Intelligent Transportation Systems

Rolland Vida, BME TMIT

What does automated driving mean?

- **SAE International – Society of Automative Engineers**
  - Professional association and standards developing organization
  - Automotive, aerospace, and commercial vehicles
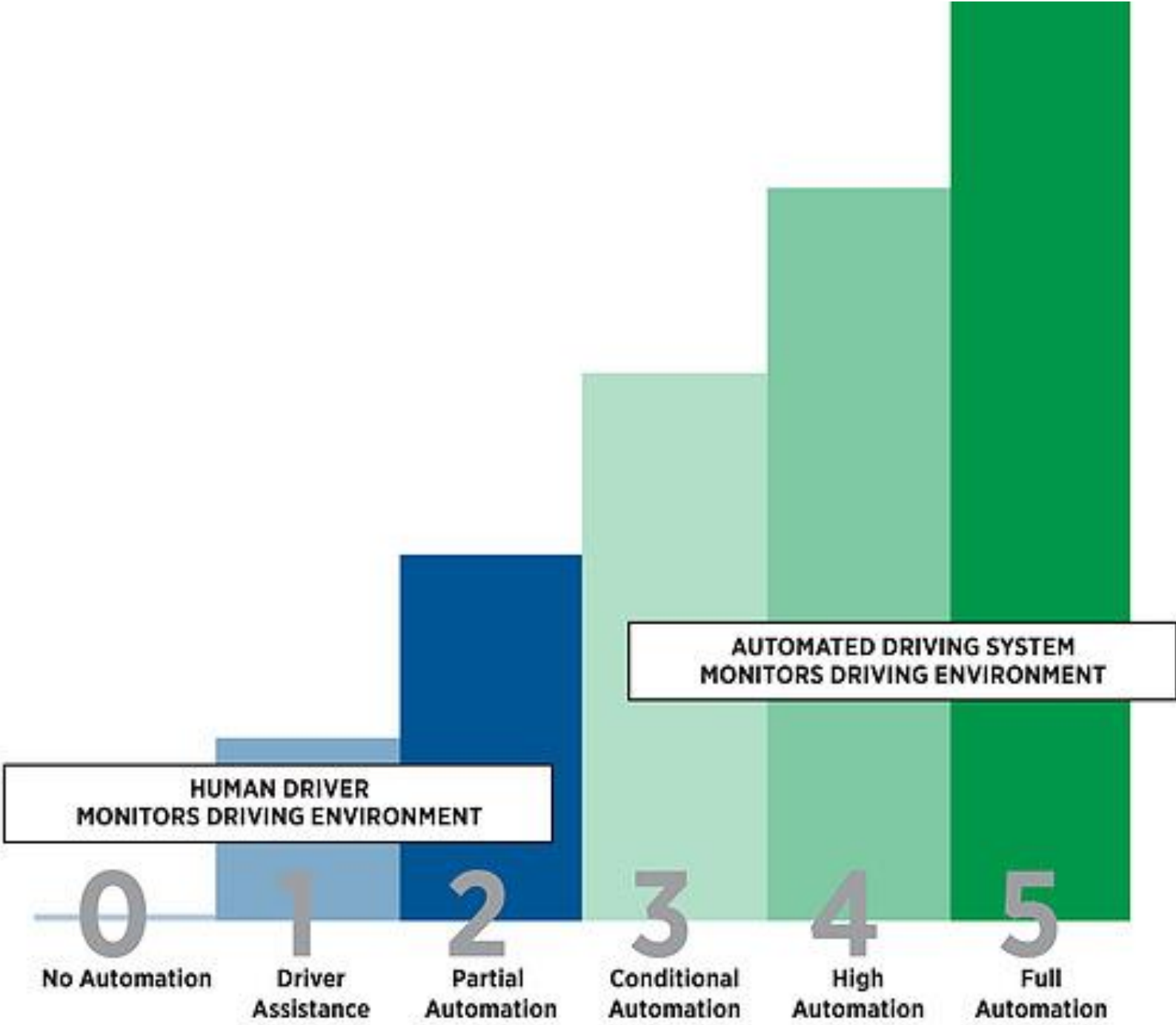 - More than 138.000 individual members worldwide

