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What Is AV (Autonomous Vehicle)?

What Is AV (Autonomous Vehicle)?

A **self-driving car**, **also known** as an **autonomous vehicle** (AV), connected and autonomous vehicle (CAV), driverless car, robo-car, or robotic car, is a vehicle that is capable of sensing its environment and moving safely with little or no human input. (Wikipedia)

A Waymo self-driving car. *Wikipedia* [online]. [cit. 2020-01-25]. Dostupné z: https://upload.wikimedia.org/wikipedia/commons/c/cf/Waymo_self-driving_car_front_view.gk.jpg

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What Is AV (Autonomous Vehicle)?

- Ground vehicles
- Autonomous aerial vehicles (drone)
- Autonomous surface vehicles

An MQ-9 Reaper unmanned aerial vehicle

An MQ-9 Reaper. *Wikipedia* [online]. [cit. 2020-01-25]. Dostupné z: https://en.wikipedia.org/wiki/File:MQ-9_Reaper_UAV_(cropped).jpg

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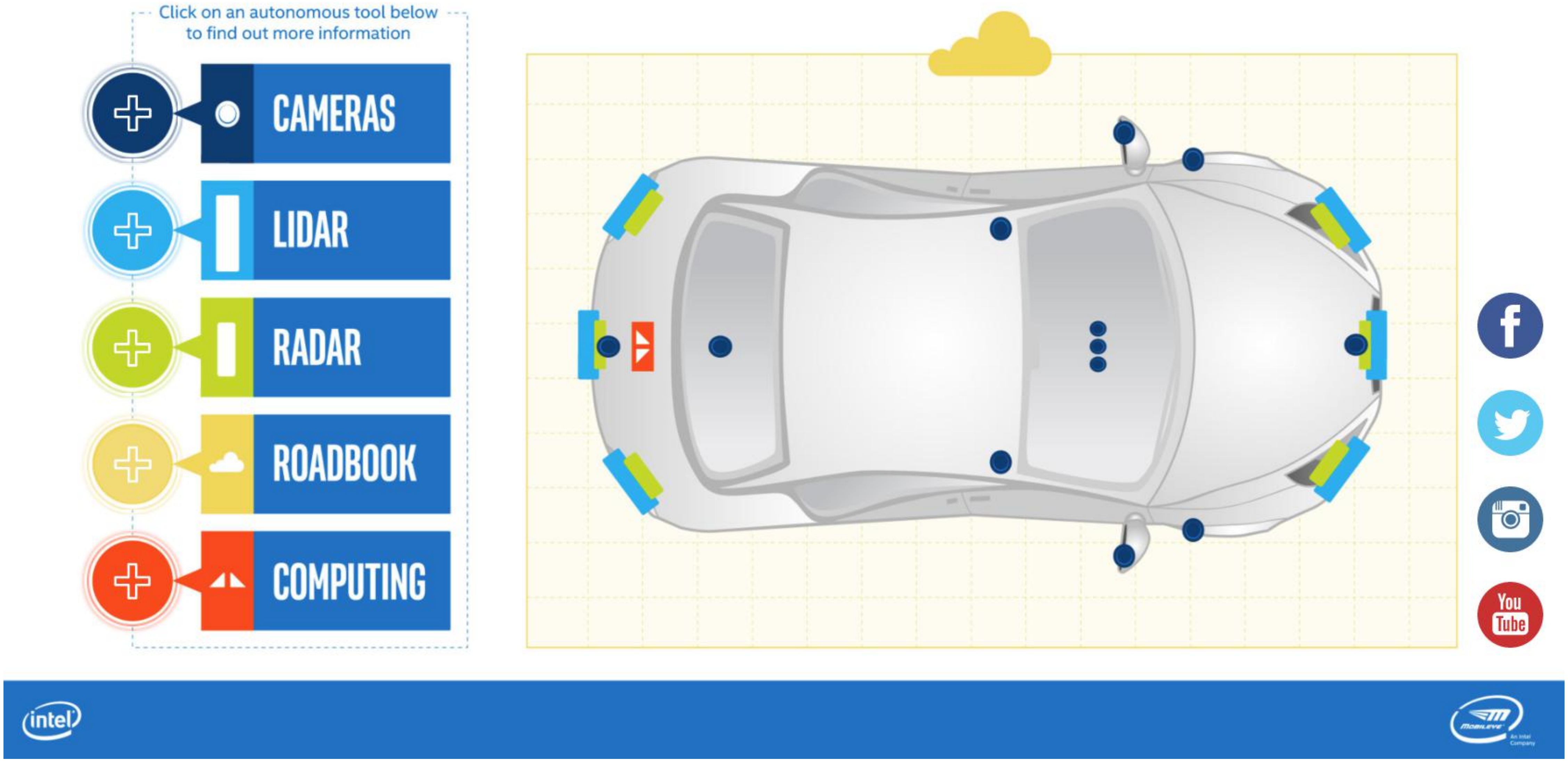
AUTONOMOUS VEHICLE PLATFORM

The sensors, hardware and software provided by **Intel** and **Mobileye** give autonomous vehicles their ability to recognize the environment around them. This technology creates the building blocks for autonomous vehicles (AV) and includes a suite of cameras, lidar, radar, and computing and mapping technologies.



