


## Self-driving future

Peter D. Kozma – ELTE IK

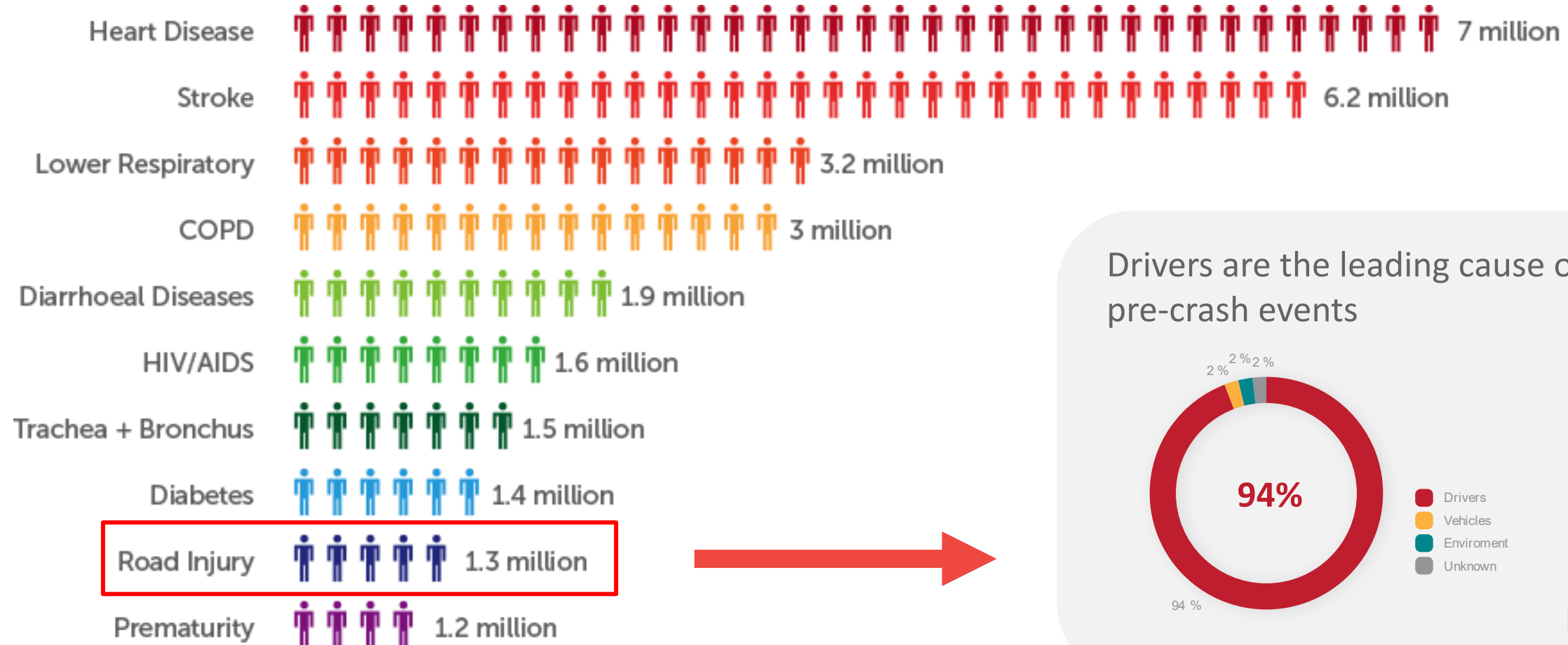
# Content overview



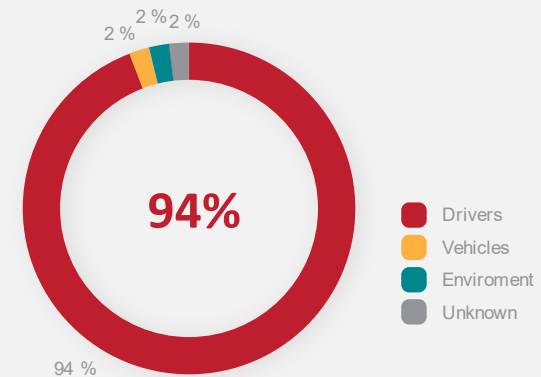
An aerial, top-down view of a city street intersection. The scene is dimly lit, appearing to be at dusk or dawn. Several cars are visible on the road, including a white van in the upper center and a white sedan in the lower center. Pedestrians are walking on the sidewalks and crossing the street. The road has white lane markings and crosswalks. The overall tone is dark and moody.

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# The top 10 causes of death



Drivers are the leading cause of critical pre-crash events



# Self-driving car prototype

Camera sensors  
Lidar sensors  
Radar sensors  
Ultrasonic sensors



GNSS unit  
IMU sensor  
Wheel odometers  
Actuators



Central Computer



Vehicle to Everything



360°

An aerial, top-down view of a city street intersection. The image is dimly lit, appearing as a dark, monochromatic scene. In the center, a white van is driving across the intersection. To its right, a dark-colored sedan is also visible. Further down the street on the right, another car is seen. On the left side of the intersection, several pedestrians are crossing the street. The road features white lane markings, including a prominent crosswalk. Streetlights and traffic signals are visible at the corners of the intersection. The overall atmosphere is that of a busy urban environment captured from a high-angle perspective.

What else will self-driving technology change?