- **Standard J3016: Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems (2014)**
  - Identifies six levels of driving automation from "no automation" to "full automation"
  - Describes categorical distinctions for a step-wise progression through the levels
  - Eliminates confusion, useful across numerous disciplines (engineering, legal, media)
  - Educate a wider community by clarifying for each level what role (if any) drivers have in performing the *dynamic driving task* while a driving automation system is engaged.

Taxonomy

- **Dynamic driving task**
  - Includes **operational aspects**
    - Steering, braking, accelerating, monitoring the vehicle, monitoring the road
  - Includes **tactical aspects**
    - Responding to events, deciding when to change lanes, turn, use signals
  - *Does not include* **strategic aspects**
    - Determining destinations and waypoints

- **Driving mode**
  - Type of **driving scenario** with specific dynamic driving task requirements
    - Expressway merging, high speed cruising, low speed traffic jam, etc.

- **Request to intervene**
  - Notification by the automated driving system to a human driver that he/she should promptly begin or resume performance of the dynamic driving task

- **Autonomous vs. Automated**
  - Autonomous – self governance, taking decisions independently
  - Automated – operates, takes decisions without human intervention
  - Automated more accurate, but autonomous more widespread

OKOS VÁROS
@ BME TMIT

Levels of automation

HUMAN DRIVER
MONITORS DRIVING ENVIRONMENT

AUTOMATED DRIVING SYSTEM
MONITORS DRIVING ENVIRONMENT

0 No Automation
1 Driver Assistance
2 Partial Automation
3 Conditional Automation
4 High Automation
5 Full Automation

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
Human driver monitors the driving environment						
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
Automated driving system ("system") monitors the driving environment						
3	Conditional Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	High Automation	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

Levels of automation

- **Level 0 (no automation)** – The human driver controls all (steering, brakes, throttle, power)
  - Only warnings form the automated system

- **Level 1 (driver assistance)** – „hands on"
  - Most functions still controlled by the driver
  - One function (steering **OR** acceleration) done automatically by the car
  - Driver must be always ready to take over the full control
  - E.g., adaptive cruise control – driver controls the steering, the automated system controls speed
  - E.g., parking assistance – driver controls speed, the automated system controls steering

- **Level 2 (partial assistance)** – „hands off"
  - Driver is disengaged from physically operating the car
  - Hands off the steering wheel **AND** foot off the pedal at the same time
  - Driver must be always ready to take back the control of the vehicle
    - Often, the hand is required to be on the steering wheel, to confirm that the driver is ready to take over control, if needed

Levels of automation

- **Level 3 (conditional automation)** – „eyes off"
  - Driver not required to monitor the environment anymore
    - The system (vehicle) does it, the driver can watch a movie
  - Driver still present and will intervene if needed
    - Within a limited amount of time, specified by the manufacturer
    - The car will handle emergency situations (e.g., fast braking)
  - First commercial car at level 3 – **Audi A8 Luxury Sedan**
    - Traffic Jam Pilot
    - Slow-moving traffic, up to 60 km/h, on highways, physical barrier for the opposite lane
  - Some manufacturers (e.g., Ford) want to skip this level
    - If the driver does not have to monitor the environment, you cannot expect from him to intervene

Levels of automation

- **Level 4 (high automation)** – „mind off"

  - Vehicles perform all safety-critical driving functions, and monitor the roadway conditions

  - Driver may go to sleep, or leave the driving seat

  - It does not cover all driving scenarios, only limited areas (geofencing) or special conditions (traffic jam)
    - Outside these scenarios, the vehicle must safely abort the trip, park the car, until the driver retakes control