Intel Explainer: Sensors. *Businesswire* [online]. [cit. 2020-01-25]. Dostupné z: https://www.businesswire.com/news/home/20180816005108/en/Intel-Explainer-Sensors-%E2%80%93-Eyes-Ears-Autonomous

https://www.youtube.com/watch?v=x7_GRigShU

- Cameras
- Lidars
- Radars
- Maps

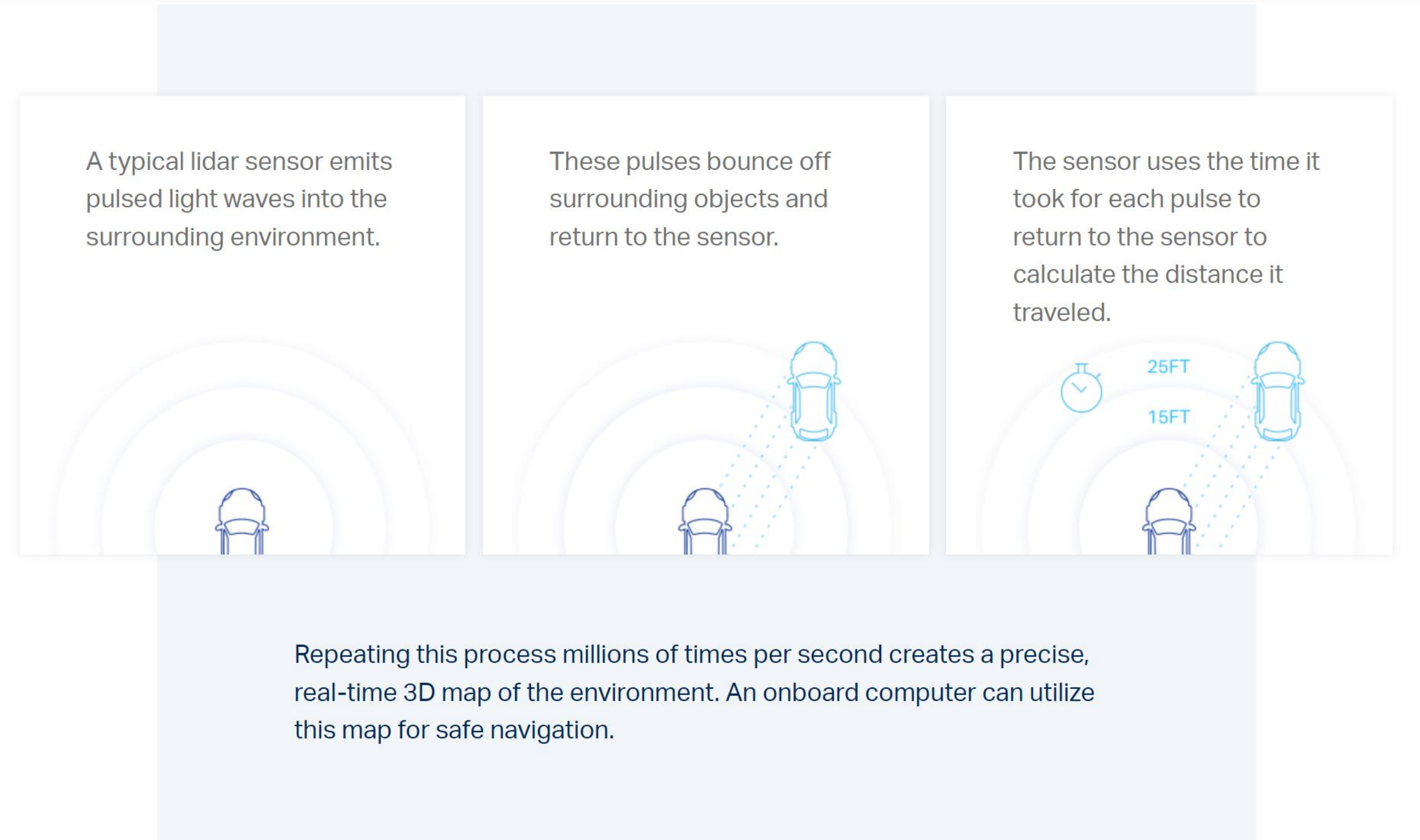
Puck Lidar Sensor. *Velodynelidar* [online]. [cit. 2020-01-25]. Dostupné z: https://eak2mvmpt4a.exactdn.com/wp-content/uploads/2019/08/Velodyne_Puck600.png?strip=all&lossy=1&ssl=1

Intel® RealSense™ Technology. *Intel* [online]. [cit. 2021-01-25]. Dostupné z: https://www.intel.com/content/www/us/en/architecture-and-technology/realsense-overview.html

https://velodynelidar.com/products/puck/

What is Lidar?

Lidar ("light detection and ranging") uses eye-safe laser beams to "see" the world in 3D, providing machines and computers an accurate representation of the surveyed environment.



https://velodynelidar.com/what-is-lidar/

https://velodynelidar.com/products/puck/

What is Lidar?

