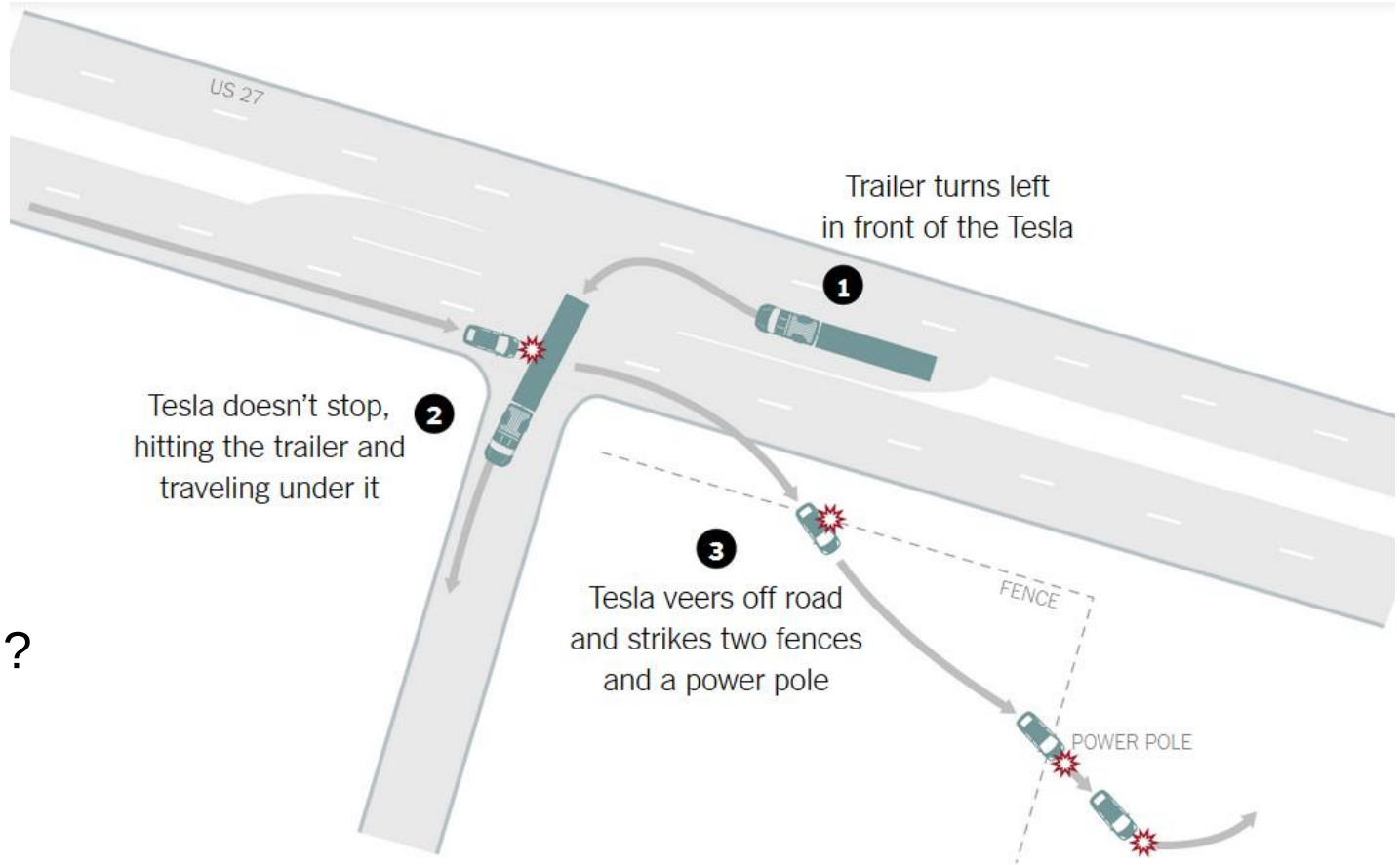
"….large suburb with a pedestrian-friendly downtown and a population of 74,066."



