
# Outline

1. **Potential Safety benefit?**
2. **Level of Automation (SAE)**
3. **CRASH INVESTIGATIONS**
   - ❑Tesla crashes (Level 2)
   - ❑Uber (Level 4)
   - ❑Google chrashes (Level 4)California records)
   - ❑Singapore
4. **How can we improve interaction**?

2

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# Automated vehicles (AV's) can operate:

- **Remote controlled** – Surveilled and/or externally controlled
- **Autonomous** – Based only on own sensors and systems
- **Cooperative** – Based on own sensors and other road traffic information (V2X)

4

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# Expected benefits of self-driving vehicles

- **Improved Traffic Safety**
- Improved traffic flow
- Improved mobility for all
- Enviromental impact



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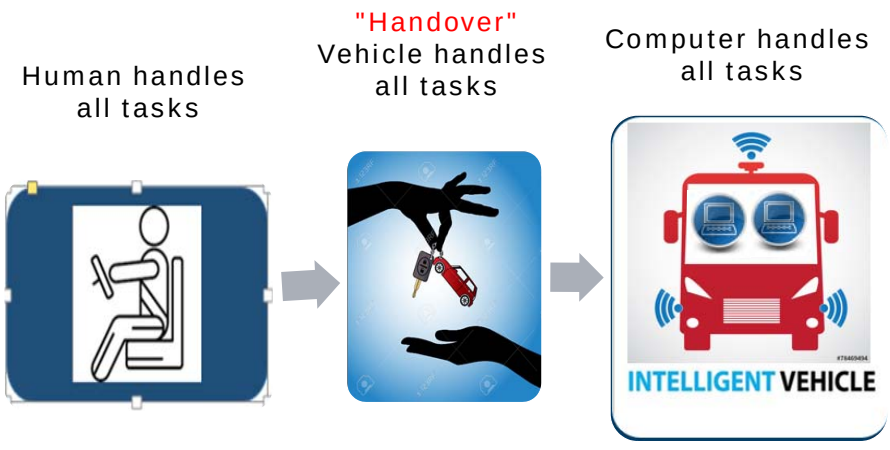
# Automation of the Driving Task

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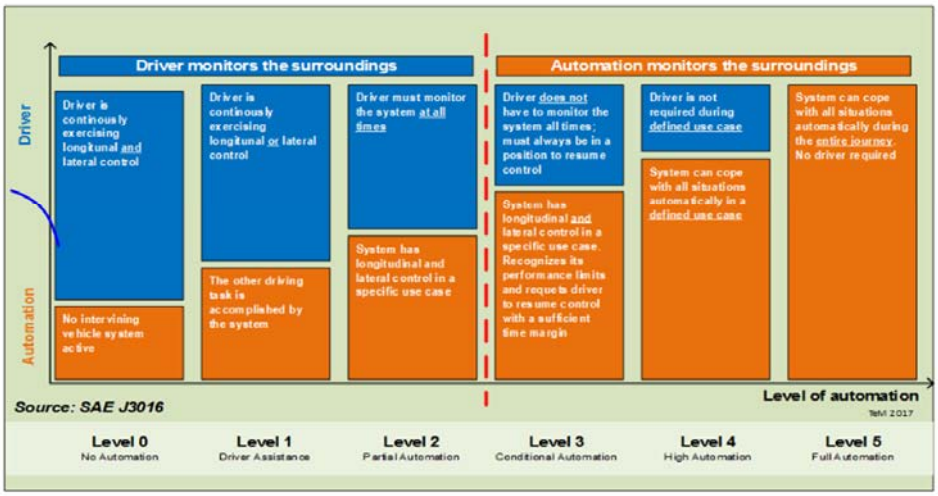
## SAE J3016, levels of automation

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## Why do accidents with AV's happen?

- Development level is that it is not yet reliable and safe?
- Reaction time?
  - When automated driving fails, or is limited, the autonomous mode disengages and the drivers are expected to resume manual driving
- Lack of trust
- To much trust

8

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# Sources

✓Crash reports

✓California regulators require self-driving car firms to report when humans have to take over from robot drivers for safety

- The DMV rule defines **disengagements** as deactivations of the autonomous mode in two situations:

1. "when a failure of the autonomous technology is detected, " or
2. "when the safe operation of the vehicle requires that the autonomous vehicle test driver disengage the autonomous mode and take immediate manual control of the vehicle. "Technical failures

- Note! Self reported: Google Uber, Nissan Mercedes etc is giving only select data



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# Autonomous Vehicle Disengagement Reports 2016

- BMW
- Bosch, LLC
- GM Cruise
- Delphi Automotive Systems, LLC
- Ford
- Google Auto, LLC/Waymo
- Honda
- Nissan North America, Inc
- Mercedes-Benz Research & Development North America, Inc
- Tesla Motors, Inc.
- Volkswagen Group of America, Inc.