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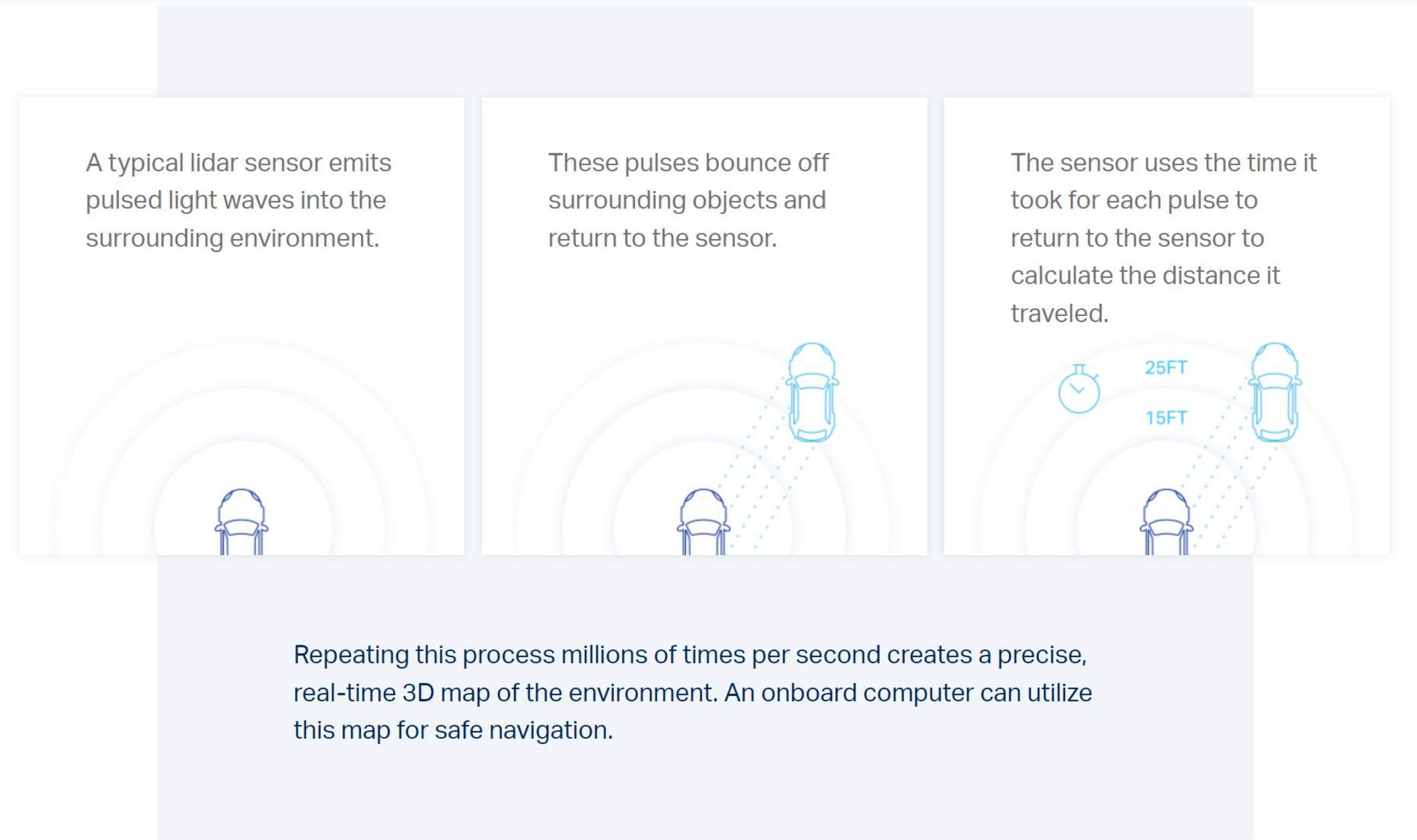
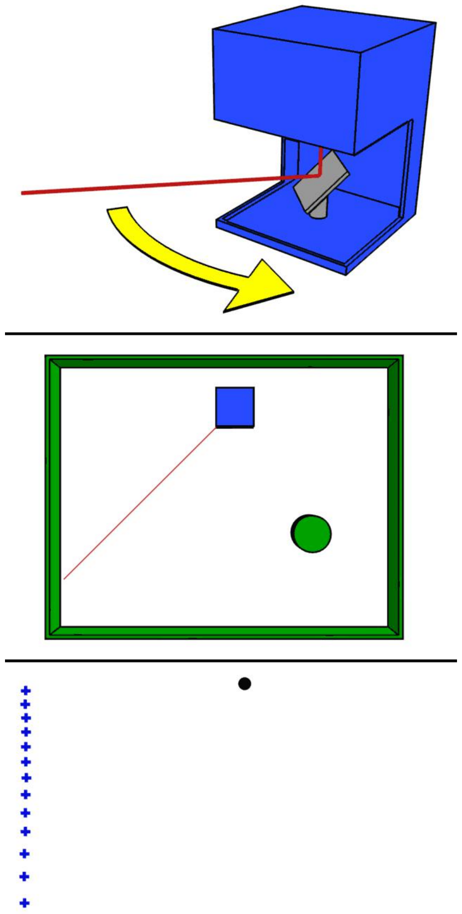




https://velodynelidar.com/what-is-lidar/ https://upload.wikimedia.org/wikipedia/commons/c/c0/LIDAR-scanned-SICK-LMS-animation.gif https://velodynelidar.com/products/puck/