# What will self-driving technology change?



Image: <https://williamsonsource.com>

## Our time

- 2 x 30 minutes a day
- About 30 days of working time per year can be saved



Image: [www.shutterstock.com](http://www.shutterstock.com)



Image: <https://money.cnn.com>

## New group of car users

- completely new groups of people:
  - elderly
  - disabled
  - too young to drive themselves



Image: [www.sites.google.com](http://www.sites.google.com)

# What will self-driving technology change?



Image: <https://coolhunting.com/>

## Energy efficiency

- Current car-owning culture replaced with car-sharing culture
- Compact, trip-suited cars could reduce energy demand by 20-40 %.



Image: [www.foxnews.com](http://www.foxnews.com)



Image: [www.newatlas.com](http://www.newatlas.com)

## Parking slots

- A car sits idle 96% of the time
- 1 car needs about 4 parking slots
- In some cities, 20% of land could be freed up by car-sharing culture



Image: [www.startribune.com](http://www.startribune.com)



# What will self-driving technology change?



Image: www.iliketowastemytime.com

## Roads

- Cities are designed for cars, not for people
- V2X communication
- Controlled, optimized traffic needs fewer roads



Image: www.greencitytrips.com



Image: www.michellechange.com

## Delivery

- Automatic supply chain
- Delivering goods becomes more efficient
- Cheaper goods



Image: www.dreamstime.com

An aerial, top-down view of a city street intersection. The image is dimly lit, showing a white van in the upper center, a white sedan in the lower center, and several other cars on the right side. Pedestrians are visible on the sidewalks and crossing the street. The scene includes traffic lights, crosswalks, and street markings.

# Evolution of self-driving cars

# The first „self-driving” cars

Pontiac phantom (1930s)



Image: www.theatlantic.com

Carnegie Mellon University Navlab 1 (1980)



Image: www.pbase.com

# First self-driving cars

Eureka PROMETHEUS Project (1995)

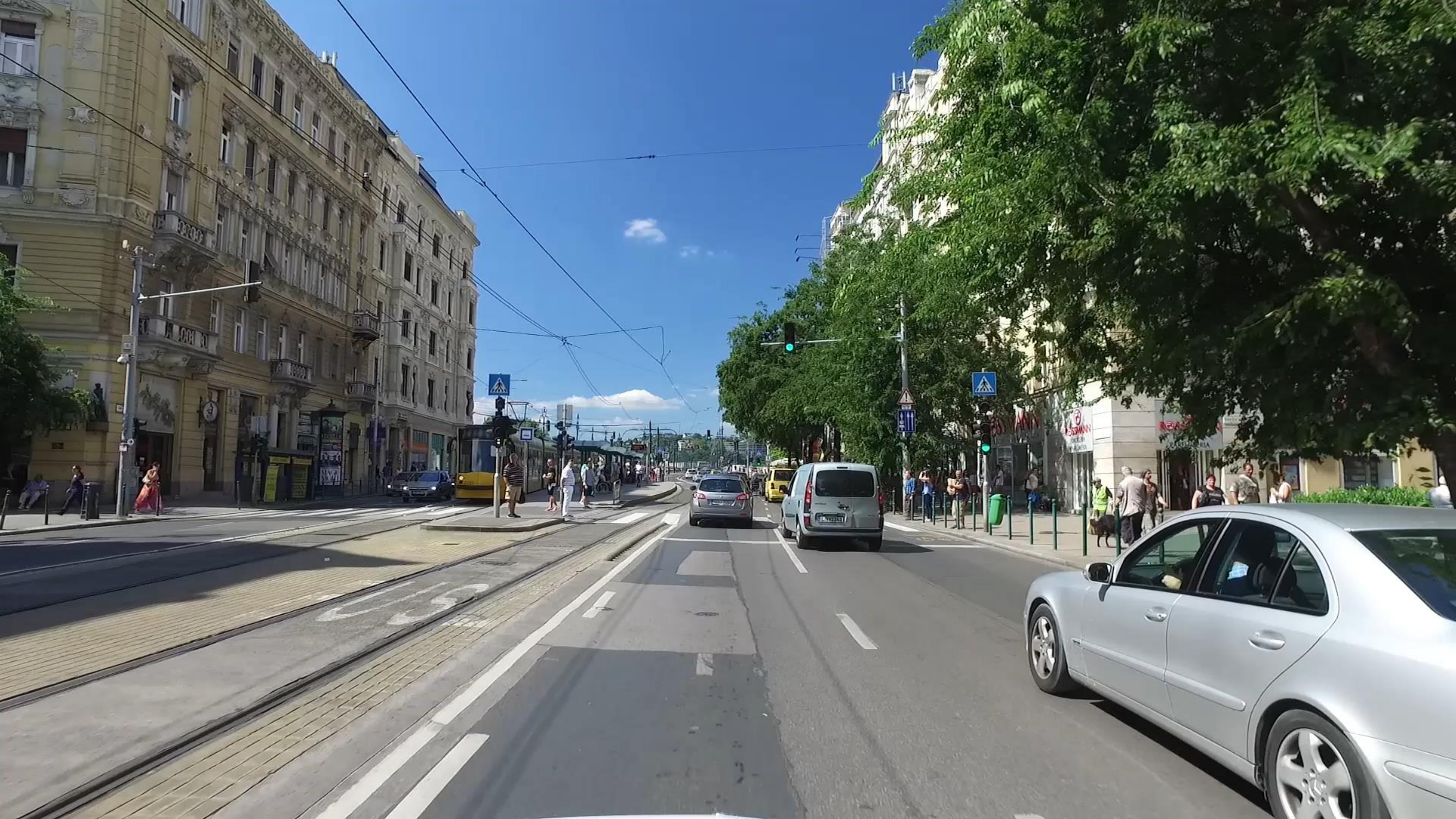


Image: [www.autoevolution.com](http://www.autoevolution.com)

