

**SINTEF**

Hvis du går for lenge  
i det samme spor  
Møter du toget

*De Hælland bombarder*

**Vehicle technology, driving support and automation**

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Presentation March 21st 2019

NTNU - TRAFFIC ENGINEERING AND ITS

## Some past and ongoing projects

- 2019, Smartfeeder, Sarepta AGV, Snowtonomy, AF drum roller, Lambda etc (public, private)
- 2018 Smartfeeder, Sarepta (NFR)
- 2017 Technology Changes Society (NTVA)
- 2016 Mobinet (EU project)
- 2014 Automated winter maintenance (AV)
- 2011 Waypilot, Wisecar (SMITS)
- 2010 PhD – Driver support
- 2008 Citymobil (EU)
- 2006 Claresco (EU project)
- 2003 Traffic 2000 (Norwegian technology council)
- 2001 Streetrust (EU project)
- 1990 HMI –Traffic messages (Telenor etc)
- 1989 Prometheus (EU project)

## History



Hest og vogn fra 1890



Carl Benzs patenterte motor-  
kjøretøy fra 1886

## Increasing speed leads to accidents



Trafikkulykke i 1912



Trafikkulykke i 1918

# Passive safety

## Passive safety systems

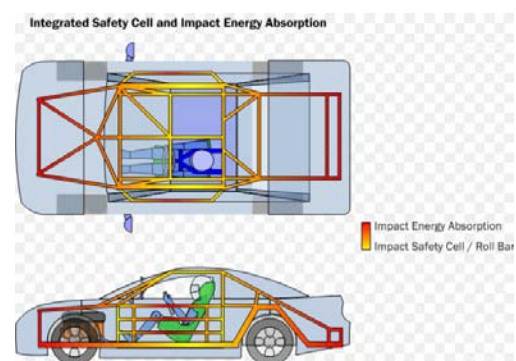
Reduce damage to driver and passenger

When accident occurs!

Damage reducing

Examples of passive safety systems:

- **Mechanic construction, "safety cage"**
- **Seat belsts**
- Airbag
- Bilheltstrammer



## Deformation zone in both vehicles



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## What is done to improve vehicle safety?

Euro NCAP, test from 2009

Adult



Child



Pedestrian



### ■ Collision tests

- Front
- Sideways
- Collision with pillar
- Pedestrian

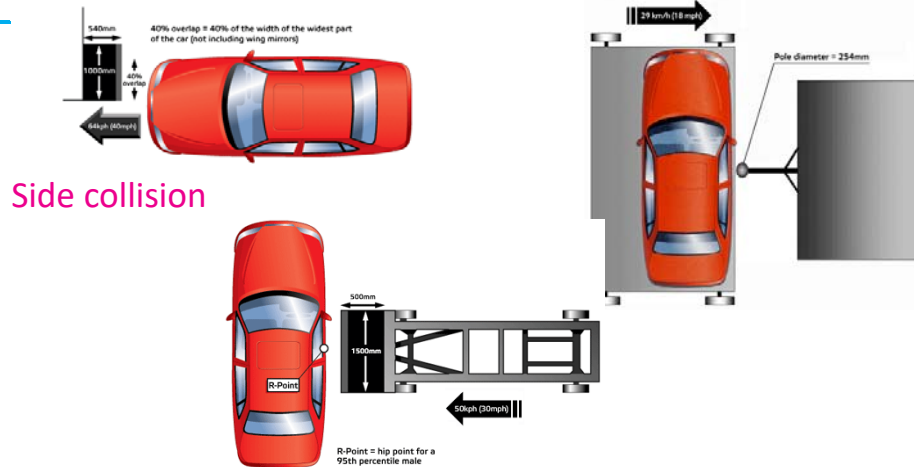
### ■ Safety support

- Seat Belt Reminder
- ESC (anti skid)
- Speed Limiters, inkl ISA (Automatisk fartstilpassning)

### ■ ESC as standard to get 5 stars

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## Front collision



## Pedestrian safety



From 2009 a minimum of 25% pedestrian protection necessary to achieve 5 stars. From 2010 it increased to 60%