- **Level 5 (full automation)** – Equal the human driver in every driving scenario

  - Extreme environments and road conditions (e.g., dirt roads)

  - Driverless vehicles not expected at this level in the near future

History of automated cars

- Experiments since the 1920s, promising trials from the 1950s

- General Motors Firebird II (1956)
  - For the „highway of the future"
  - Electric wire embedded in the road sends signals to guide the car

- First truly autonomous prototype cars in the 1980s

- ParkShuttle in the Netherlands, Schiphol Airport (1997)
  - World's first driverless vehicle
  - Magnets embedded in the road surface

- Would they be allowed on public roads?
 - In 2015, allowed in Nevada, California, Florida, and some other states

Zalaegerszegi tesztpálya

- Önvezető járművek és járműkommunikációs megoldások tesztelésére

- 40 milliárd HUF, 250 hektár (a Bosch boxbergi tesztpályájánál kétszer nagyobb)

- 2018-ban első ütem, 2019-ben teljes átadás

- Nem autóversenyekre, hanem kutatási, innovációs célokra

- Járműdinamikai modulok, fékfelületi tesztelések

- 4.5 km-es oválpálya, 250 km-es sebességgel közlekedő konvojoknak

- „műváros" – önvezető autók felkészítése a városi környezetre

- C2C, C2I kommunikáció

- Első 5G teszthálózat Magyarországon

- Titoktartás, a tesztelő cégek számára rendelkezésre álló garázsok, laboratóriumok, tárgyalók, éttermek

TESZTPÁLYA RENDSZER
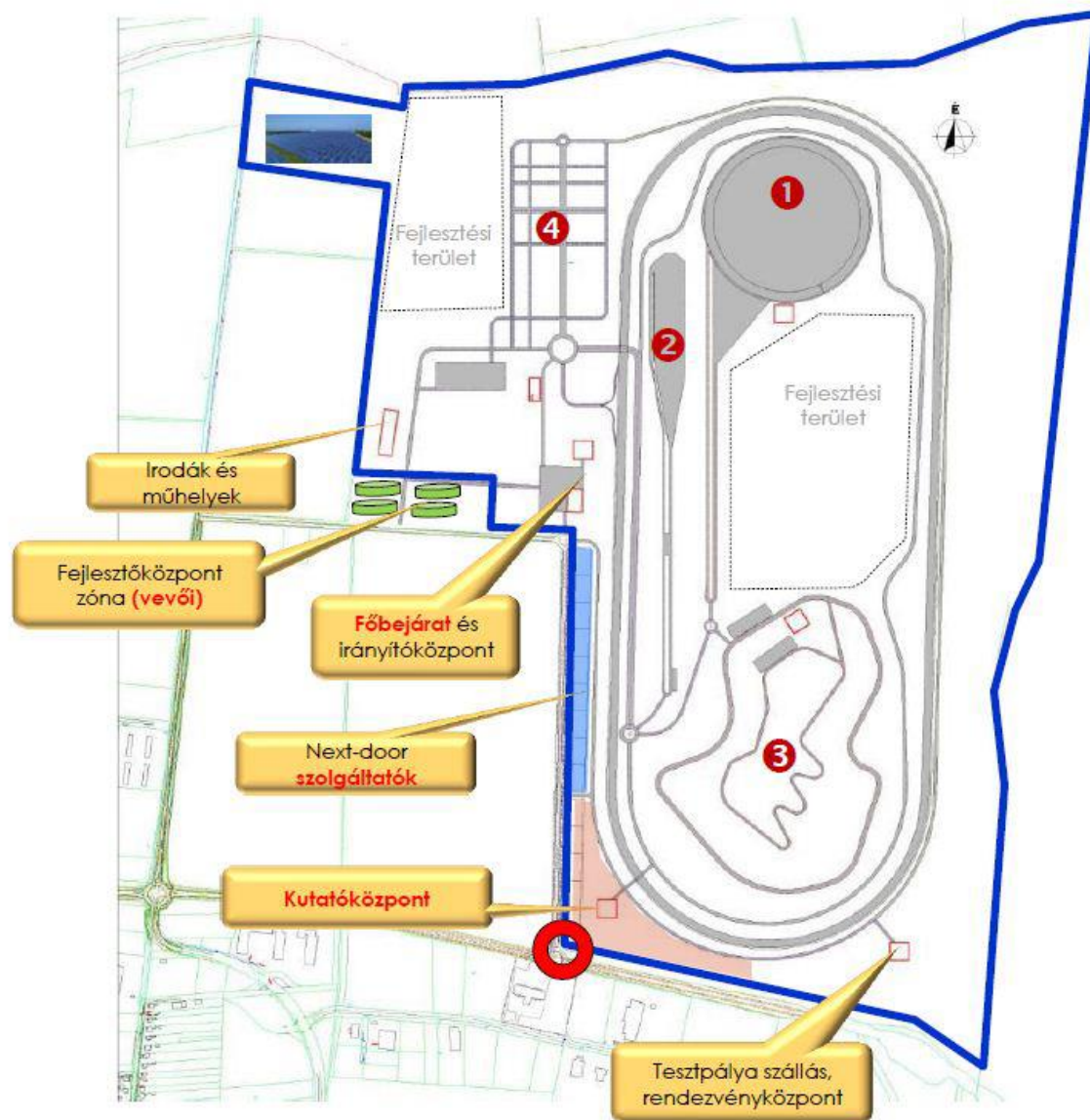
Projekt 1. fázis: *2017*

