

Autonomous Road Vehicles

Self-driving Cars



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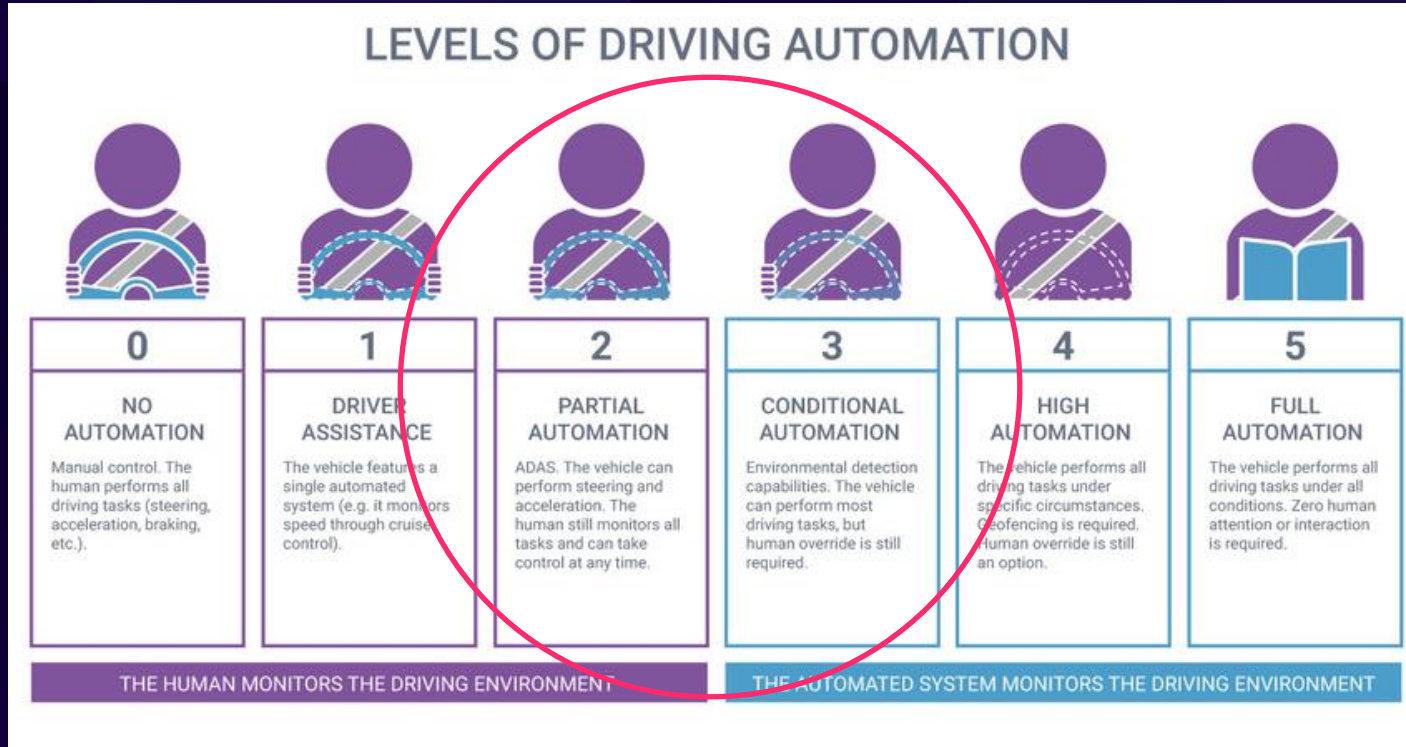
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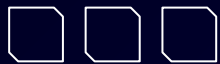
Timeframe to Maturity

A

Appendix

Reminder: Levels of Automation





01

The Evolution of Self-Driving Cars



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The Evolution of Self Driving Cars



Google started testing robot cars on roads



Uber tested autonomous taxis with human co-pilot

Autonomous Vehicle (AV) Testing Statistics

Number of AVs tested in various countries (as of 2017)

Country	AVs Tested	AVs Tested
USA	15	15
UK	12	12
Germany	10	10
France	8	8
Spain	7	7
Italy	6	6
Japan	5	5
China	4	4
South Korea	3	3
India	2	2
Others	1	1

- Uber AV with human safety driver on board killed a pedestrian
- Autonomous lorries tested on highways
- Nissan-DNA launched self-drive experiment
- Waymo ran a limited commercial robotaxi service

14th Century ... 1990's

2000's

....2015

2016

2017

2018

Appendix 1: The Evolution



- Tesla unveiled Autopilot
- Baidu drove a retrofitted BMW 3 Series autonomously
- Delphi AV drove from coast to coast