## Test dolls for adults and children



Hybrid III: Samler data fra frontkollisjon



ES-2: Samler data fra sidekollisjon

## BS6 Brilliance from China tested according to Euro NCAP protocol



\* (1 star)  
Test nr 1 (2007),  
ADAC, Germany



\*\*\* (3 stars)  
Test nr 2 (2007) 79 dager senere, IDIADA,  
Spania



## Active safety

Pro-active  
avoid accidents before they occur

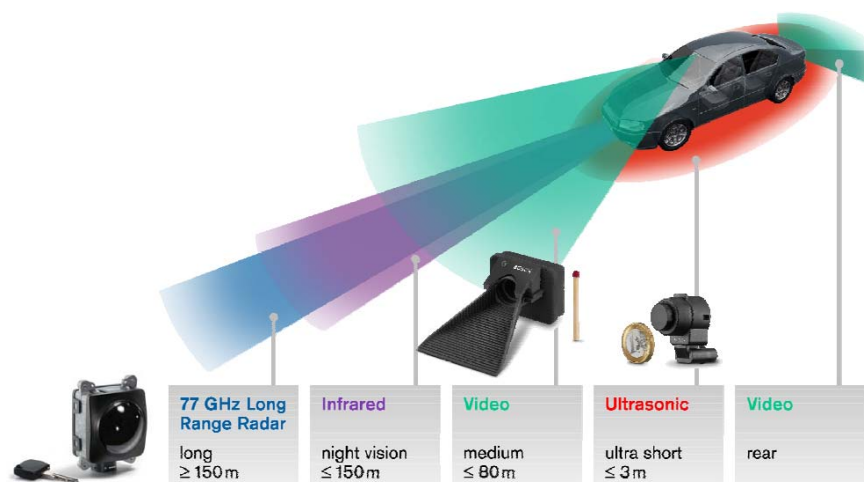
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## From biology to aktive vehicle systems

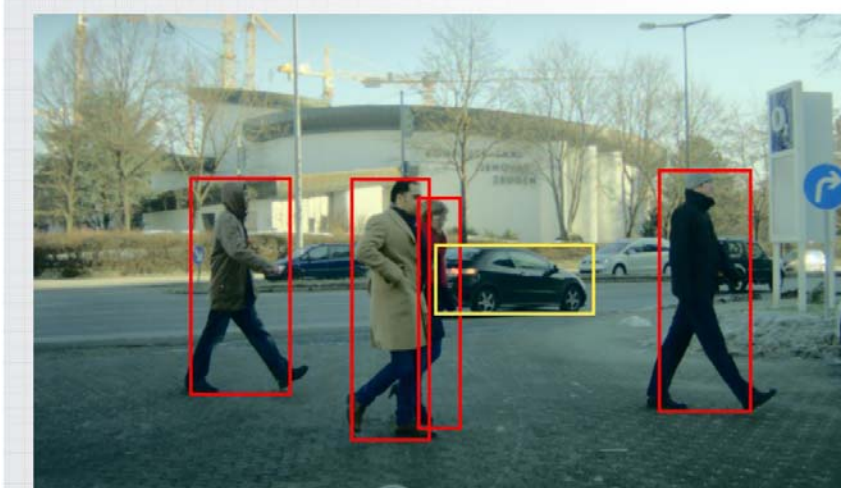


## New sensors enable vehicles to "see"





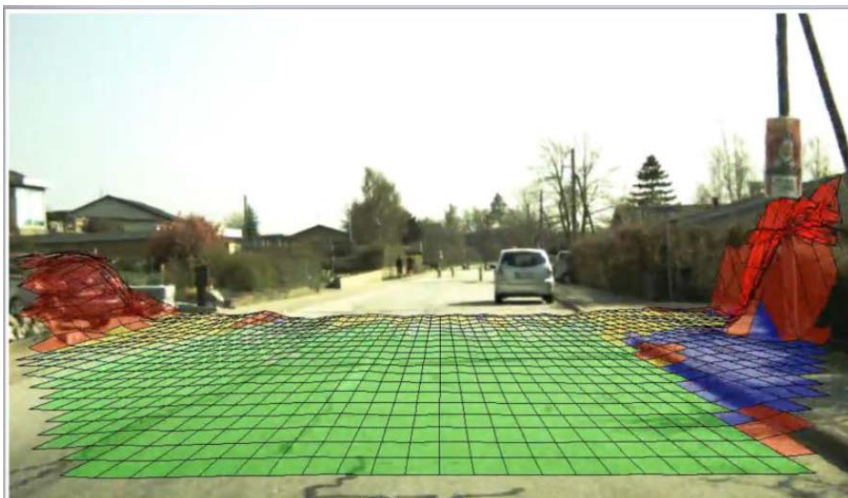
## Stereo camera gives a lot of information



Kilde: Autoliv AB



## Stereo camera, detection of "roadway", summer



Kilde: Autoliv AB





# Behavioral Adaptation

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## Behavioral Adaptation

**If we notice relevant change, we change behaviour to adapt to the new situation**

- We can behave **more carefully** if changes are perceived as dangerous
- Or we can try to use the opportunity to achieve operational goals in a more effective way by being **more uncaring**

- **Phenomena:**

Described in transport research as ***behavioural adaptation***, ***risk compensation*** eller ***risk homeostasis*** (Wilde, 1994)

What do we do when the driving task is automated?

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**What do we know  
about the safety effect  
of driver support?**

## Problems with estimating safety effects

- Technology changes rapidly
- Integrated systems
- Behaviour changes over time
- Lack exposure, accident data
- Potential for misuse
- User acceptance
- Market share, deployment (accept)



## Anti skid – ESC

Sensors note steering, rotation and speed of every single wheel –  
*"where does the driver want to steer the car?"*

### Conclusions:

- 50% red. of accidents it should have an effect on
- Problem -up hill



**ESC checks 25 times per second:**  
 Where does the driver want to steer?



**ESC checks 25 times per second:**  
 Where is the vehicle going?



**ESC takes action:**  
 It "steers" the vehicle by brake interventions. The car is kept more safely on track

Figure 46. ESC is active all the time. It recognizes critical situations before the driver can and intervenes independently. From (Bosch 2008).