AV «perception»/algorithms

Tesla fatal accident May 2016

«Neither Autopilot, nor the driver, noticed the white side of the tractor trailer against a brightly lit sky, so the brake was not applied» (Tesla spokesperson 30th June 2016)



A software error ? A human error ?

A programmer not considering this situation ?

Driver was “killed by the car” ?

Office of Defects investigation (NHTSA)
“AEB” did not fail”

Obstacles are “filtered out” ?

Fatal accident with UBER/Volvo Tempe, Florida 18th March 2018

Fatal accident with UBER/Volvo Tempe, Florida 18th March 2018

Radio news January 2019: Autonomous vehicle fleet

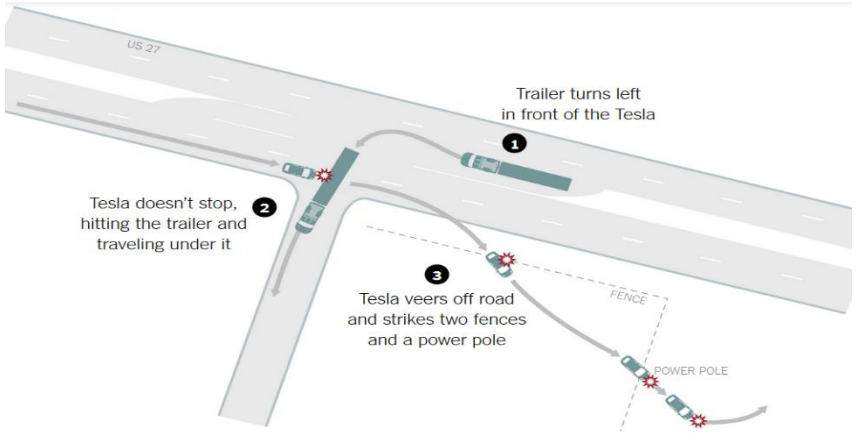
"Pedestrian w/bicycle is no "plastic bag". It should be recognized as a "Pedestrian w/bicycle"

Algorithm update and distributed to whole fleet of 72 000 vehicles (UBER?)

Autonomous mode and the effect on the emergency/safety driver

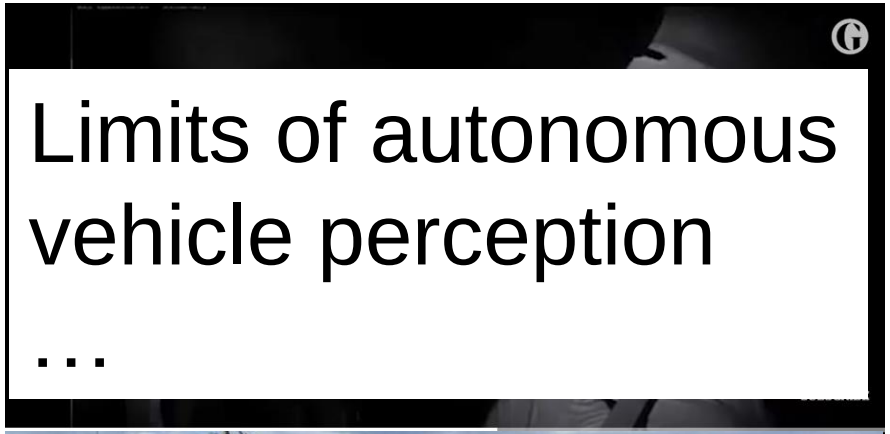
Tesla fatal accident May 2016:
7 seconds before impact: Driver Joshua Brown decides to set cruise control on 74 mph
No reaction recorded before impact

Complacency….



UBER fatal accident March 2018
Safety driver looks down for 5,2 seconds b efore impact with a woman walking with bicycle.