- NuTonomy self-drive taxis tested
- Gallup poll in the US shows majority public concern about AVs



Level 2 Automation

The Evolution of Self Driving Cars



2020

- GM launched Origin robotaxi with Lyft
- Volvo and Uber announced plan for robotaxi service with Geely and Nvidia
- UNECE WP.29 GRVA established regulation on SAE Level 3

2021



- Honda leased limited edition of 100 Legend Hybrid EX sedans with Level 3 automated driving equipment that legally allow drivers to take their eyes off the road
- Mercedes-Benz received German approval for a Level 3 Automated Lane Keeping System (ALKS) self-driving technology

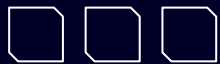
Level 2+/3 Automation

2022



- Mercedes-Benz launched sales of its Drive Pilot system capable of operating at SAE Level 3 autonomy
- Baidu unveils new autonomous vehicle Apollo RT6
- Nvidia launched a mapping product for the autonomous vehicle industry
- California regulator claims Tesla falsely advertising its Autopilot and Full Self-Driving features
- Baidu Inc. obtained permits to operate fully driverless robotaxi services on open roads without human safety drivers in the car
- Alibaba teams up with Tesla rival Xpeng on tech for driverless cars
- Wejo partners with Roadside Telematics for intelligent 9-1-1 crash data, directions and traffic with RTTI
- Open Data and Open-Source collaboration models gain momentum
- More regulation in place but commercialization hurdles persist





02

Competitive Landscape



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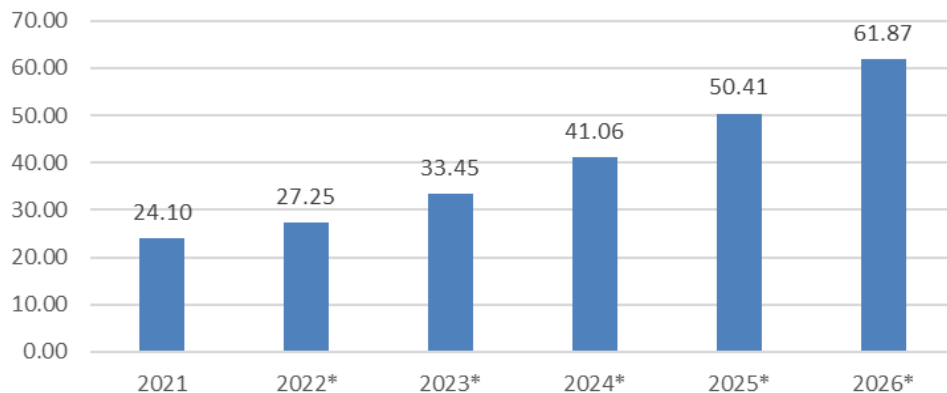


Quick Glance

Worth \$USD 27Billion,
expected to reach \$USD62
Billion by 2026

Consolidated Market in the
next few years

Size of the global autonomous car market in
2021, with a forecast through 2026 (in billion U.S.
dollars)



Source: Statista: Projected Size of Global Autonomous Vehicle Market by Vehicle Type