## Intelligent Speed Adaptation - ISA

### Several systems:

- Informing ISA – limited effect
- Supportive ISA – some speed reduction
- Controlling ISA – Significant speed reduction

### Other behavioral adaptations:

- Tendency to "drive according to speed limit" (neg.)
- Tendency to stop for pedestrians (pos.)

### Conclusions:

- Large accident reducing potential 20-25%
- Challenge –accept and employment

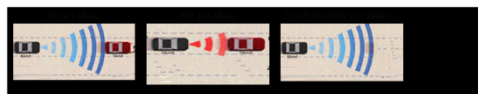
Norwegian ISA  
On-board speed, speed limit  
and overspeed warning  
Integrated in PDA



- Display
- Digitalt kart m/fartsgrenser
- GPS

## Adaptive Cruise Control (ACC)

1. **Intended behavior**  
ACC mostly used as intended
2. **Misuse by approx. 10 %**  
(Jenssen et al, 2003)
3. **No accidents with ACC reported so far**
4. **Potential**  
ACC has a large safety potential if problems related to driving in snow slush, and emergency braking are solved



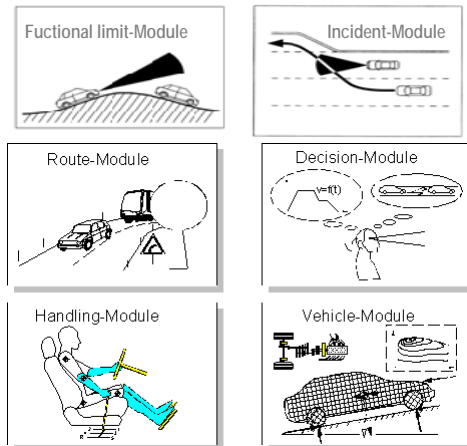
## Advanced Driver Assistance – Potential safety problems

### Mental modell

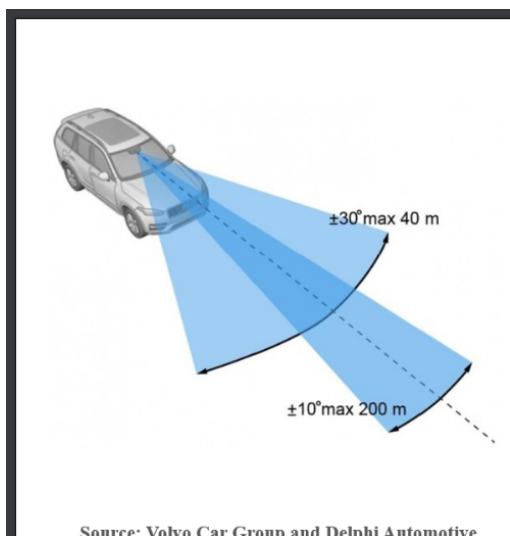
#### ■ Misunderstand function

#### ■ Eksamples

- Think ACC is an anti collision system
- Scared when ACC accelerates "target vehicle" disappear over hilltop, round bend
- Don't know with ABS og ESC use full brake



Teknologi for et bedre samfunn



Source: Volvo Car Group and Delphi Automotive

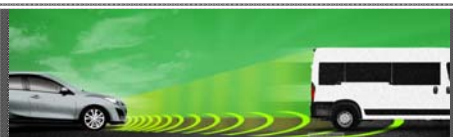
### Radar and Camera system (RACam) inside the wind shield

- 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.

## US survey

57,000 CR subscribers reported on the nearly 66,000 vehicles they own, with model years ranging from 2011 to 2017

- Blind-spot warning and Rear cross-traffic warning most popular



## Adaptive Cruise Control (ACC)

### ADAPTIVE CRUISE CONTROL

DO OWNERS LIKE IT?




SAY THE SYSTEM HELPED THEM AVOID A CRASH



FIND THE SYSTEM ANNOYING



Source: Consumer Reports' Advanced Safety Systems Survey.

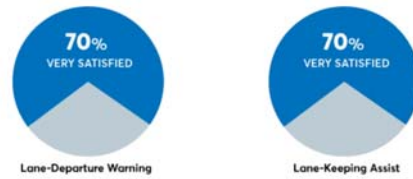


**Lateral control**

"love it. It has a vibration in the seat and a visual cue on the dashboard. It's good for me, but it's critical for my husband, who frequently drifts"

**Lane Departure & Lane keeping**

## DO OWNERS LIKE IT?



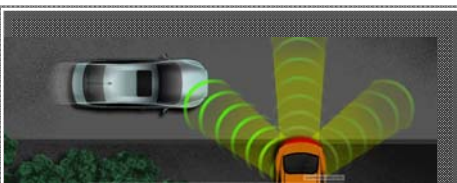
## LANE-DEPARTURE WARNING



## LANE-KEEPING ASSIST

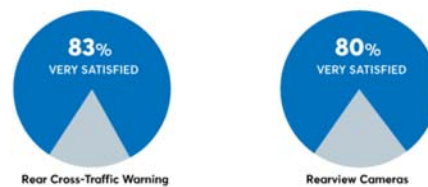


Source: Consumer Reports' Advanced Safety Systems Survey.