Uber operator was also streaming an episode of reality show *The Voice*



Tesla fatal accident 1st April 2018
"….did not have his hands on the steering wheel for six seconds before the crash, despite several warnings from the vehicle"
(Tesla crashed into concrete lane divider)

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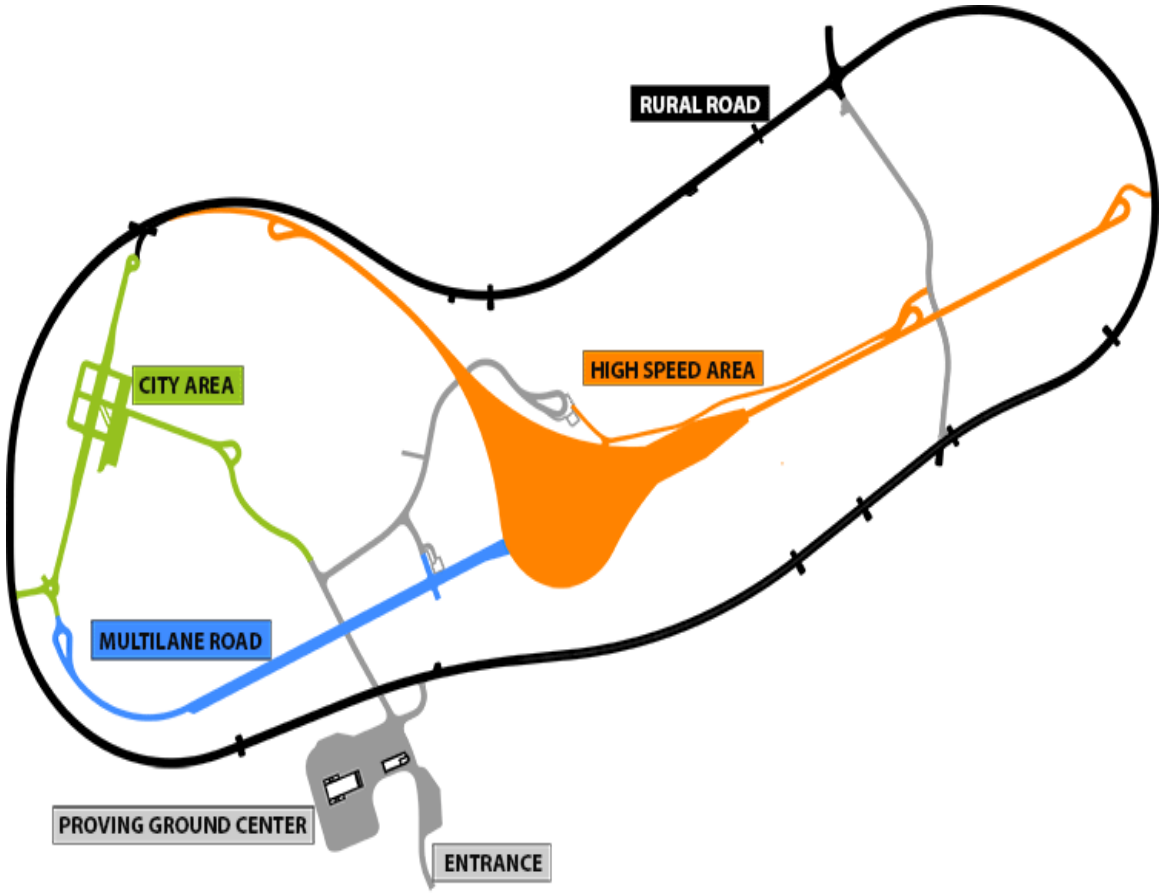
H2020: DriveToTheFuture approved