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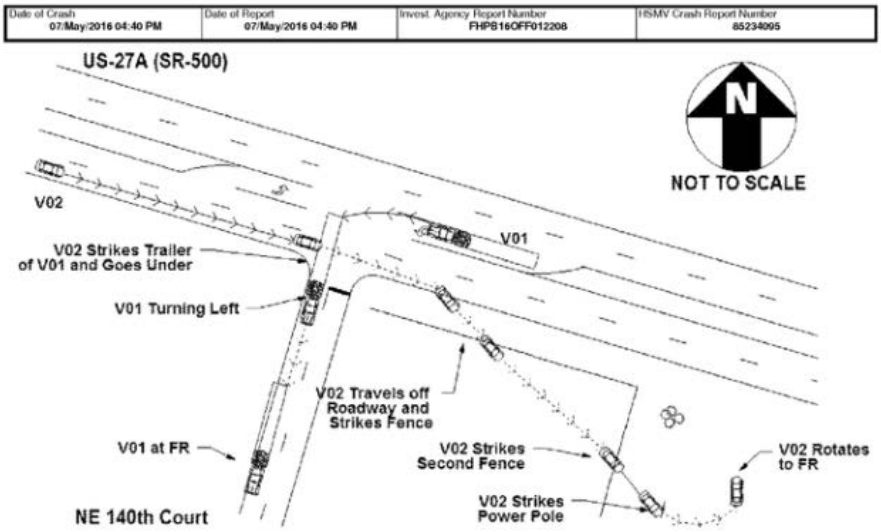
# Chrash investigations

11

## Driver killed in Tesla crash

12




A diagram from the police report about the Tesla crash shows how the vehicle in self-driving mode (V02) struck a tractor-trailer (V01) as it was turning left. Florida Highway Patrol

13

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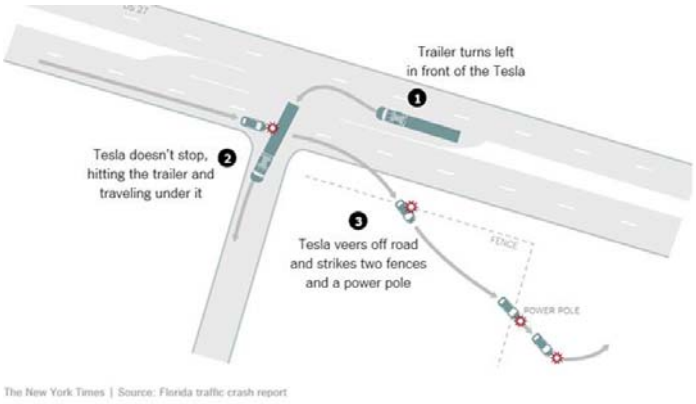
# Tesla accident




The New York Times | Source: Florida traffic crash report

14

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# Accidents as a function of miles driven

- One hundred million. That's the number of miles, on average, that it takes a human driver to kill someone in the United States.
- It's also the number of miles Tesla's semi-autonomous 'Autopilot' feature had driven by May 2016.
- Tesla claim their level 2 vehicles have 40% less collisions than non-equiped vehicles

15

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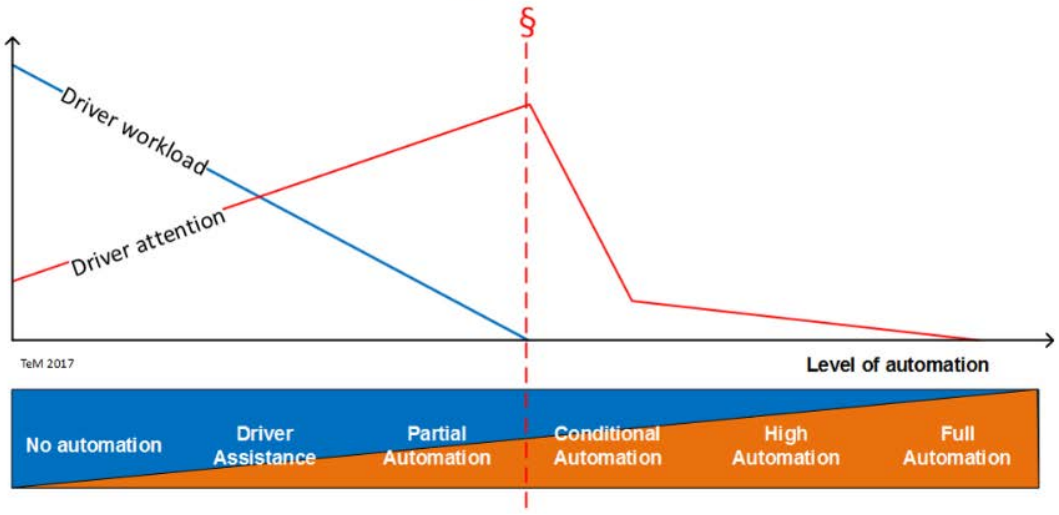
# Automation challenges