DARPA Urban Challenge (2007)



Image: [www.roadtalk.worldpress.com](http://www.roadtalk.worldpress.com)



# Today

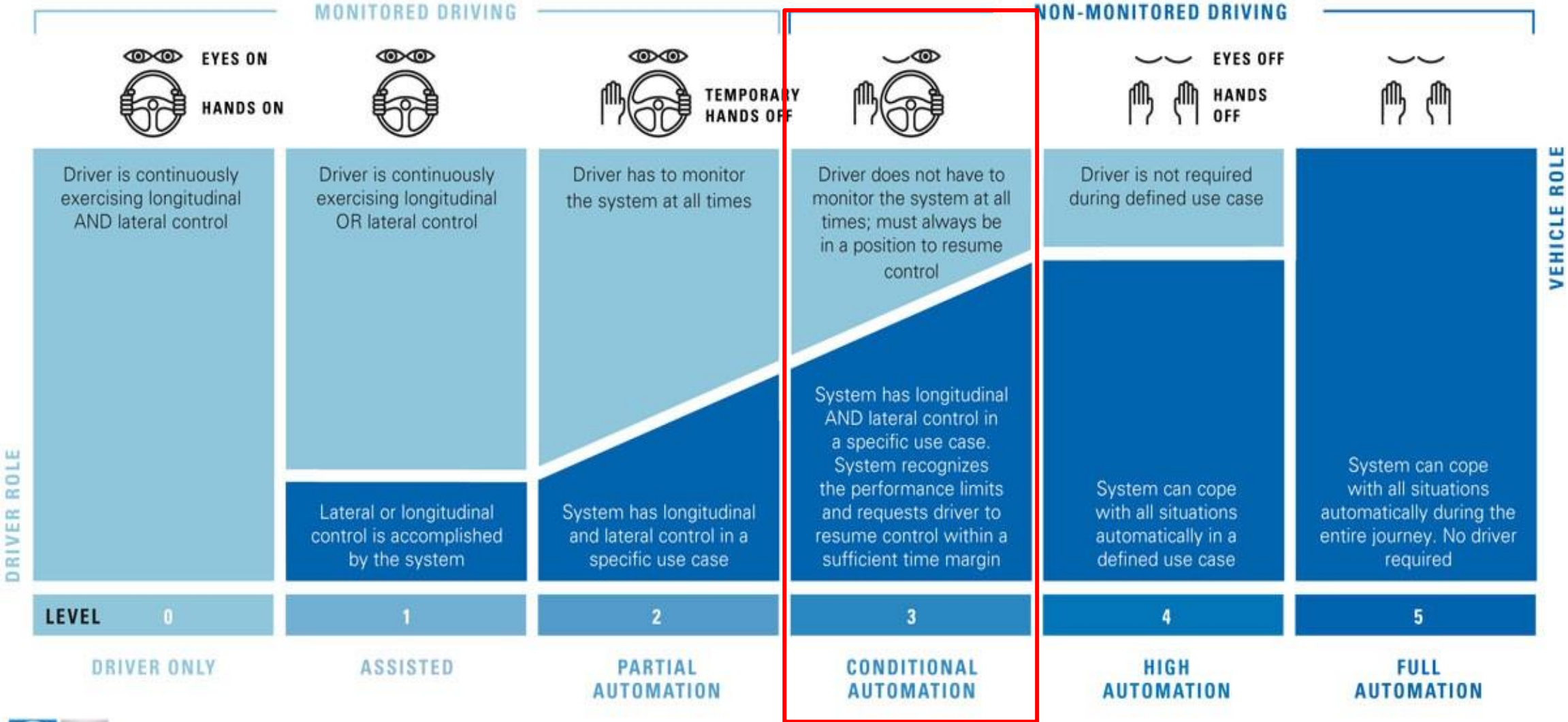


Images: Tesla, Aptiv, Uber, Waymo, Cruise, nuTonomy, Aimotive, Pony.ai, Aurora, Argo AI, Mobileye, Nuro, Baidu Apollo, Zoox, Nvidia, WeRide

An aerial, top-down view of a city street intersection. The scene is dimly lit, possibly at dusk or dawn. A white van is driving through the intersection from the top towards the bottom. To its right, a white sedan is driving in the same direction. Further down the road on the right, another white sedan is visible. On the left side of the road, several pedestrians are crossing the street. The road has white lane markings and crosswalks. There are streetlights and traffic signals visible. The overall atmosphere is quiet and focused on the movement of vehicles and pedestrians.