Lidars

https://velodynelidar.com/what-is-lidar/

https://velodynelidar.com/products/puck/

Lidars

https://www.youtube.com/channel/UCKyHFNyJ3QV-1rjogCYHkRA

https://velodynelidar.com/products/puck/

Lidars

https://www.youtube.com/c/ANYbotics/videos

https://velodynelidar.com/products/puck/

Lidars vs. Cameras

Tesla CEO Elon Musk: “Anyone relying on LiDAR is doomed”

https://www.youtube.com/watch?v=HM23sjhtk4Q

Lidars vs. Cameras

https://youtu.be/HLczErXDujI

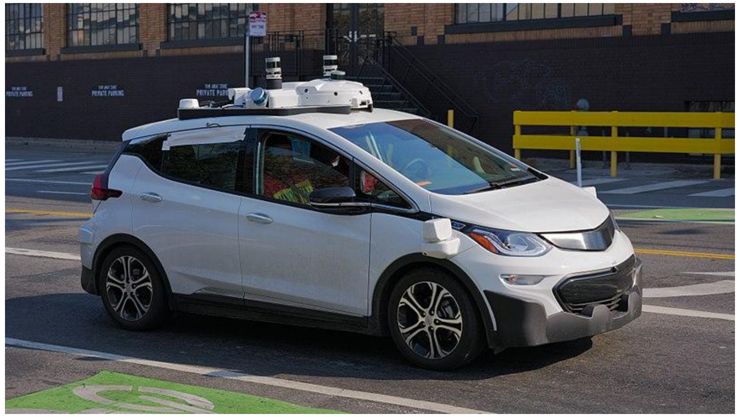
What Tesla See

https://www.youtube.com/watch?v=zRnSmw1i_DQ

Lidar vs Camera

LiDAR

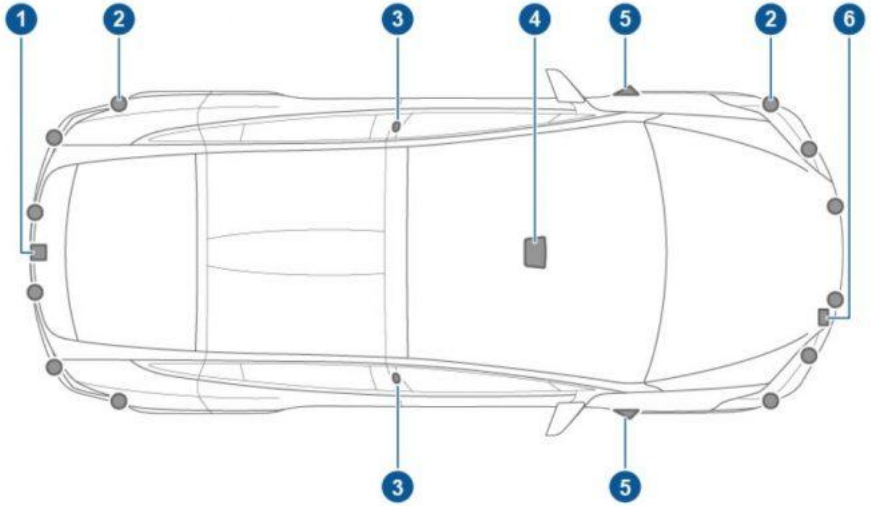
- cannot detect colors
- cannot interpret the text
- Impossible to identify traffic lights or road signs
- can achieve good results day and night
- high level of accuracy
- is more expensive
- requires more space
- gives self-driving cars a three-dimensional image



https://www.autopilotreview.com/lidar-vs-cameras-self-driving-cars/
https://medium.com/0xmachina/lidar-vs-camera-which-is-the-best-for-self-driving-cars-9335b684f8d
https://leddartech.com/lidar-radar-camera-demystifying-adas-ad-technology-mix/

Camera

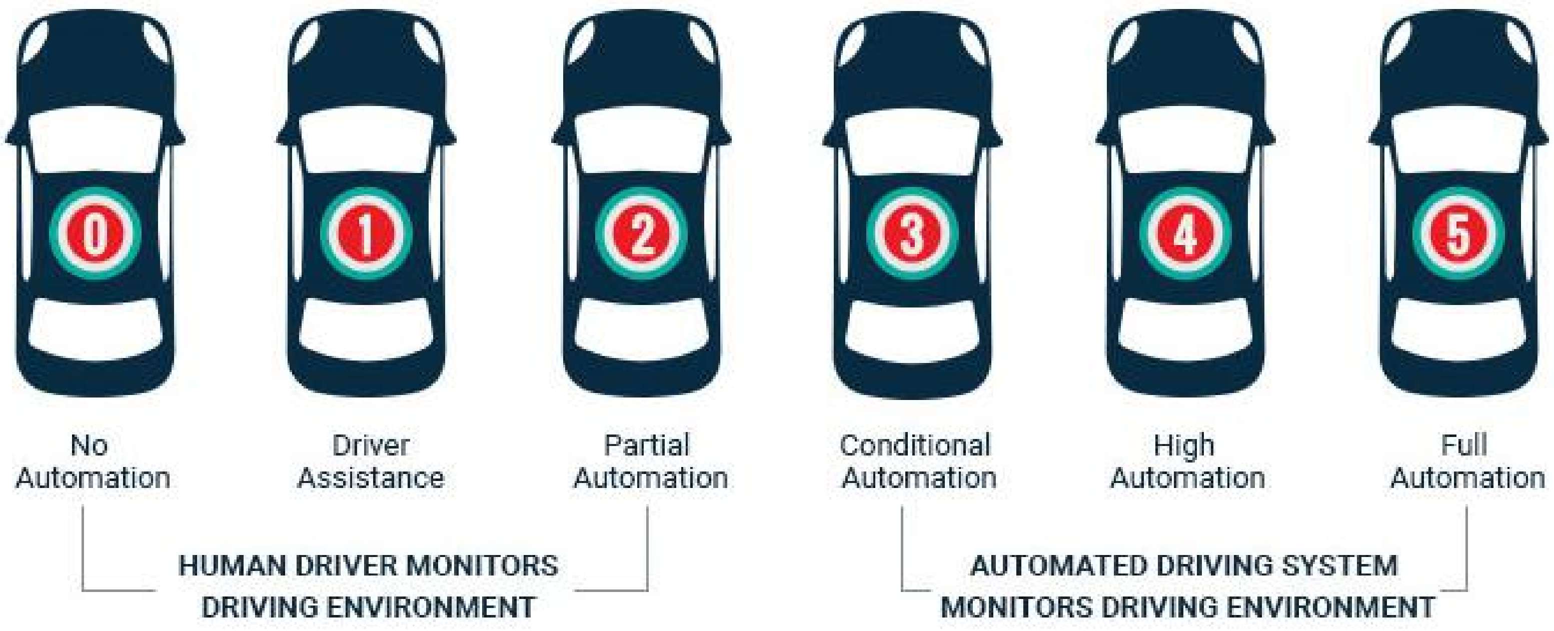
- can recognize colors and read road signs
- many modern AI methods to identify objects or distances
- require significantly more computing power
- camera systems are almost invisible
- challenging low-light conditions