- Járműdinamikai modulok I.:
  - **1** • dinamikai felület
  - **2** • fékfelületek
  - **3** • kezelhetőségi pálya

- **4** • Autonóm jármű tesztzóna 1 (AD)

- Épületek I.

- Nagysebességű oválpálya előkészítés

Projekt 2. fázis: *2018-2020*

- Járműdinamikai modulok II.
- Autonóm jármű tesztzóna 2-3
- Épületek II.
- Nagysebességű oválpálya

2017.10.17

R76-os gyorsforgalmi

- 176 milliárd HUF

- „Okos út", C2C, C2I

Tesla Autopilot

- **Autopilot 8.0** – October 2014

  - Tesla Model S and X, Level 2 (partial assistance)

  - Assist highway driving, enable cars to self-steer, adjust speed, detect nearby objects, apply brakes and park

  - Driver advised to keep his hands on the steering wheel

  - Forward looking radar (up to 150 meters) – detect the vehicle's surroundings

  - Front camera – backup for the radar, can see traffic signs, traffic lights

  - Sonar – 360 degrees, 12 ultrasonic sensors, detect nearby obstacles (children, dogs, cars in blind spot)

  - GPS, navigation system – automatically change lanes and exit freeway

    - Activated also with the turn signal
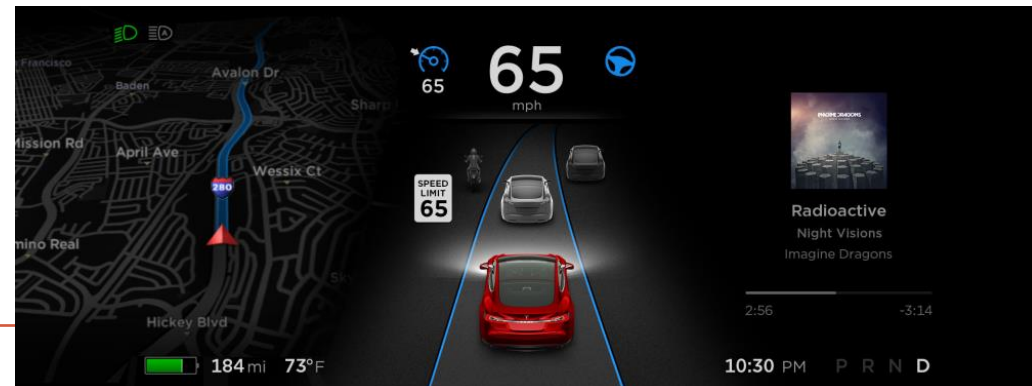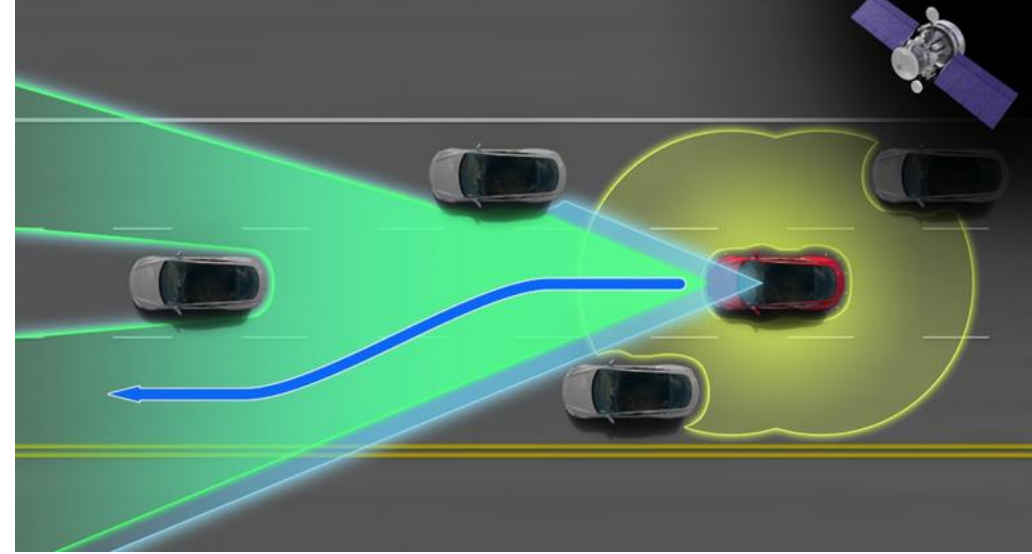
Tesla Autopilot

- Autopilot 8.1 (Enhanced Autopilot) – October 2016

  - Equip all cars with the hardware necessary for self-driving cars
    - Just a software update, when software is ready, safe and mature enough to be activated

  - 8 cameras instead of the single front camera
    - 4 currently active, 4 will become active later, in the „fully self-driving mode"

  - 360 degree vision extended to 250 meters

  - In fully self-driving mode, just tell the car your destination
    - If not, it guesses from your calendar
    - Or it takes you home
    - Let you off and park itself later