# Autonomous vehicle development

# Levels of autonomy



Mike Lemanski



## Components of autonomous vehicles

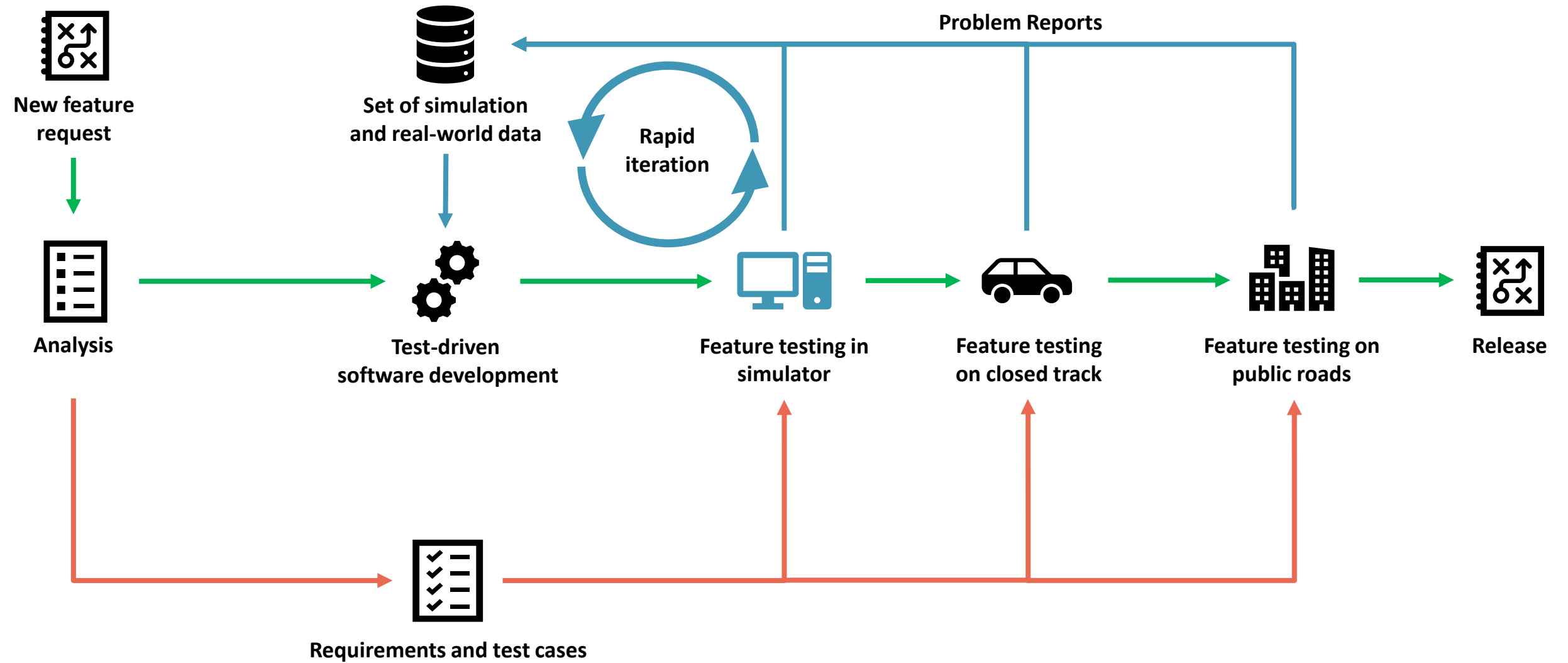
- Perception
- Localization and Mapping
- Prediction
- Planning
- Control




Image: www.shutterstock.com

- Actuation
- Human-Machine Interface
- Safety System
- Redundancy
- Vehicle-to-Everything

# Development pipeline





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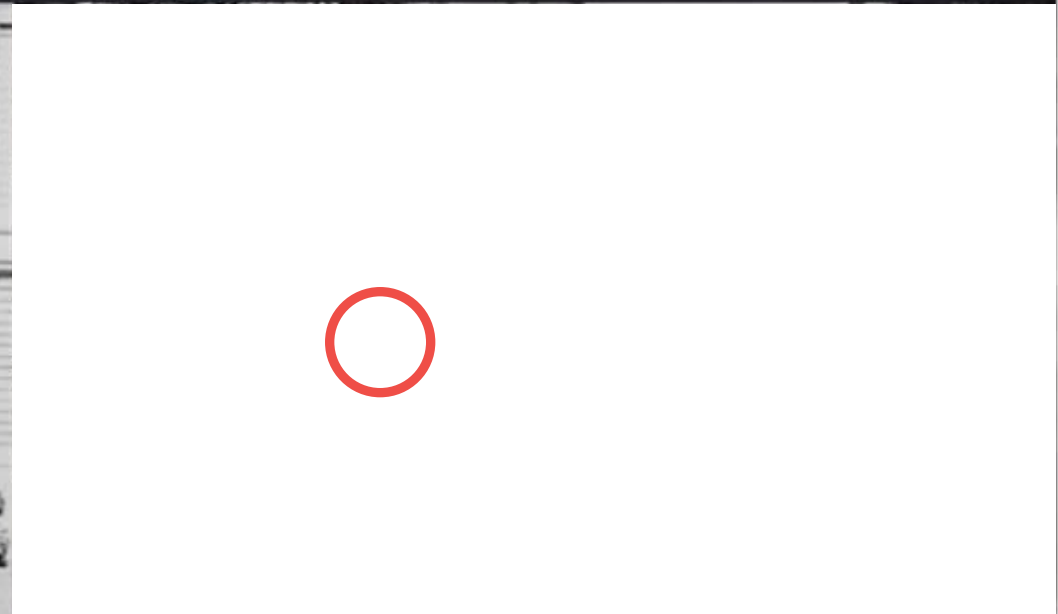
When can the technology be deployed?