1. A camera is mounted above the rear license plate.
2. Ultrasonic sensors are located in the front and rear bumpers.
3. A camera is mounted in each door pillar.
4. Three cameras are mounted to the windshield above the rear view mirror.
5. A camera is mounted to each front fender.
6. Radar is mounted behind the front bumper on the right side of the vehicle.

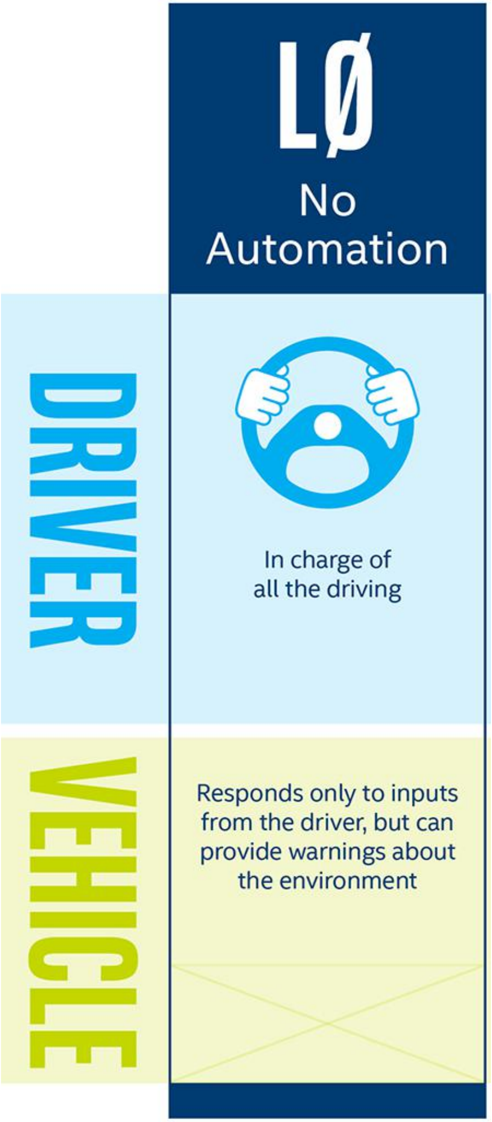
Model X is also equipped with high precision electrically-assisted braking and steering systems.

Levels of Autonomous Cars



Levels of autonomous cars [online]. [cit. 2020-01-25]. Dostupné z: https://geospatialmedia.s3.amazonaws.com/wp-content/uploads/2018/02/bi-graphics_autonomous-cars.png

Levels of Autonomous Cars

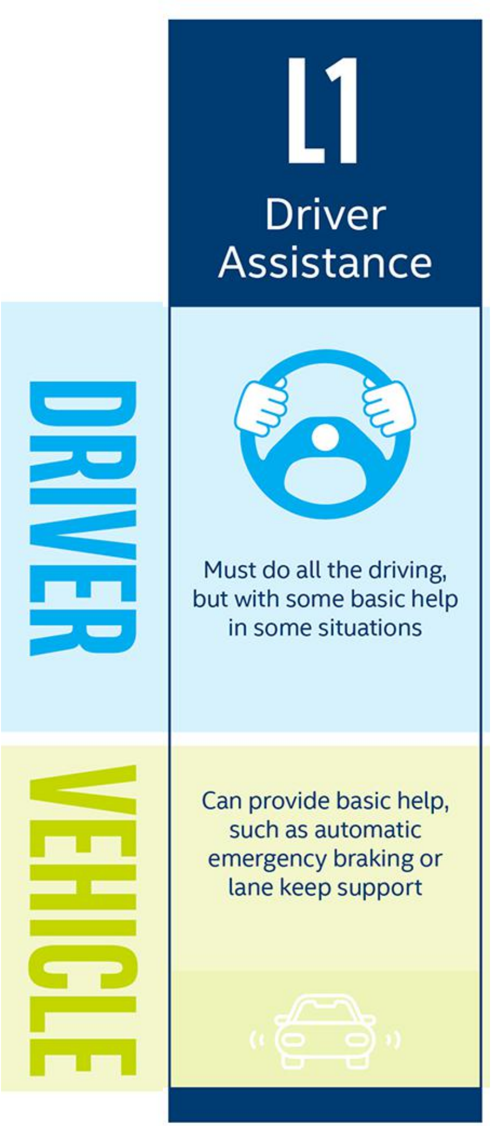


https://www.businessinsider.com/what-are-the-different-levels-of-driverless-cars-2016-10