Market Leaders



Value: \$899.45 B
Miles Driven: 35 million



Value: \$30 B
Miles Driven: 2.3 million



Value: \$21 B
Miles Driven: 876,104



Industry challengers



Value: \$8.5 billion
Miles Driven: 305,616

ZOOX

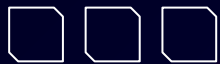
Value: \$1.2B
Miles Driven: 155,125



Value: \$7.2 B
Miles Driven: 21,037

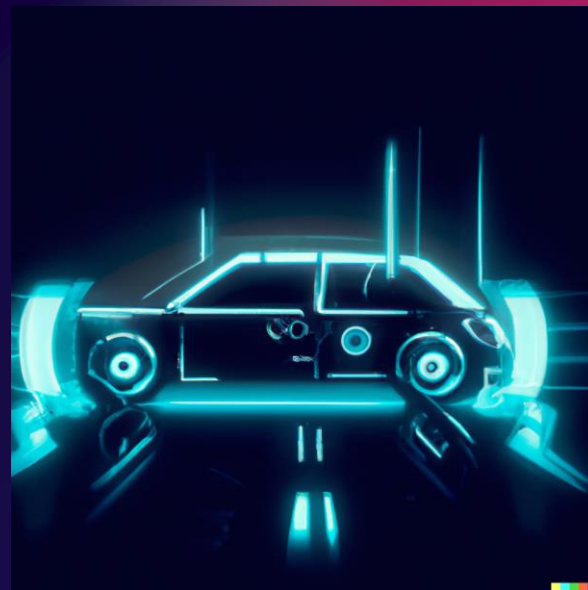
Industry enablers





03

Industry Trends

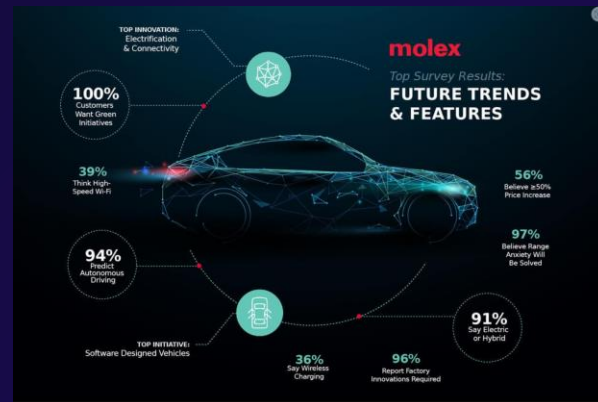


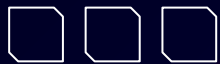
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Industry trends

<u>Category</u>	<u>Current state</u>	<u>Future state</u>
Technology	Sensors (LiDAR, RADAR), Cameras, Basic computer vision	Deep reinforcement learning, Simultaneous Localization and Mapping (SLAM), Path planning
Market Type	Robotaxi, Ride sharing	Autonomous delivery vehicles and trucks, Mobility-as-a-Service (MaaS)
Features	Advanced Driver Assist System (ADAS), sign recognition, autopilot (Tesla)	Electrification, Connectivity, AR based navigation
Safety	Prevent road accidents, minimize vehicle system malfunction	Better cybersecurity and privacy features, Reduce radiation exposure





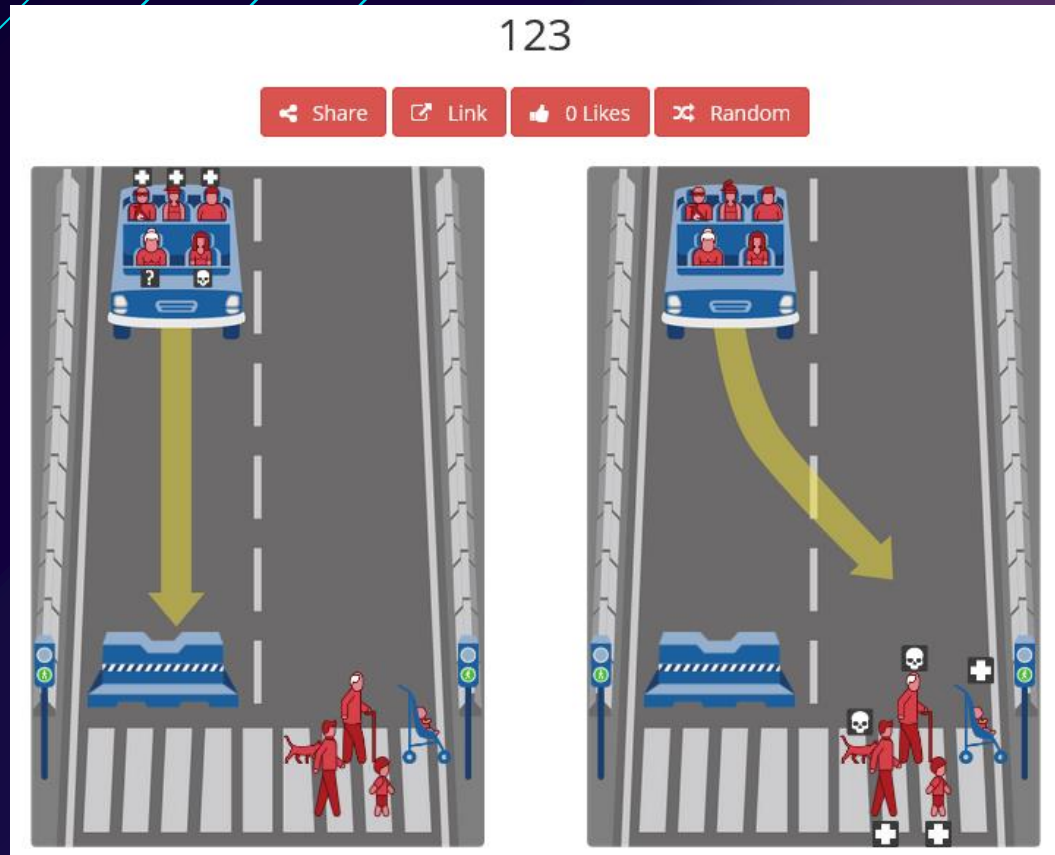
04

Ethical Concerns



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Trolley Problem



Source: Moral Machine

Who is responsible?