# Transition

## Easter Parade on Fifth Avenue, New York, 13 years apart

1900: where's the car?

1913: where's the horse?

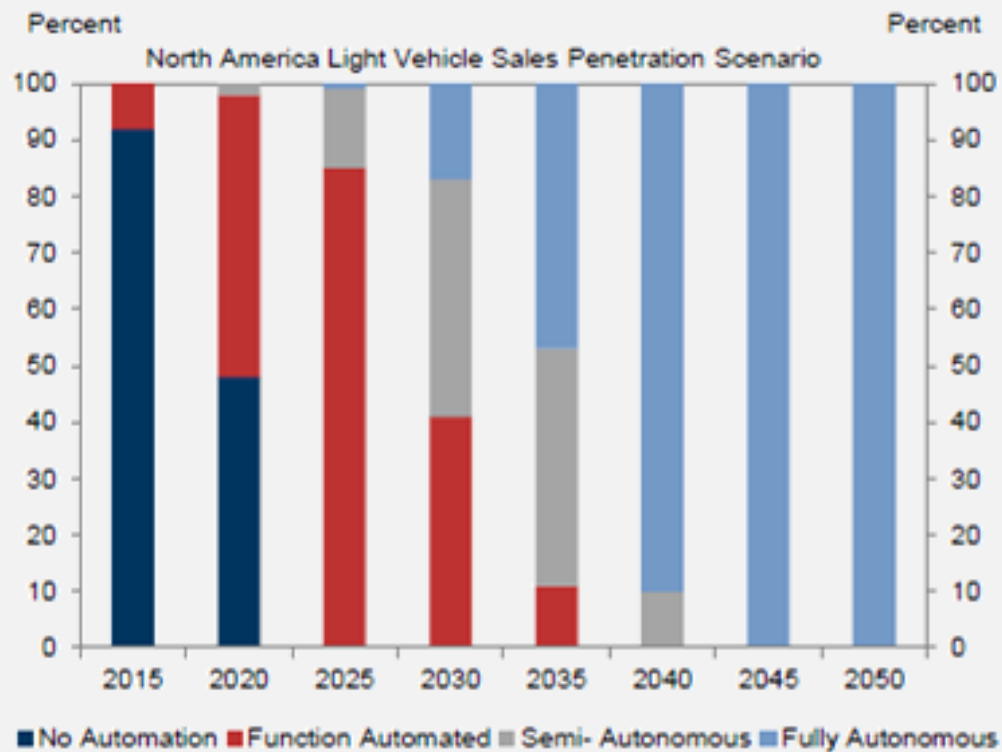


Images: L. National Archive, [www.archives.gov/research/american-cities/images/american-cities-101.jpg](http://www.archives.gov/research/american-cities/images/american-cities-101.jpg)  
R. [shoppy.com/node/204](http://shoppy.com/node/204)  
Inspiration: Tona Seba's keynote lecture at AltCar, Santa Monica, CA, 28 Oct 2014,  
<http://tonyseba.com/keynote-at-altcar-2014-100-electric-transportation-100-solar-by-2020/>

Source: Rocky Mountain Institute



# Forecasting the future in 2015



Source: Goldman Sachs Global Investment Research

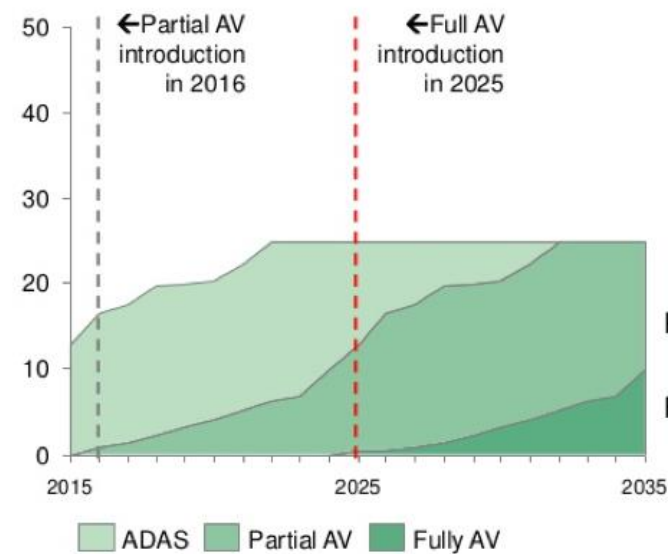
## By 2035, 12 million full AV units could be sold a year globally

Market for partial and full AV features expected to grow from ~\$42B in 2025 to ~\$77B in 2035

**In 2035, 25% of market to be AV sales with 15% partial and 10% full AV systems**

**Represents 12M full AVs and ~18M partial; ~\$77B market for AV features in 2035**

Penetration of new vehicle sales (%)<sup>1</sup>



2025 global sales

Share (%)	Volume (M)	Sales <sup>3</sup> (\$B)
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Estimated global new light vehicle sales: ~111M<sup>2</sup>

Partial	12.4%	13.9	36
Full	0.5%	0.6	6

Total \$42bn

2035 global sales

Share (%)	Volume (M)	Sales <sup>3</sup> (\$B)
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Estimated global new light vehicle sales: ~122M<sup>2</sup>