16

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## What do we know about accidents with higher level self-driving cars?

- Driven 2.3 million miles on closed and track and public roads


17

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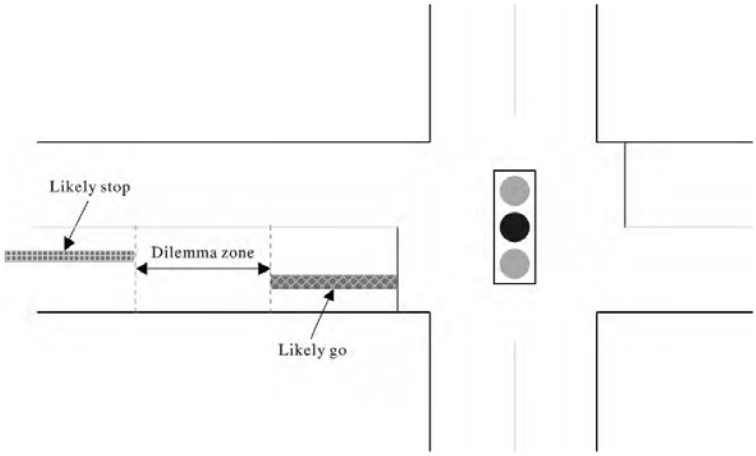
## Dilemma Zone, Google patent 4. februar 2016:

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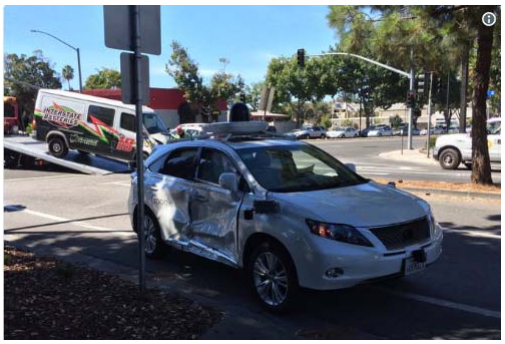
## Google self-driving car in broadside collision after other car jumps red light

September 2016


One of Google's self-driving Lexus SUVs was hit in the side by a driver running a red light. Photograph: Tony Avelar/AP



Google car speed 20mph
Other car speed 30mph



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## Google says:

***"Our light was green for at least six seconds before our car entered the intersection."***

***" Thousands of crashes happen everyday on US roads, and red-light running is the leading cause of urban crashes in the US. Human error plays a role in 94% "***



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- Google's cars have driven more than 1.3 million miles since 2009. They can recognize hand signals from traffic officers and "think" at speeds no human can match. As of January, 2016 they had been involved in 17 crashes, all caused by human error



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# Driver in China Autopilot crash blames Tesla's 'self-driving' pitch

**Model s driver escapes injury but blames automaker, report says**



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# NuTonomy- rear-end accident Singapore Oct 2016

- Driverless car collides with lorry in one-north The NuTonomy test vehicle had been changing lanes when it collided with a lorry,
- There were no casualties.

23

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The First Study Of Self-Driving Car Crash Rates Suggests They Are Safer

- Virginia Tech Transportation Institute found that the crash rate for self-driving cars is lower than the national crash rate.