“For maximum safety, we can install a shiny metal bull bar, or more discreetly, an AI that always puts passengers first.”

Source: Evil AI Cartoons: Consider the Incentives of Paying Customers in Shaping AI Behavior

Other Ethical Concerns



Safety

Privacy

Environment

Social





05

Timeframe to Maturity



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Words from the Oracle...

**ELON MUSK PROMISING TESLA
ROBOTAXIS FOR NEXT YEAR
FOR ALMOST A DECADE!**



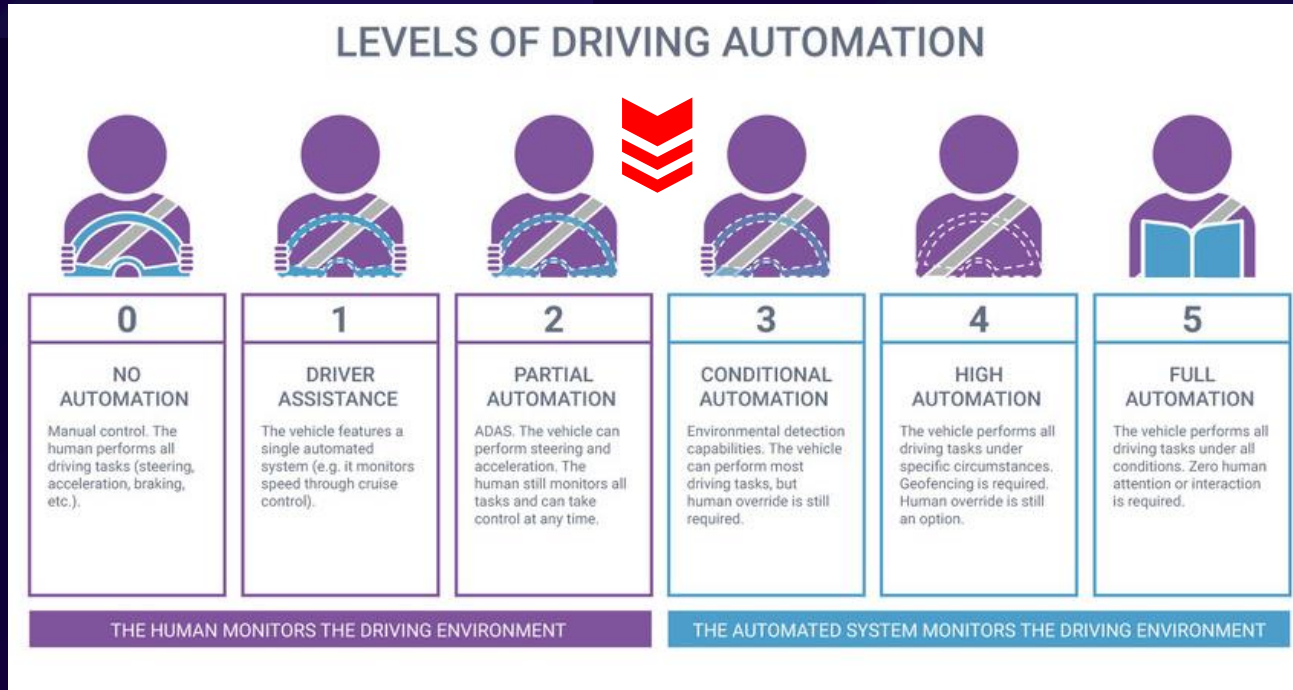
2014

**Vision
vs
Reality**

 [YouTube Link](#)

Recap: Levels of Automation

~ We are here ~



Source: Synopsys – Autonomous Driving Levels

TIMELINE



2010s

2023

2025?

2030+?