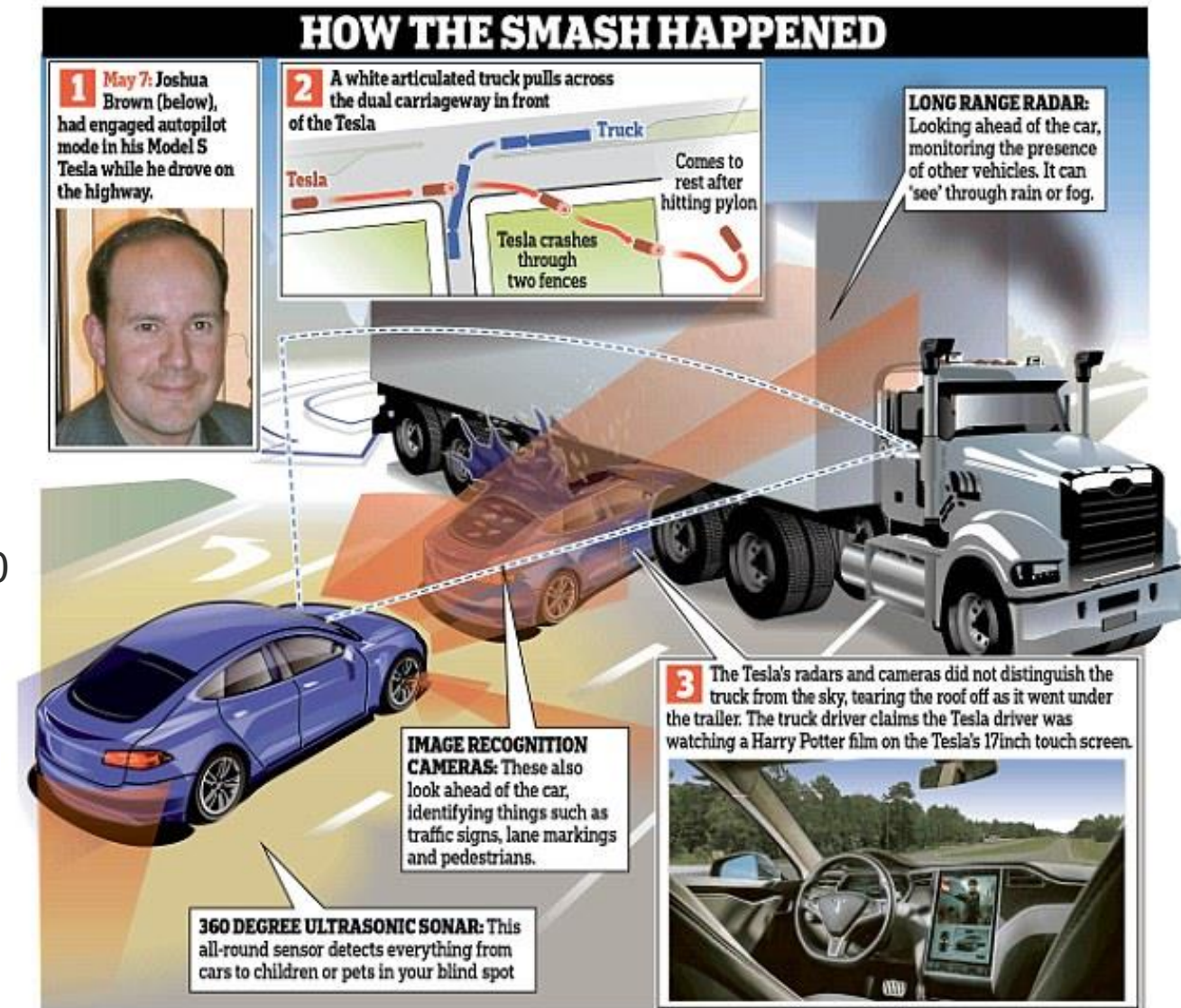# First fatality with Tesla Autopilot

- In May 2016, Joshua Brown died, while using Autopilot mode

- The car struck a tractor trailer that turned left, and crossed the path of the Tesla