Partial	15.0%	18.4	38
Full	9.8%	12.0	39

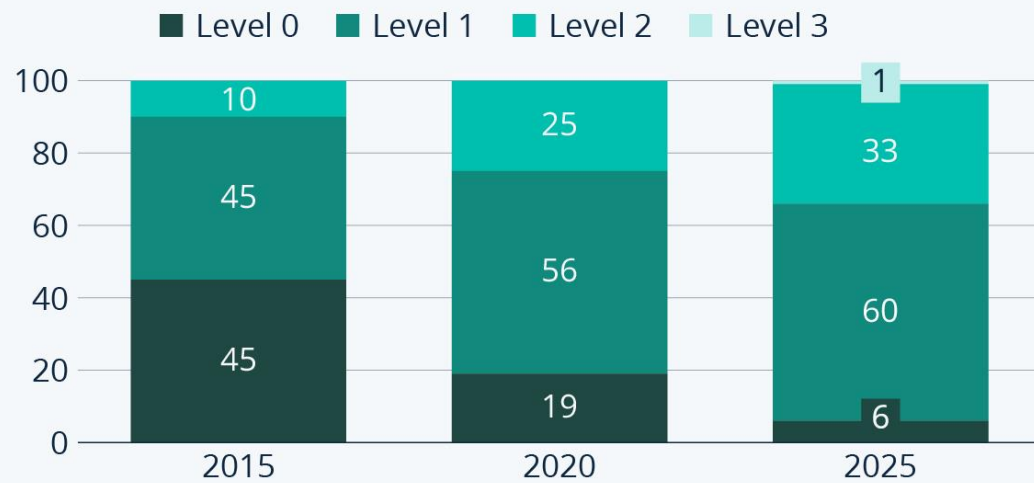
Total \$77bn

Source: Boston Consulting Group

# Forecasting the future in 2023

## Cars Increasingly Ready for Autonomous Driving

Estimated share of newly registered cars worldwide by autonomous driving level



Level 0=no autonomous driving  
 Level 1=partly assisted driving (steering OR braking)  
 Level 2=assisted driving (steering AND breaking below 60 km/h)  
 Level 3=highly autonomous driving

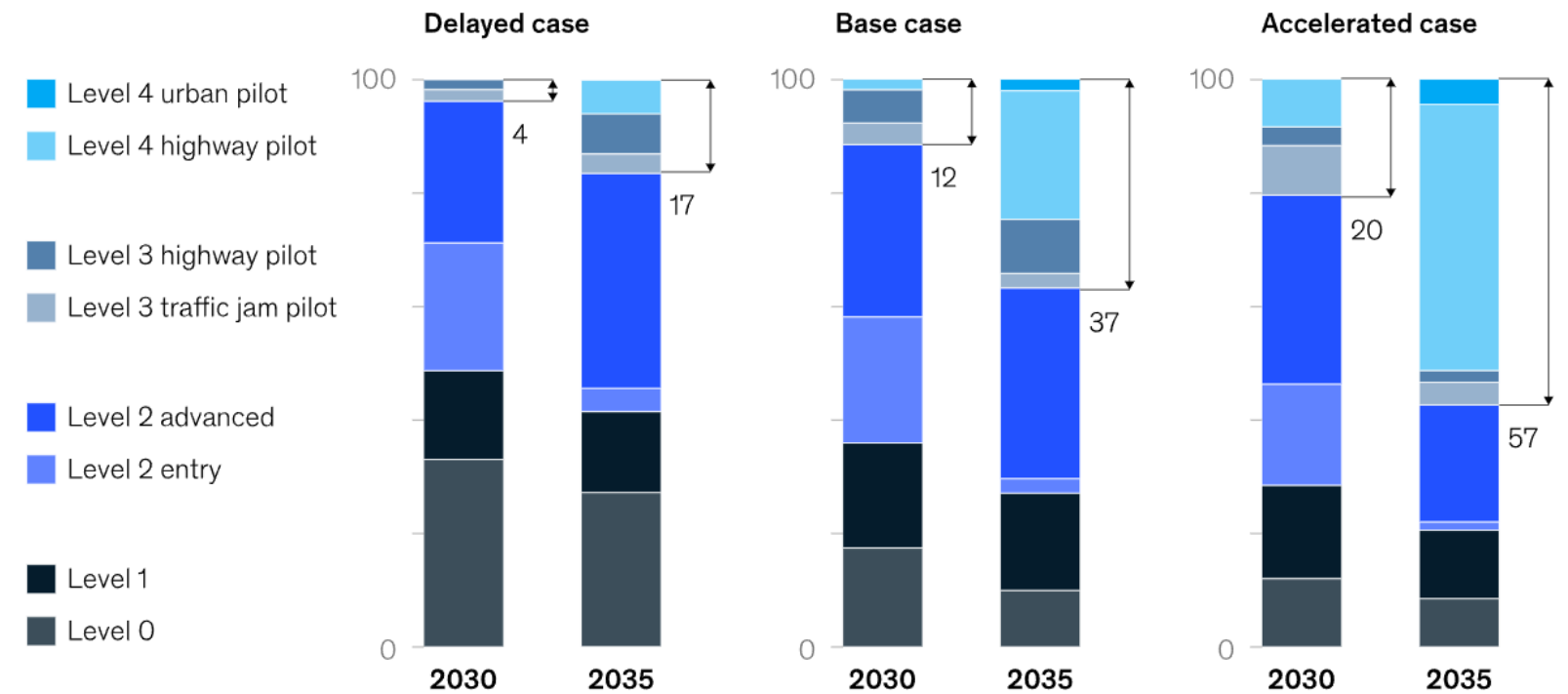
Source: Statista Market Insights



statista

## Three scenarios for autonomous-passenger-car sales in 2030 and 2035 show varying levels of consumer adoption.

Estimated passenger vehicles sold with autonomous-driving technologies installed, %