24

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## Virginia Tech Transportation Institute study (2016)

- National crash rate of 4.2 accidents per million miles
- Crash rate for self-driving cars, is 3.2 accidents per million miles
  - The data took into account the severity of crashes, and it adjusted for unreported incidents
  - The study was commissioned by Google
  - Mainly Google cars (2014-2016) in the study?
  - Google cars driven 2 million miles on public roads Mountain view California

25

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## Insights based on data released from the California trials

- Reaction time
  - The reaction times to take control of the vehicle in the event of a disengagement was found to have a stable distribution across different companies at **0.83 seconds** on average.
  - The number of accidents observed has a significantly high correlation with the autonomous miles travelled.
  - However, there were differences observed in reaction times based on the type of disengagements, type of roadway and autonomous miles travelled.
- Lack of trust
  - Exposure to automated disengagements was found to increase the likelihood to take control of the vehicle manually.
- To much trust
  - With increased vehicle miles travelled the reaction times were found to increase, which suggests an increased level of trust with more vehicle miles travelled

26

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# What are the effects of automation?



## What do we know from theory and research?

Automation causes

- Control issues
- Misuse
- Distrust, resentment, resistance
- Loss of manual skills
- Can make us passive

# Human in the loop?


Yerkes-Dodson curve – Driver perfomance/workload

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# What do we do when the driving task is automated?

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## What do we do when we trust the autopilot?

**Passiv**

- "Out of the loop"
- Not paying attention
- Confusion of system modus

Longer term

- Loss of manual control skills

Kilder: Stevens (2008), Sheridan and Nadler (2006), Sheridan (2001), Bainbridge (1987)

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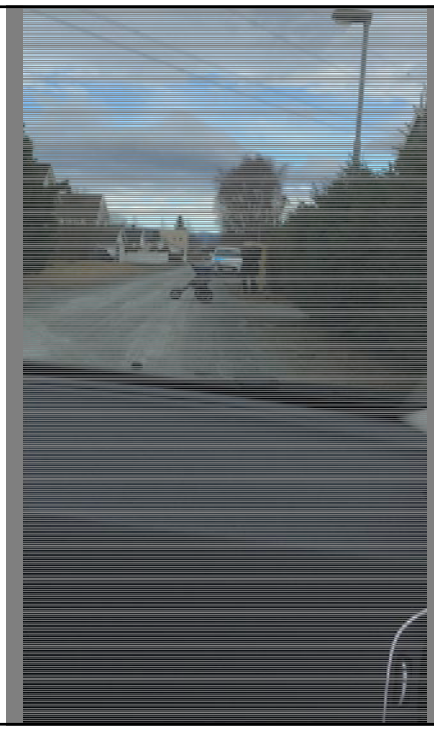
# Is the technology good enough?

32

# Automated Emergency Braking System (AEB)



33

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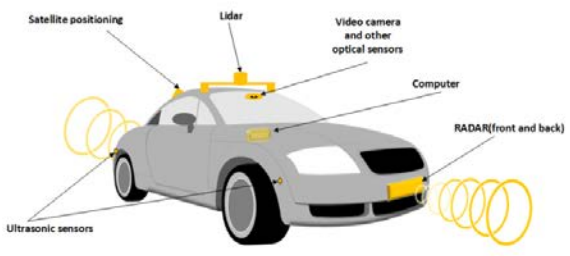
## Key on-board technologies




34

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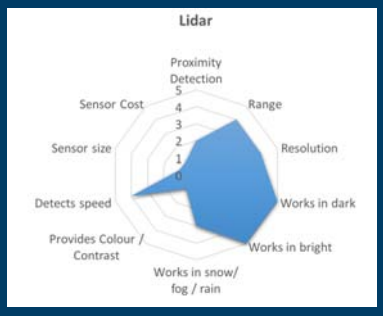
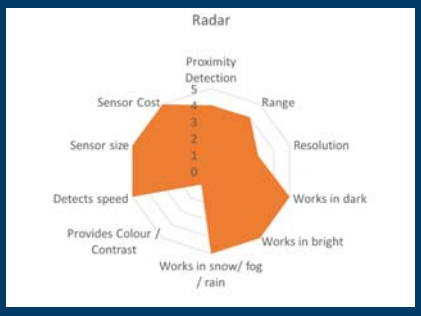
# Is it a question of technology?