Zero autonomy; the driver performs all the driving, but the vehicle can aid with blind spot detection, forward collision warnings and lane departure warnings.

https://newsroom.intel.com/news/autonomous-driving-hands-wheel-no-wheel-all

Levels of Autonomous Cars



The vehicle may have some active driving assist features, but the driver is still in charge. Such assist features available in today's vehicles include adaptive cruise control, automatic emergency braking and lane keeping.

https://newsroom.intel.com/news/autonomous-driving-hands-wheel-no-wheel-all

https://www.businessinsider.com/what-are-the-different-levels-of-driverless-cars-2016-10

Levels of Autonomous Cars

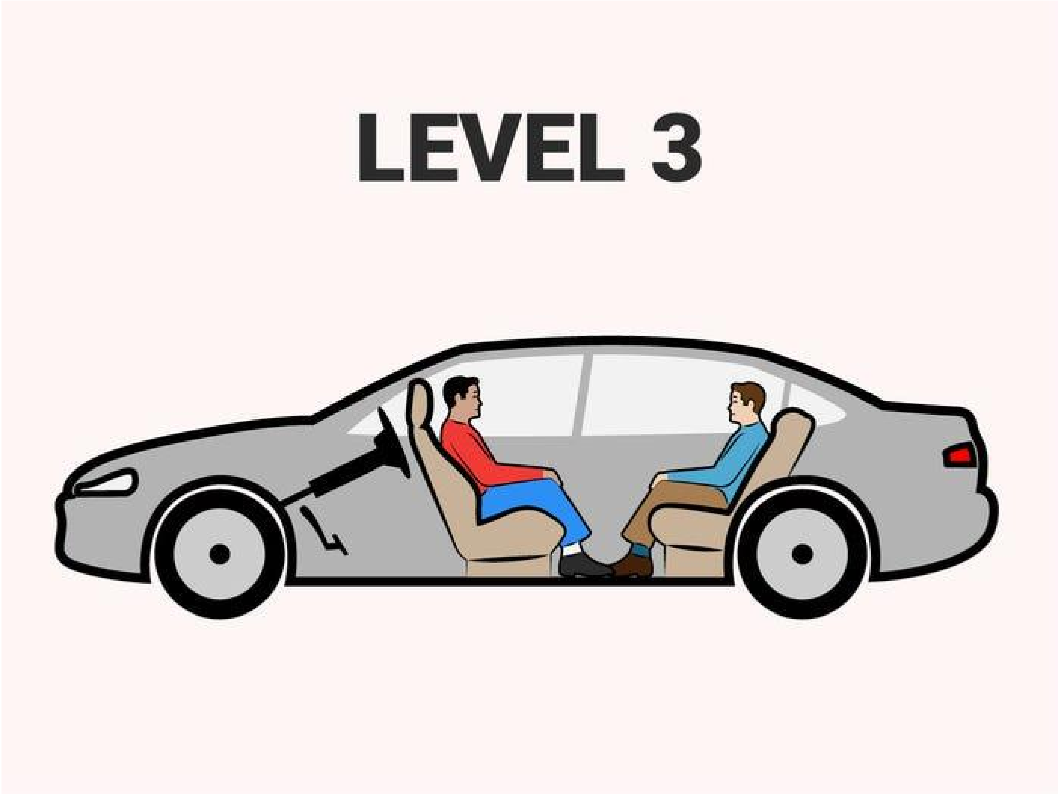
The driver still must be alert and monitor the environment at all times, but driving assist features that control acceleration, braking and steering may work together in unison so the driver does not need to provide any input in certain situations. Such automated functions available today include self-parking and traffic jam assist (stop-and-go traffic driving).

https://newsroom.intel.com/news/autonomous-driving-hands-wheel-no-wheel-all

https://www.businessinsider.com/what-are-the-different-levels-of-driverless-cars-2016-10

Levels of Autonomous Cars

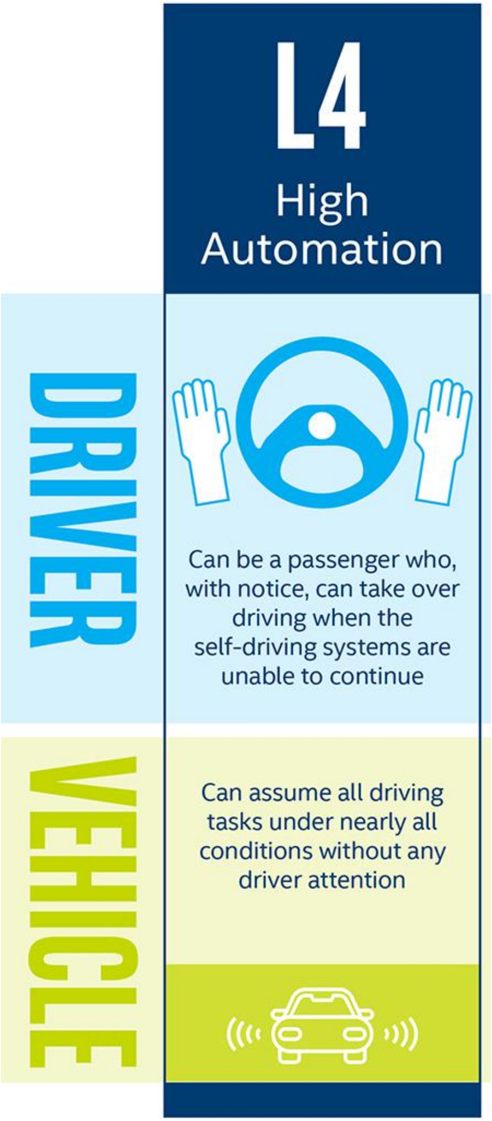
https://www.businessinsider.com/what-are-the-different-levels-of-driverless-cars-2016-10