Source: McKinsey Center for Future Mobility

McKinsey & Company

# When does it become reality?

Technology



Legislation



Market



Social acceptance

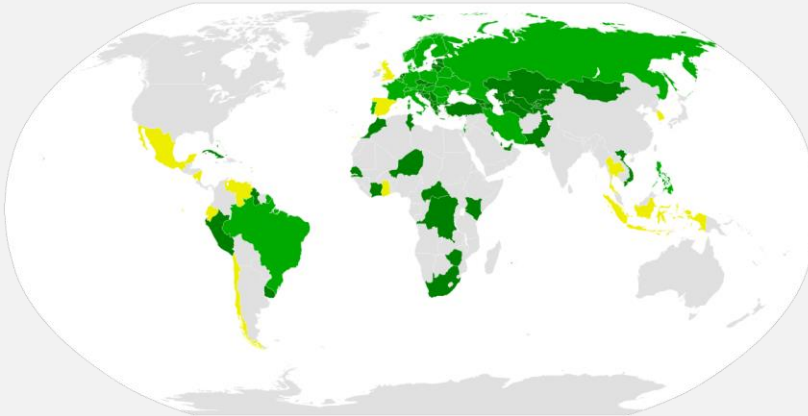




An aerial, top-down view of a city street intersection. The image is dark and semi-transparent, serving as a background for the text. It shows a multi-lane road with white lane markings and crosswalks. Several vehicles are visible, including a white van in the upper center, a white sedan in the lower center, and a dark SUV on the right. Pedestrians are seen crossing the street at various points. Traffic lights and streetlights are also visible. The overall scene is a busy urban environment.

# Legislation & Market

# Is self-driving legal?



**Vienna Convention on Road Traffic 1968**

Driver must always have full control over the vehicle.

2021: modified law in Germany for new Audi A8 (Level 3) car

Driver can be human as well as software



# Who takes the responsibility?

- In case of an accident, who takes responsibility?
  1. Passenger
  2. Vehicle operator
  3. Car manufacturer
  4. Component manufacturer
  5. Technology provider
- Multiple defendants: prosecution based on black box information
- The responsibility of car manufacturers increases
- Increased liability raises the price of self-driving cars and delays their market penetration
- Governmental task: participation in designing insurance policies and liability strategies for faster market penetration
  - England & Wales: Automated and Electric Vehicles Bill
  - Special type of insurance, insurer is always liable

An aerial, top-down view of a city street intersection. The image is dark and semi-transparent, serving as a background for the text. It shows a multi-lane road with a central crosswalk. A white van is driving through the intersection from top to bottom. To the right, a white sedan is driving away from the viewer. In the bottom right corner, a red fire hydrant is visible. Pedestrians are seen crossing the street at various points. The overall scene is a busy urban environment.

# Social Acceptance

## Ethical questions

Will self-driving cars be programmed to make moral decisions?