Level 2

Growing adoption
~30% market share

Level 3

Soon...
Premium Vehicles

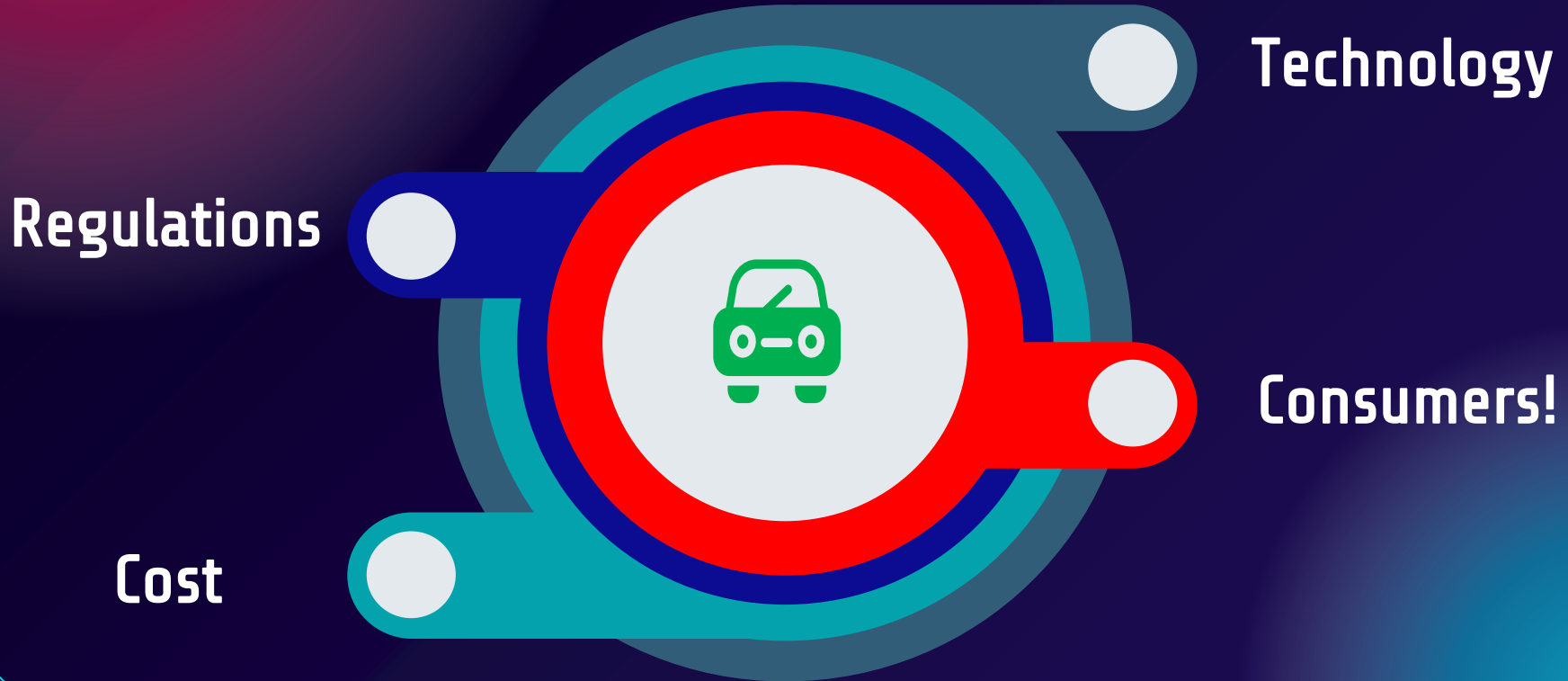
Level 4

Robotaxis/Rideshare
In select Locations

Level 5

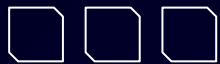
Is it even possible?

Challenges to Adoption



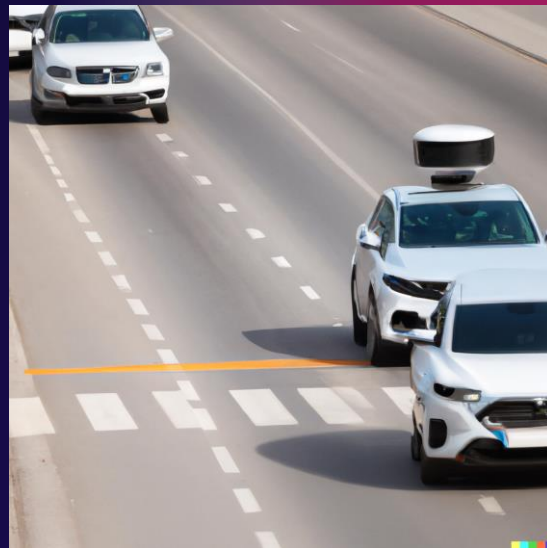
Questions ?