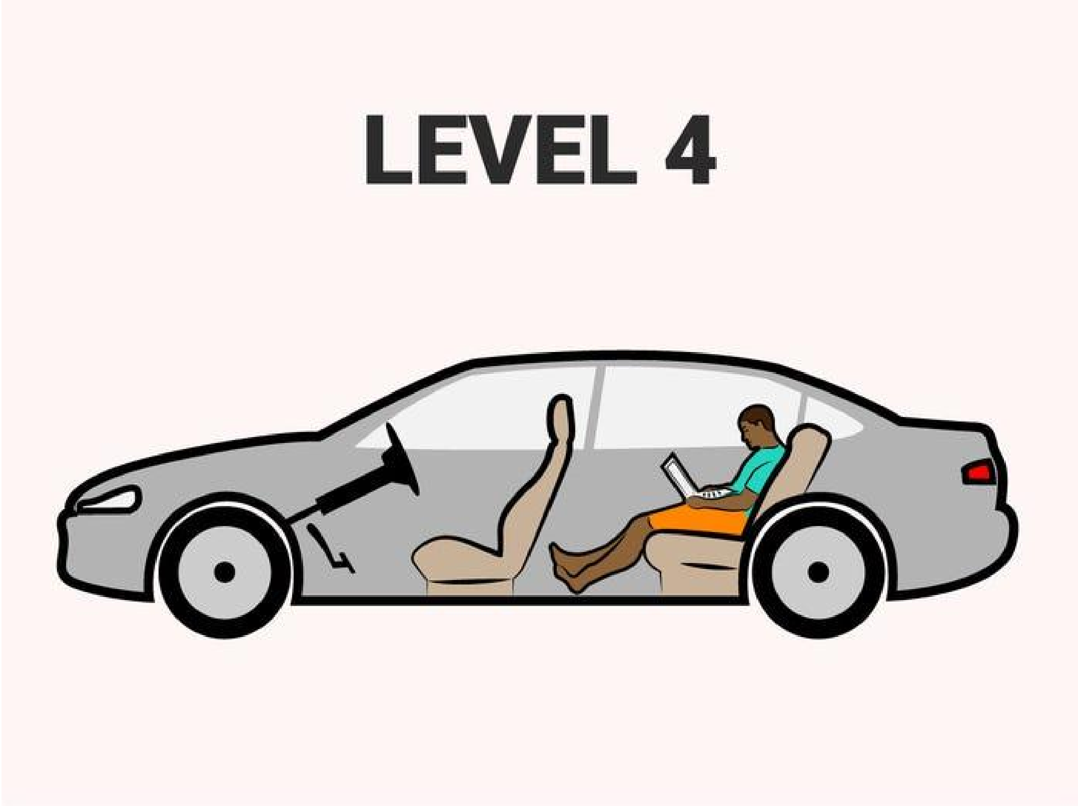


The vehicle can itself perform all aspects of the driving task under some circumstances, but the human driver must always be ready to take control at all times within a specified notice period. In all other circumstances, the human performs the driving.

https://newsroom.intel.com/news/autonomous-driving-hands-wheel-no-wheel-all

Levels of Autonomous Cars

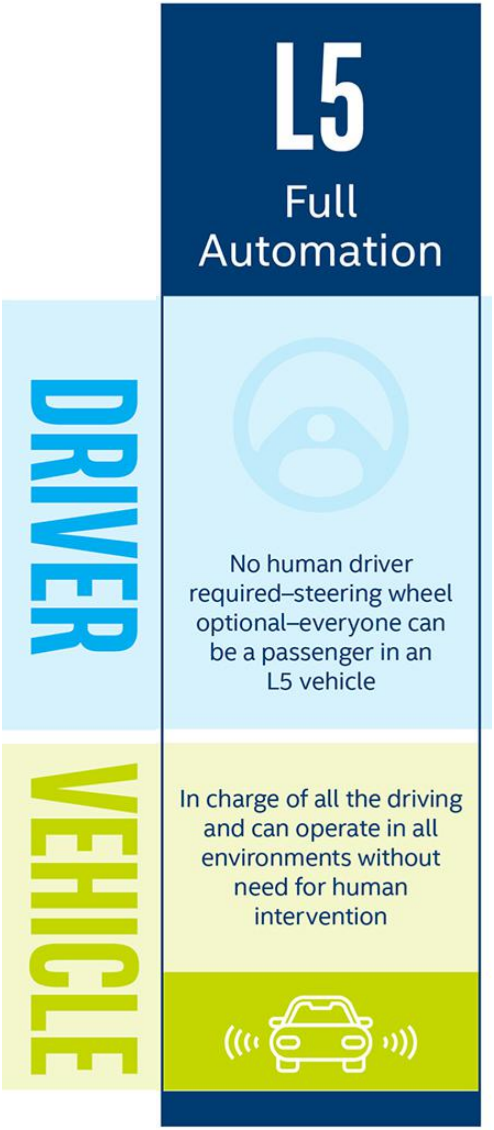




This is a self-driving vehicle. But it still has a driver's seat and all the regular controls. Though the vehicle can drive and "see" all on its own, circumstances such as geographic area, road conditions or local laws might require the person in the driver's seat to take over.
https://newsroom.intel.com/news/autonomous-driving-hands-wheel-no-wheel-all

https://www.businessinsider.com/what-are-the-different-levels-of-driverless-cars-2016-10