**Google**




**Tesla**




35

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## Vehicle radar blocked by slush or snow

36

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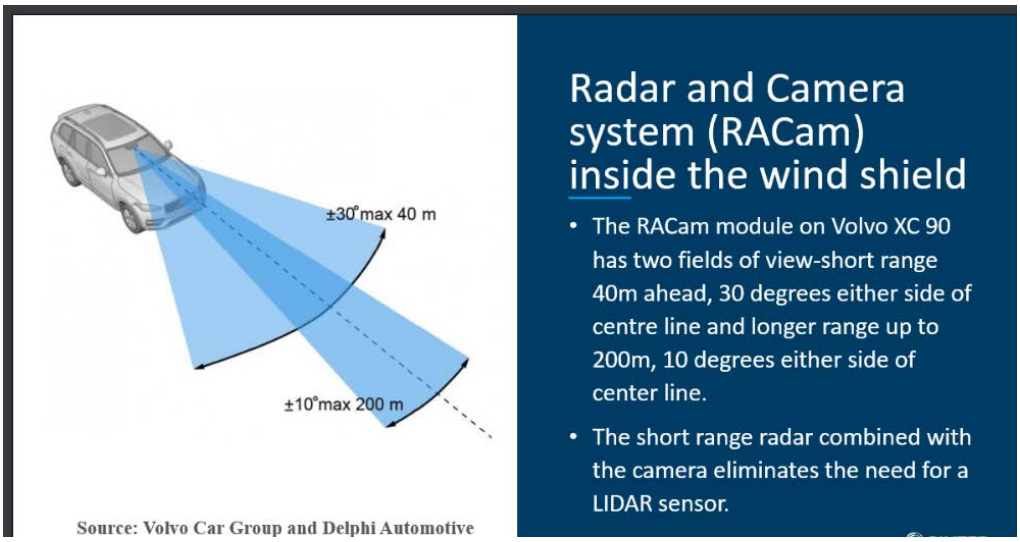


Source: Volvo Car Group and Delphi Automotive

## Radar and Camera system (RACam) inside the wind shield

- The RACam module on Volvo XC 90 has two fields of view-short range 40m ahead, 30 degrees either side of centre line and longer range up to 200m, 10 degrees either side of center line.
- The short range radar combined with the camera eliminates the need for a LIDAR sensor.

37

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## Ice and dew problem

- Ice and dew inside or outside the windshield may give malfunction in camera sensors placed behind the windshield

12

38

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## A critical issue:

- Automated driving at current stage of its development is not yet reliable and safe
- AV's  do not yet have the technology and or AI to handle all road, weather conditions and traffic interactions
- We have as humans not yet learnt how to handle all SAE levels of Automation as drivers in the loop, as salesmenn, passengers, pedestrians, cyclists, bikers (MC)…nor as legislators, regulators



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# What can we do to reduce conflicts with other road users?



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# Some of the challenges

**Autonomous Vehicle – Interaction with pedestriansm cyclists (VRU's)**

dagbladet.no

**Autonomous Vehicle – Interaction with non - automated traffic**

nrk.no

41

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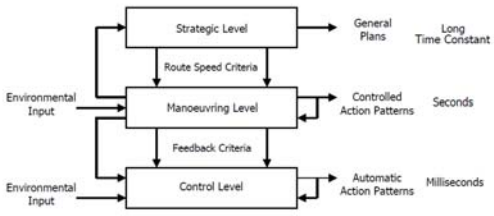
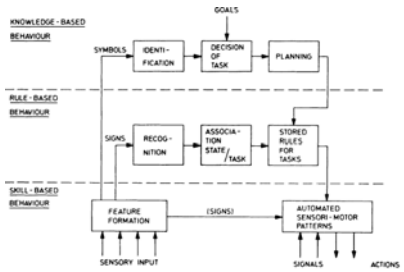
# Mismatch of behaviours

- Normative versus formative




Michon 1985. Driver behavior model




Rasmussen 1983. Model of operator perfomance

42

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# Infrastructure

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# Making humans understand robot cars



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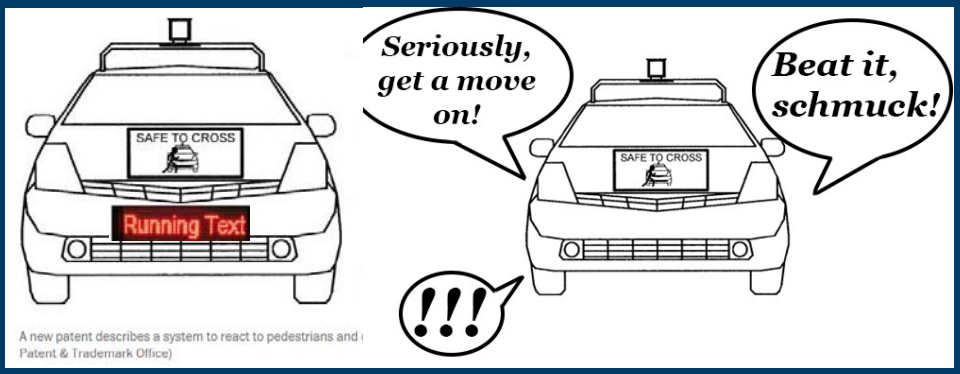
# Google patent