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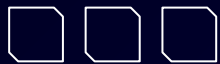


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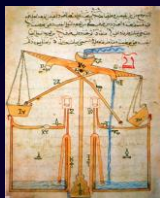
Appendix



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The Evolution of Self Driving Cars



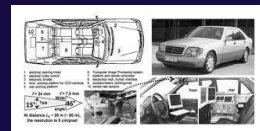
Leonardo da Vinci:
A cart that could
move without
being pushed or
pulled



GM's Futurama
exhibit at the
World's Fair
envisages cars
that drive
themselves



Stanford University
roboticists
developed the
autonomous
Stanford Cart
based on the Lunar
Rover platform



A vision-guided
Mercedes-Benz
robotic van,
designed by
Ernst Dickmanns



14th Century

1500's

1920's

1930's

1950's

1960's

1970's

1980's

1990's

Al Jazari:
"The Book of
Knowledge of
Ingenious
Mechanical
Devices"



Radio-
controlled
"American
Wonder"



GM tested a
rudimentary
self-steering
Chevrolet



Tsukuba Lab
created a car
equipped with
cameras and
analogue signal
processing
computers



A team of CMU
roboticists drove
a 1990 Pontiac
without human
help

Level 0 Automation

Level 1 Automation



Autonomous Vehicle Ecosystem



Source: greyb.com: Top 30 Self Driving Technology and Car Companies Q2 -2021



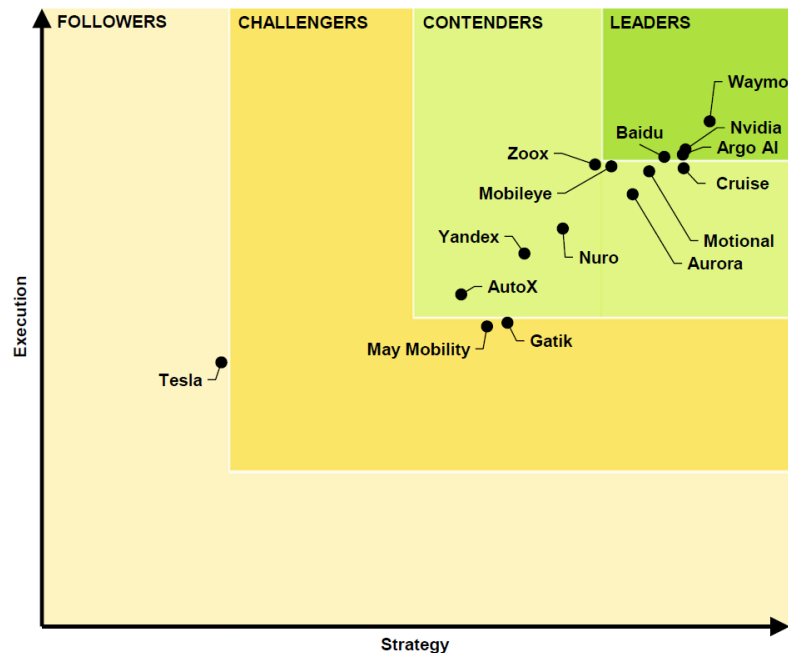
The Guidehouse Insights Leaderboard Grid

Q2 2021

The criteria by which manufacturers are compared:

- Vision
- Go-to-Market Strategy
- Partners
- Production Strategy
- Technology
- Sales, Marketing, and Distribution
- Commercial Readiness
- R&D Progress
- Product Portfolio
- Staying Power

Chart 1-1. The Guidehouse Insights Leaderboard Grid



(Source: Guidehouse Insights)



Industry trends

Trends:

- Innovation - Electrification and connectivity
- Price - Cars to be 50% more expensive by 2030
- Technology - Better hardware + software integration
- Manufacturing – Improvements in process efficiencies

Features:

- Semi-autonomous / Fully autonomous
- ML/AI to learn passenger routines and preferences
- Better safety, cybersecurity and privacy features
- Augmented reality (AR) based navigation

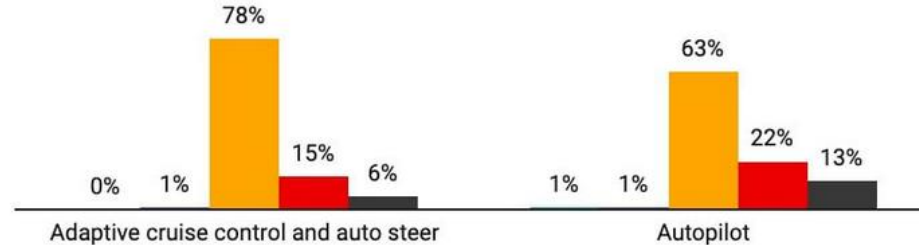


Potential Negative Environmental Impact

When people drive partially automated vehicles, they travel farther

In a 2019 survey of 940 owners of partially automated vehicles in California, 21%-35% reported that they did more long-distance travel such as weekend and vacation trips because of the cars' partially automated operating systems.