**Rear cross-traffic warning (RCTW)**

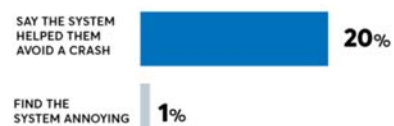
## DO OWNERS LIKE IT?

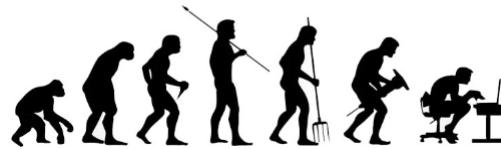


## REAR CROSS-TRAFFIC WARNING



## REARVIEW CAMERAS





## VIDEO Autonom Barnevogn






**Autonomous = Self sufficient**

**Automated vehicles (AV's)**

Driverless Vehicles  
Robotic vehicles



Technologies: Visual sensors –  
Digital maps Radar, Lidar, GPS, etc.

Based on ADAS: ABS, ESP, ACC, Antikollisjon, Lane keeping etc.

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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)

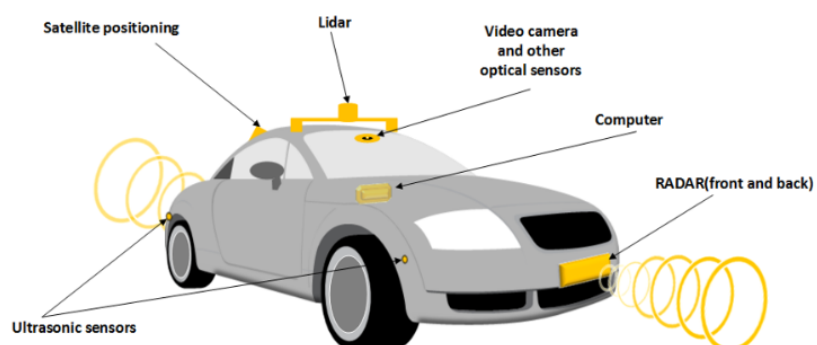
## Expected benefits of self-driving vehicles

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



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## Key on-board technologies



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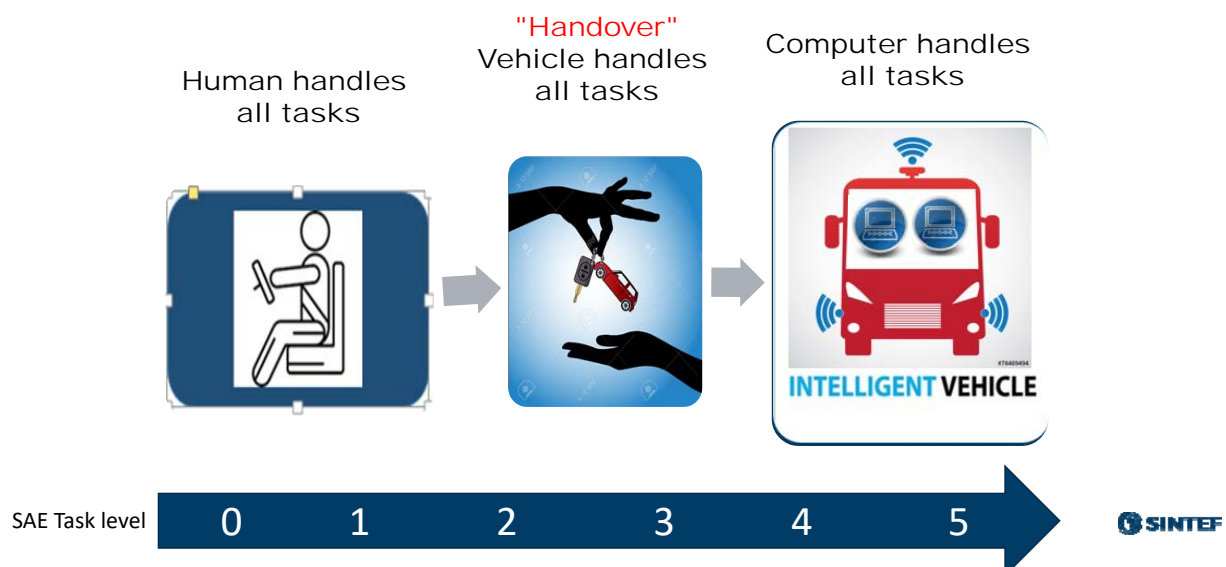
# SAE J3016

*Taxonomy and Definitions for Terms Related to Driving  
Automation Systems for On-Road Motor Vehicles*

På norsk: **Konsept, terminologi og klassifiseringen av  
systemer for automatisert kjøring med motorkjøretøyer  
på veg**