# Ethical dilemma

J. Bentham

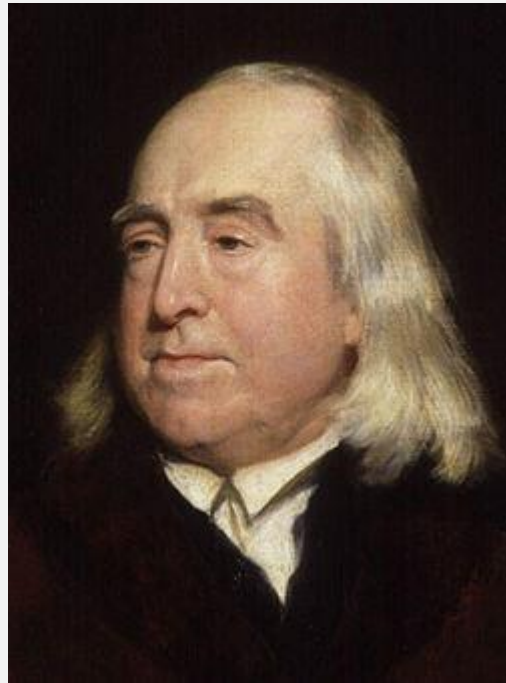
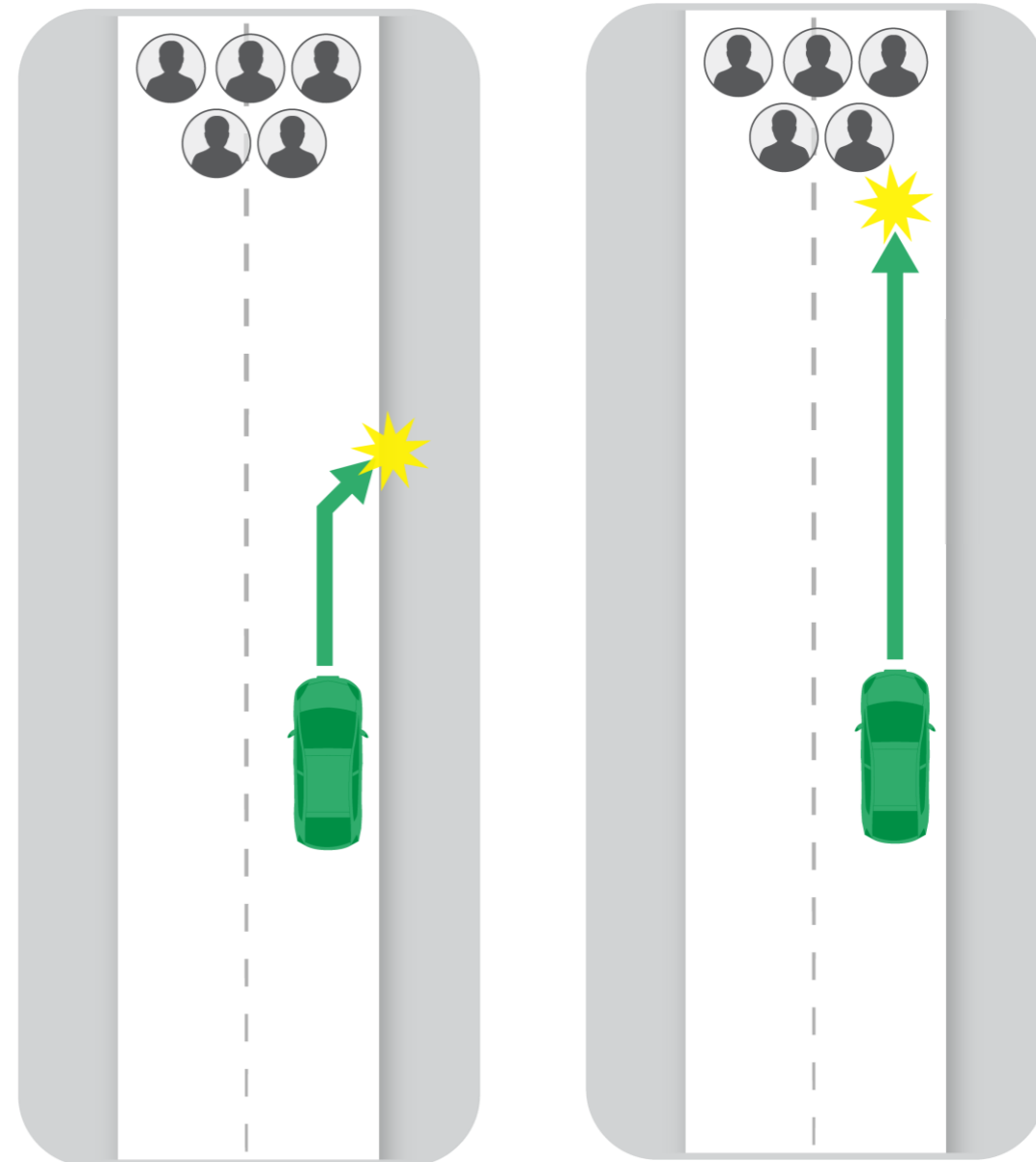


Image: www.wikipedia.org



Internal

I. Kant

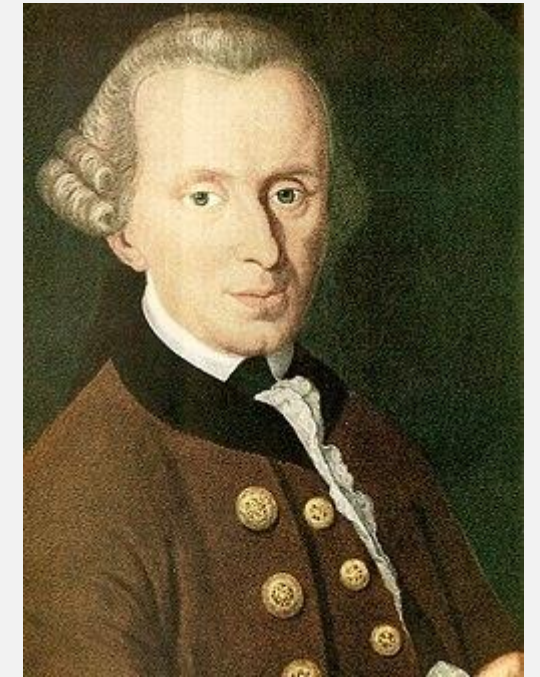
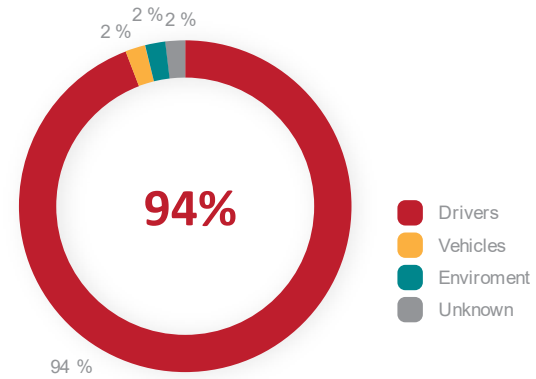


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Do we need self-driving cars?

## Take home message





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Q&A