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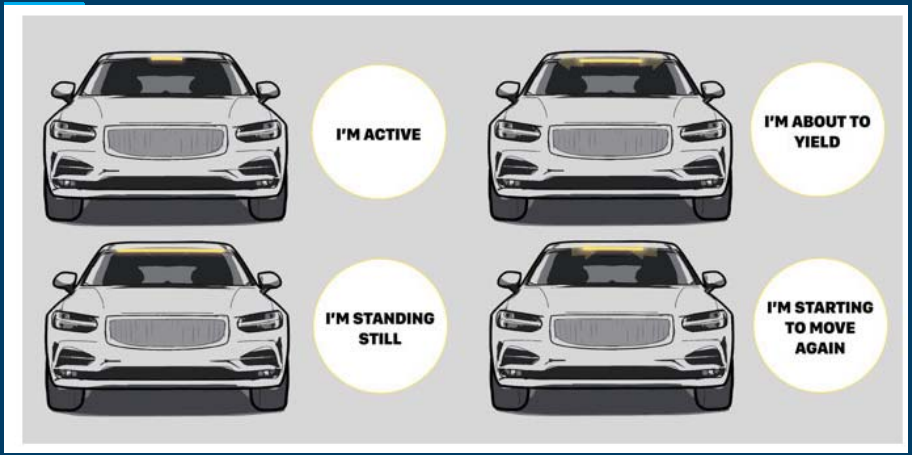
# Chalmers study




Tobias Lagström &Victor Malmsten Lundgren (2015). AVIP - Autonomous vehicles´ interaction with pedestrians. An investigation of pedestrian-driver communication and development of a vehicle external interface. Chalmers University of Technology. Gothenburg, Sweden.



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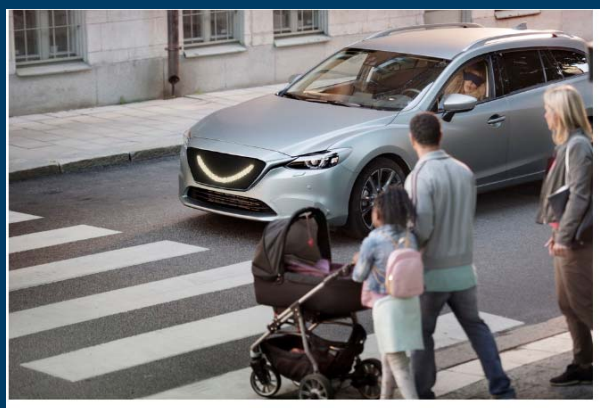
# Semcon



**SEMCON'S SMILING CAR CONCEPT**
This family probably feels safer while crossing the street.
*Semcon*



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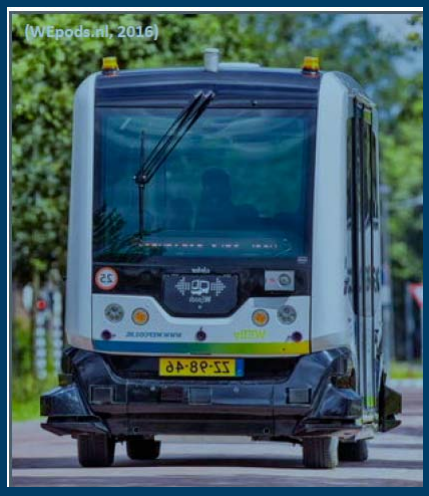
# Delft study

Velasco, Rodrigues Farah, hagenzieker (2016)

- Results Interviews & Focus group
  - Eye contact is important (Low speed )
  - Expectations
    - Expected WEpod to stop in all instances
    - Steward present? Majority di not know
  - Communication - Should be Visual & audiotory



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# Take away points!

- AV's on market or in pilot testing are at different SAE levels
- Technology is imperfect
- Accidents will happen,- on public roads with or without your consent
- "Proof" - Accidents are already lowered by 40%  (level 2)



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# Take away points!

Manufacturers/Salesmenn must allow user to understand

*1.What the system capabilities and limitations are*



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## Take away points!

With driver in the loop (level 2-3 )

- System must allow user to understand:
  1. *What the system does presently*
  2. *What it plans to do*
  3. *What it can not do*



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## Take away points!

- R&D is needed to improve interaction between:

1. AV's and vulnerable road users
2. AV's and non automated vehicles



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Technology for a better society

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