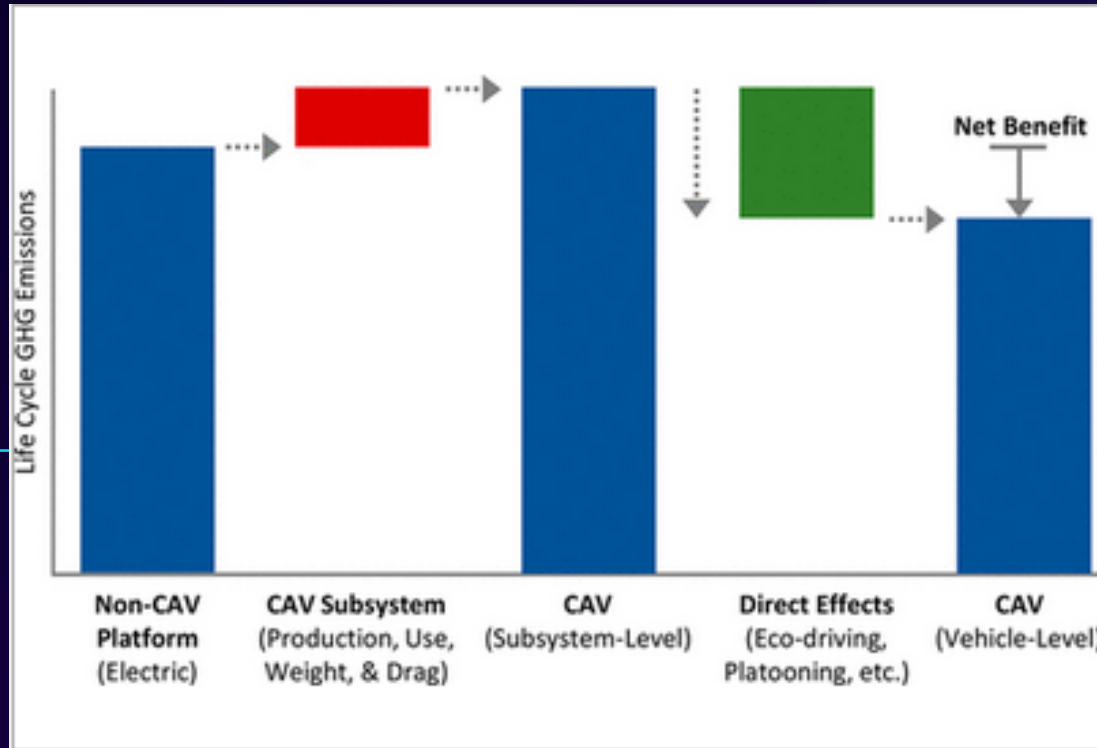
Far less travel Slightly less travel No change in distance traveled
Slightly more travel Far more travel



Autopilot refers to drivers with Tesla Autopilot. Adaptive cruise control and auto steer includes drivers of other vehicle makes with partial automation, such as Nissan Pro Pilot, BMW Driving Assistant or Cadillac SuperCruise.

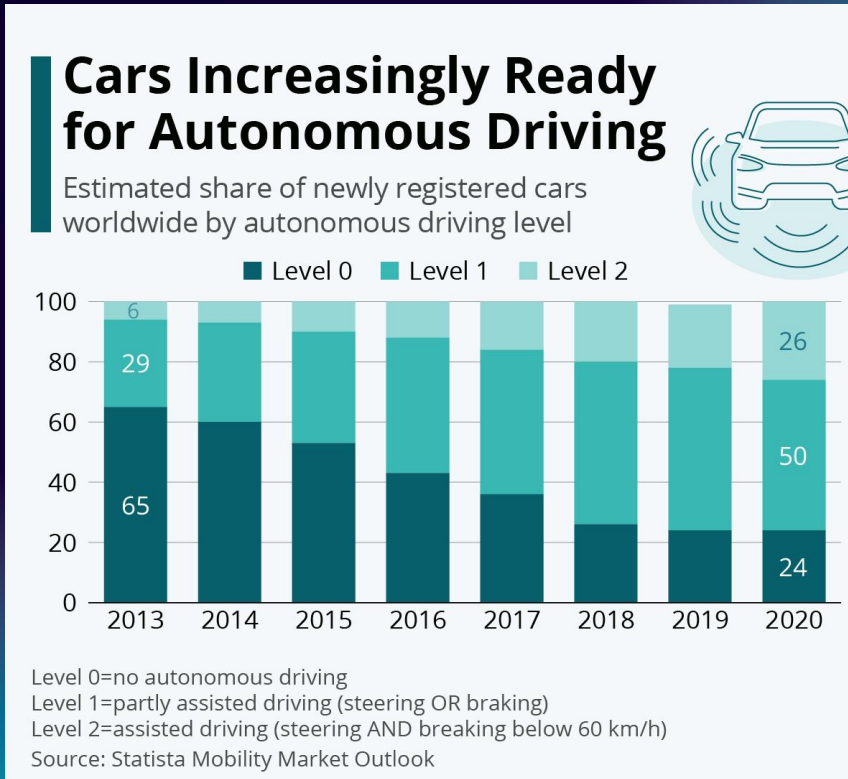
Source: Earth.org: Pros and cons of Self-driving Cars