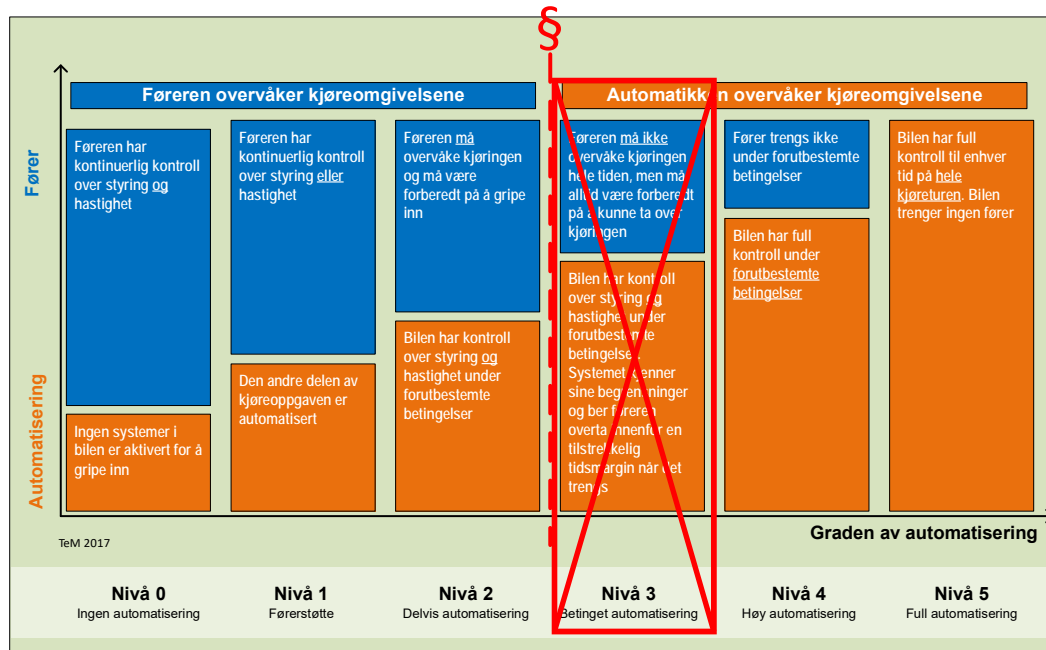


## Automation of the Driving Task



## What are the effects of automation?

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# Distrust, resentment, resistance

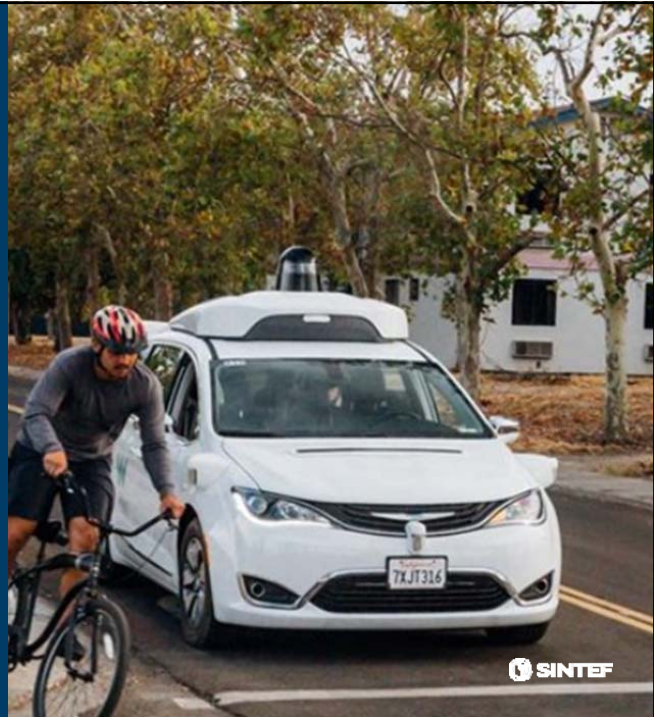
## Rage against the machine: self-driving cars attacked by angry Californians

Local residents are hitting back at their new robot neighbors - literally - as reports detail assaults on driverless cars



▲ User incident involved a pedestrian crossing the street and striking the autonomous vehicle "with his entire body" (Reutersphoto, @Reutersphoto via Getty Images)

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## Crash investigations

### Level 3 fatalities [\[edit\]](#)

A Level 3 autonomous driving system would occasionally expect a driver to take over control.

List of known autonomous car fatalities (occurring while autonomous-system acknowledged to have been engaged)

Date	Incident no.	Country	City	State/county/province	No. of fatalities	System manufacturer	Vehicle Type	Distance driven by the system at time of incident	Notes
18 March 2018	3	United States of America (USA)	Tempe	Arizona	1	Uber	'Refitted Volvo' <sup>[16]</sup>	—	Pedestrian fatality <sup>[16]</sup>

### Level 2 fatalities [\[edit\]](#)

Level 2 is considered automated driving, but not autonomous driving. A Level 2 driving system expects a driver to be fully aware of the driving and traffic situation and be able to take over any moment.