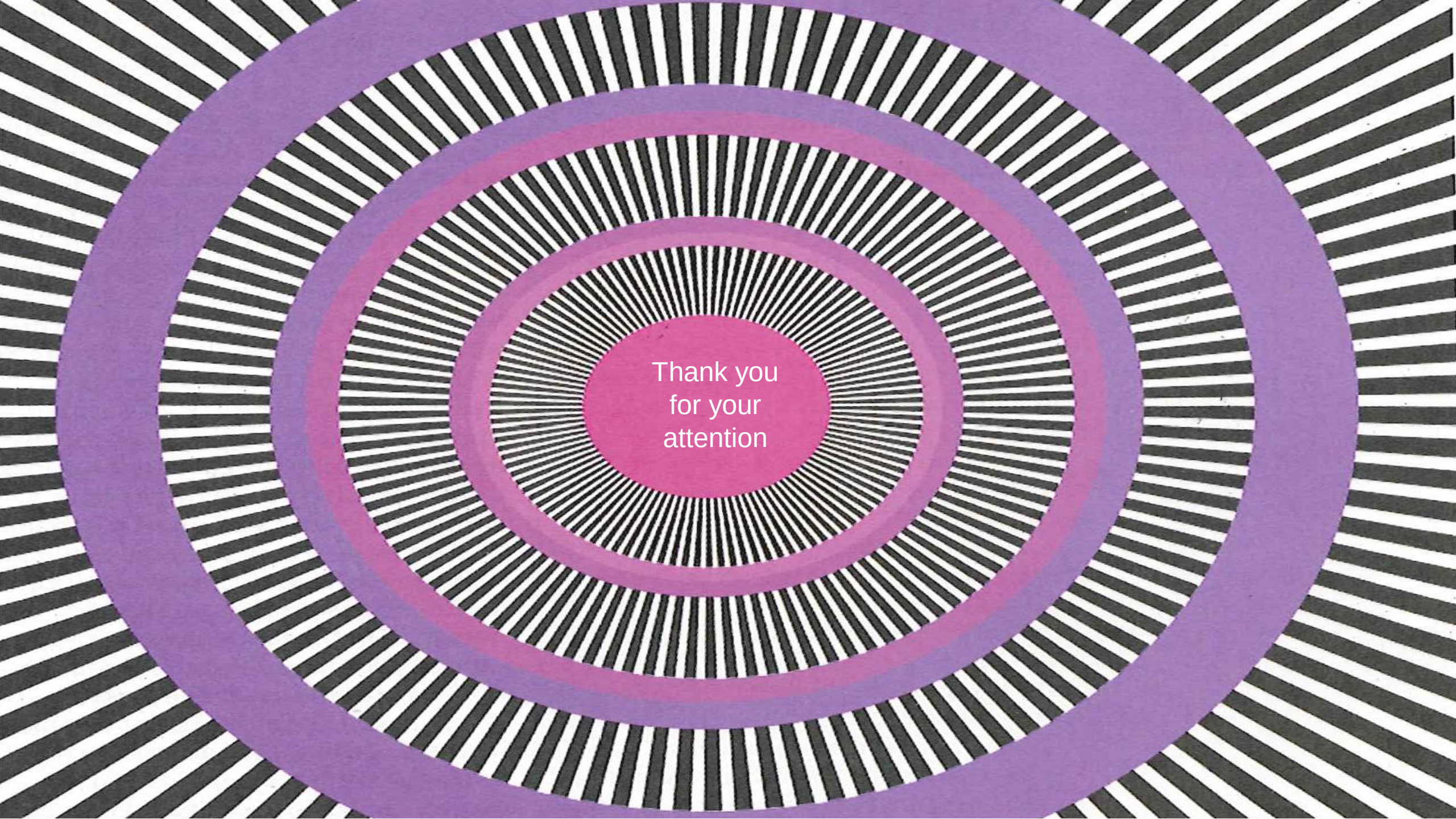


DriveToTheFuture tests:

- 2 automated vehicles (1 Tesla + 1 Volvo)
- Experimental setups mimicking emergency situations in all environmental contexts
- Tests at Level 3 and Level 4
- Exposing the AVs to dummy VRUs and operating in two conditions:

a) Without any previous experience of the route (“no learning-condition”)

b) With previous experience of the route (“experienced condition”)


Thank you
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attention