Potential Positive Environmental Impact



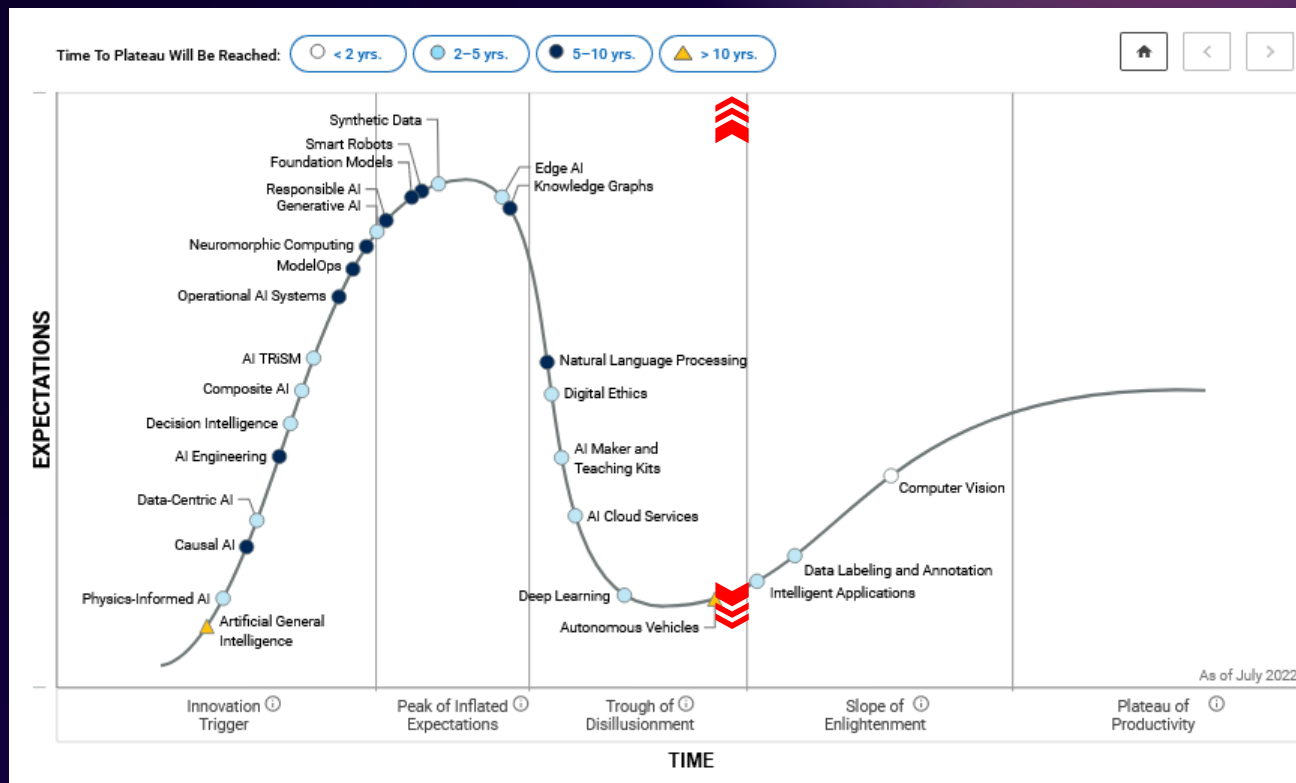
Source: Pubs.acs.org: Life Cycle Assessment of Connected and Automated Vehicles: Sensing and Computing Subsystem and Vehicle Level Effects

Marketshare of L0-L2 Automation over time



Source: Statista: Newly Registered Cars by Autonomous Driving Level

Gartner AI Hype Cycle – July 2022



Source: Gartner: 2022 Hype Cycle for Emerging Technologies

Companies investing in autonomous vehicles

Vehicles operating in SAE levels of automation 1-3 are already in commercial use and many companies are investing further in developing highly and fully automated vehicles



AV investment