List of known automated driving system car fatalities (occurring while automated driving-system acknowledged to have been engaged)

Date	Incident no.	Country	City	State/county/province	No. of fatalities	System manufacturer	Vehicle Type	Distance driven by the system at time of incident	Notes
20 January 2016	1	China	Handan	Hebei	1	Tesla (Autopilot)	Model S <sup>[18]</sup>	—	Driver fatality <sup>[18][12]</sup>
7 May 2016	2	United States of America (USA)	Williston	Florida	1	Tesla (Autopilot)	Model S <sup>[9]</sup>	130,000,000 mi 210,000,000 km <sup>[13][14]</sup>	Driver fatality <sup>[13][14]</sup>
23 March 2018	4	United States of America (USA)	Mountain View	California	1	Tesla (Autopilot)	Model X <sup>[9]</sup>	—	Driver fatality <sup>[17]</sup>

References



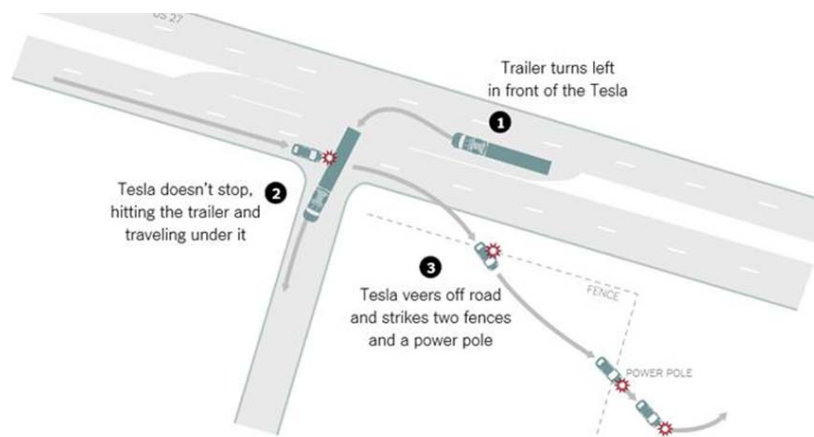
## Driver killed in Tesla crash



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## Tesla accident



The New York Times | Source: Florida traffic crash report

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Tesla ulykken med Autopilot, Jenssen 2017

## Hvit trailer truck av den typen Joshua Brown kolliderte med



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## Tesla fatal crash in China (September 2016)

### Tesla autopilot crash in China - YouTube

Video for tesla fatal china ▶ 1:21

<https://www.youtube.com/watch?v=fc0yYJ8-Dyo>

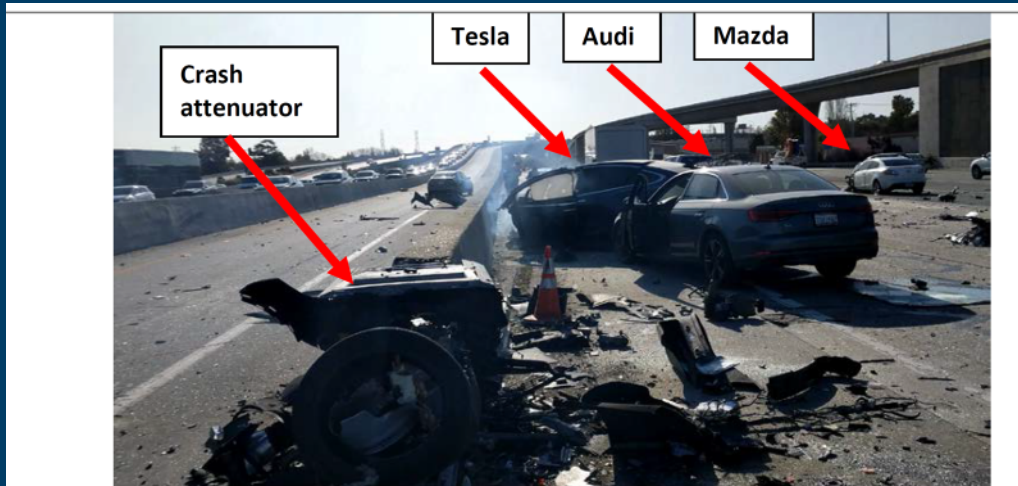
15. sep. 2016 - Lastet opp av GBTIMES

A Chinese family has sued US carmaker Tesla for a fatal crash that may have been caused by the company's ...



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## Tesla crash March 2018



51 **Figure 1.** Southbound view of US-101 depicting Tesla, Audi, and Mazda vehicles at final rest  
(Source: S. Engleman)

- Mercury news, January 22 2017

*Tesla on autopilot slams into parked fire truck on California freeway*



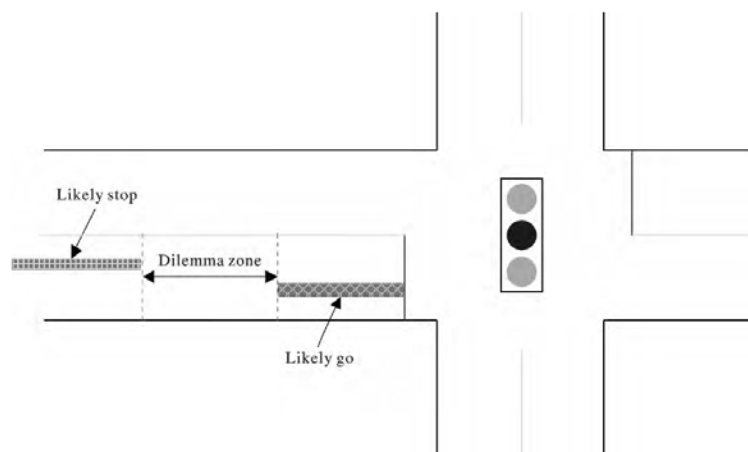
## What do we know about accidents with higher level self-driving cars?