- Could not distinguish the white side of the trailer from the bright sky (in sunny weather)
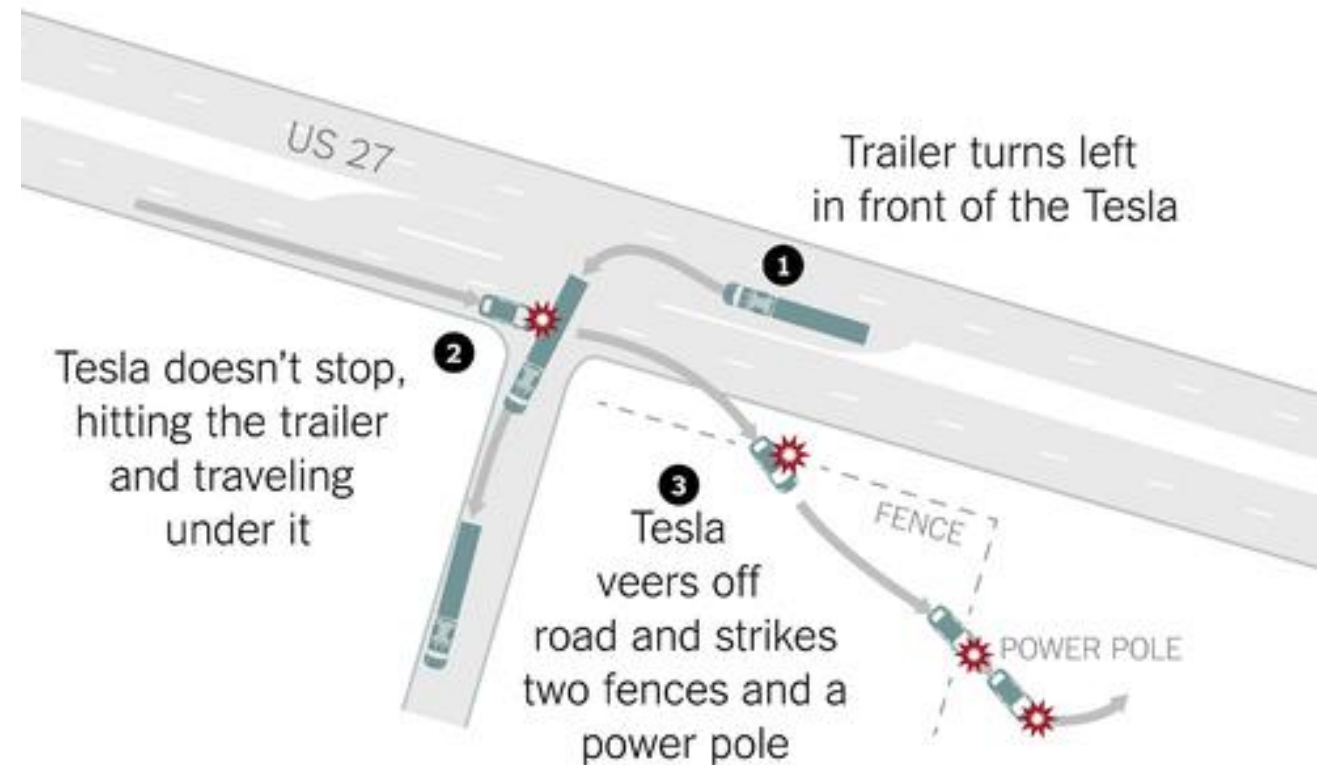
First fatality with Tesla Autopilot

- Engaged a long debate on self-driving cars
  - Although it was not a „self-driving car", just level 2 (partial assistance)

- First fatality after 130 million miles
  - For regular cars US average 1,3 deaths / 100 million miles

- Self-driving cars will make traffic safer
  - Number of accidents decreased with 80% by 2040

- New business model for insurance companies
  - They need also a classification regarding the different levels of automation / autonomy

HOW THE SMASH HAPPENED

1 May 7: Joshua Brown (below), had engaged autopilot mode in his Model S Tesla while he drove on the highway.

2 A white articulated truck pulls across the dual carriageway in front of the Tesla
Truck
Tesla
Comes to rest after hitting pylon
Tesla crashes through two fences

LONG RANGE RADAR: Looking ahead of the car, monitoring the presence of other vehicles. It can 'see' through rain or fog.

3 The Tesla's radars and cameras did not distinguish the truck from the sky, tearing the roof off as it went under the trailer. The truck driver claims the Tesla driver was watching a Harry Potter film on the Tesla's 17inch touch screen.

IMAGE RECOGNITION CAMERAS: These also look ahead of the car, identifying things such as traffic signs, lane markings and pedestrians.

360 DEGREE ULTRASONIC SONAR: This all-round sensor detects everything from cars to children or pets in your blind spot

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Google self-driving car accident

Ethical issues

- What is the ethical decision to take in case of an unavoidable accident?

  - Minimise the death toll?

  - Protect the passengers in the car?