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



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



## Uber fatal crash

### strategy

GJ1



INCREASE COMFORT  
AND SPEED



REDUCE UNNECESSARY  
BRAKING



HIGH ACCEPTANCE OF  
FALSE POSITIVES



DISCONNECTED VOLVO  
CITY SAFETY SYSTEM

## Trustworthy?

Tesla's Driver Fatality Rate is more than Triple that of Luxury Cars (and likely even higher)



Midwestern Hedge [Follow](#)  
Jul 23, 2018 · 15 min read

Tesla CEO Elon Musk has worked hard to convince shareholders, media, and the road. He

## In 2017, the feds said Tesla Autopilot cut crashes 40%—that was bogus

### Serious math errors made Autopilot look better

Tesla began shipping cars with Autopilot hardware in 2014, but the Autosteer lane-keeping system [wasn't enabled until October 2015](#). That provided something of a natural experiment: by comparing crash rates for the same vehicle before and after October 2015, NHTSA could try to estimate how the technology affected safety.





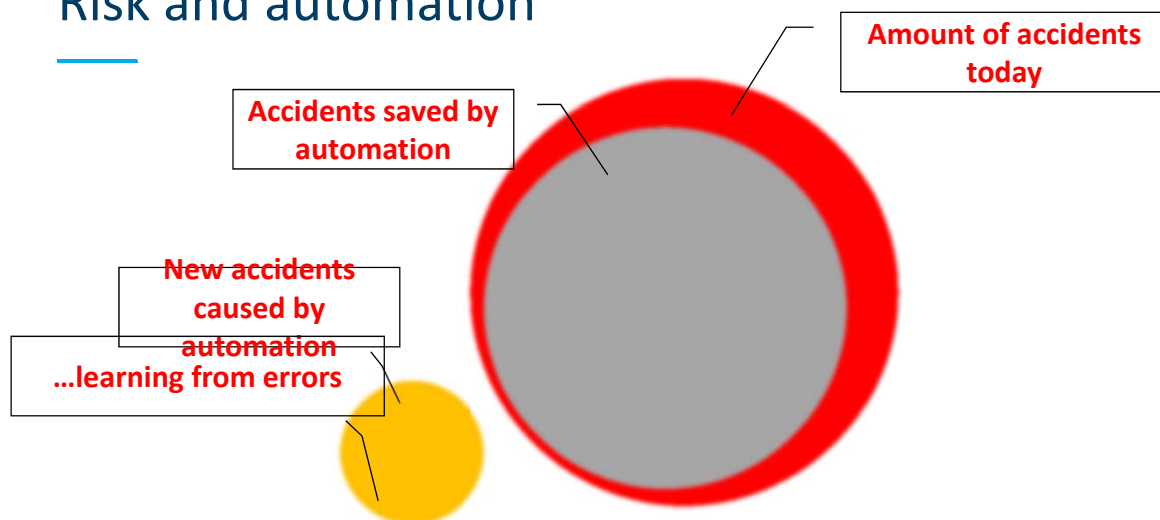
# What We've Learned From Tesla Autopilot and Self-Driving System Crashes

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## Lessons Learned

- **Drivers must pay attention:** People using advanced driver-assist systems like Autopilot must always pay attention to the road. The National Transportation Safety Board report released this week about a fatal Model X crash in California in March shows that Autopilot can't be relied upon to stop, turn or accelerate when appropriate because of the limitations of its programming. Despite its name, Autopilot operates only as a suite of driver-assist features.
- **It's not just Tesla:** Cadillac, Infiniti, Mercedes-Benz, Nissan, and Volvo offer systems similar to Autopilot, under various names. These systems, such as Volvo's Pilot Assist, can maintain a vehicle's place in the flow of traffic and keep it within the lines of its lane—and that could lull drivers into complacency. Autopilot isn't the only system that has these limitations, and all of them should only be used with the driver's full attention to the road. Only Cadillac's Super Cruise has a driver-facing camera that will issue warnings if the driver stops looking at the road.
- **Pedestrian detection still needs work:** This important technology is still in its nascent phase, as evidenced by an Arizona crash when a self-driving Uber test vehicle killed a woman pushing her bike across the road. Uber's software reportedly identified the woman as an object, then as a vehicle and finally as a bicycle. Even though the modified Volvo SUV's systems identified an object ahead, it did not alert the human test driver to the situation, and it didn't stop the vehicle on its own.
- **Automatic Emergency Braking has limits:** Though effective in important ways, this feature can't save drivers in every situation. AEB typically won't keep a car from crashing at high speeds. It works to slow down a vehicle and lessen the force of impact. That's still a potentially life-saving difference, but it's not a magic bullet for avoiding a collision. Multiple crashes every day, minor and serious, show that drivers can put too much faith in AEB.
- **Sudden changes can put drivers at risk:** Several Tesla crashes follow a common scenario. A Tesla vehicle operating on cruise control is following another vehicle. The lead vehicle suddenly leaves the lane to avoid something ahead that's stationary or moving slowly. The Tesla driver-assist systems don't have time to react to the object suddenly in its path, such as a stopped fire truck, and there's a collision.
- **Adaptive Cruise Control will do what drivers ask of it:** Cars using this driver-assist system often accelerate to the driver's preset speed preference when a slower lead vehicle veers out of the way, even if there's an object in the way, until and unless it detects that object. The NTSB reported this week that the Tesla Model X in the fatal California crash in March accelerated just before it crashed into a road barrier.
- **There may be a test car on the road with you:** The Uber crash in Arizona underscores how few standards there are for the testing of self-driving cars, and how states and the federal government are currently giving companies license to determine whether their technology is safe enough to test on public roads.

## Risk and automation



## Is the technology good enough?

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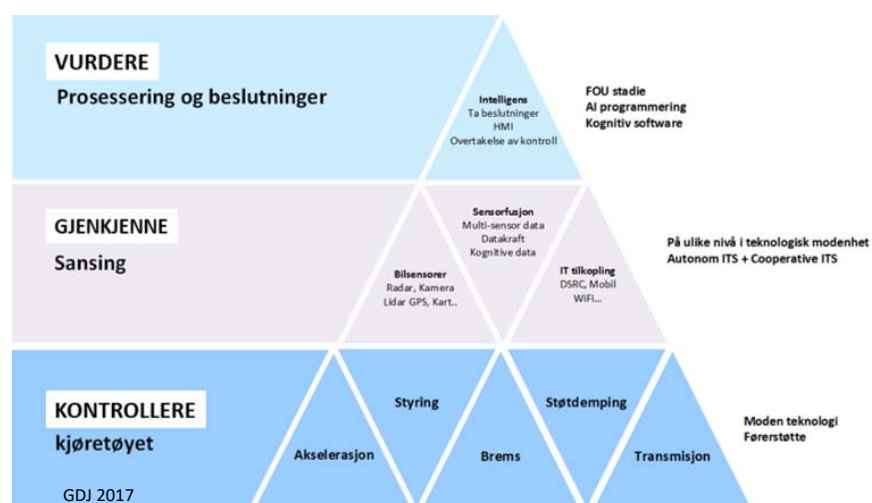
What do we know about technology strenghts and weaknesses?

## Buliding blocks in development of AV's

Decide

Recognize

Control



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## Four Trends

- SELF DRIVING
  - Automated self sufficient with data
  - Driver is less in the loop
- COOPERATIVE SYSTEMS
  - Self sufficient and connected
  - Simple positioning and navigation
- MOBILITY AS A SERVICE
  - Shared transport resources
  - Seamless transport
- ELECTRIC VEHICLES
  - Simple and reliable
  - Connected to the grid- renewable energy

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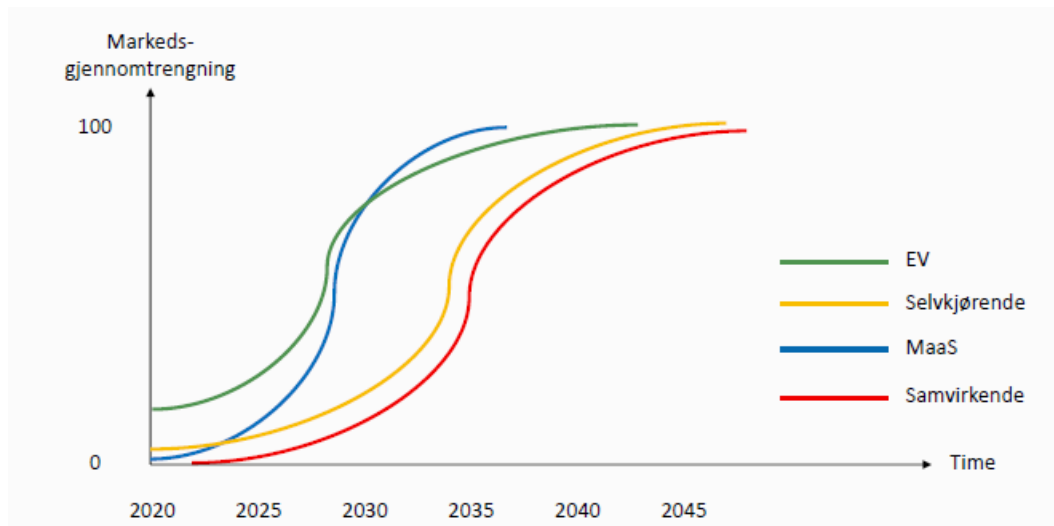


## Four Trends

- SELF DRIVING
  - COOPERATIVE SYSTEMS
  - MOBILITY AS A SERVICE
  - ELECTRIC VEHICLES
- ZERO ACCIDENTS
  - LAND USE CHANGES
  - ZERO EMISSIONS

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## Job opportunities



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CONSULTING  
EXPERTS WITH IMPACT

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