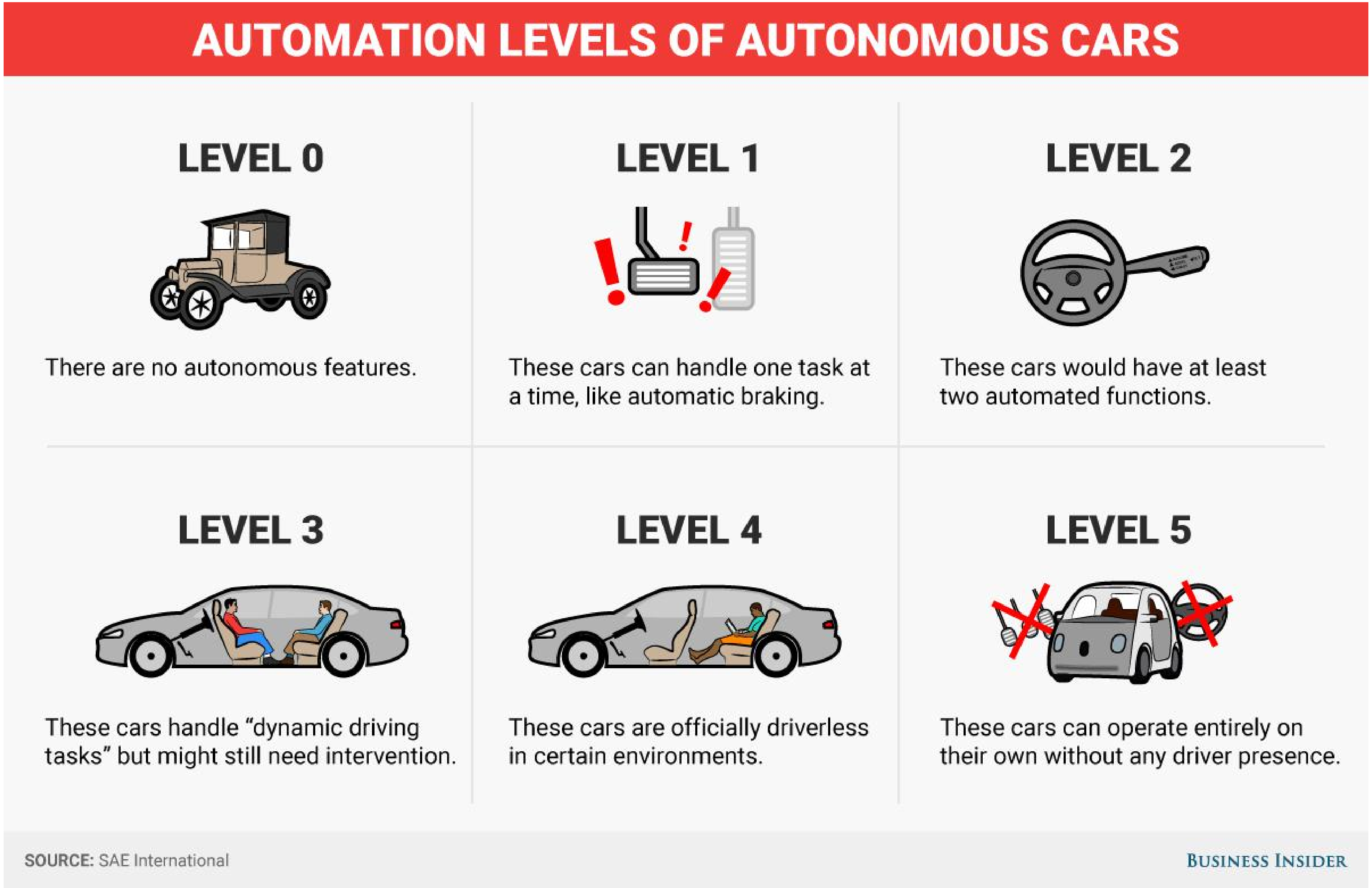
Levels of Autonomous Cars



The vehicle is capable of performing all driving functions under all environmental conditions and can operate without humans inside. The human occupants are passengers and need never be involved in driving. A steering wheel is optional in this vehicle.

https://newsroom.intel.com/news/autonomous-driving-hands-wheel-no-wheel-all

https://www.businessinsider.com/what-are-the-different-levels-of-driverless-cars-2016-10



Levels of autonomous cars [online]. [cit. 2020-01-25]. Dostupné z: https://geospatialmedia.s3.amazonaws.com/wp-content/uploads/2018/02/bi-graphics_autonomous-cars.png

Levels of Autonomous Cars in 2022 ???

"Mercedes-Benz is expected to launch the first mass-production **Level 3** car in 2022 using its Drive Pilot technology."

"BMW is widely expected to roll out **Level 3** technology in the new 7 Series"

"Alphabet's Waymo recently unveiled a **Level 4** self-driving taxi service in Arizona, where they had been testing driverless cars—without a safety driver in the seat—for more than a year and over 10 million miles.."

"Tesla is likely to achieve **Level 4** autonomy in 2022, says Elon Musk, when certain milestones in the development of full self-driving (FSD) are achieved. The data show that Tesla's system performs better than a human driver for preventing accidents."

https://www.cnet.com/roadshow/news/the-most-important-self-driving-cars-of-2022/

https://www.tesmanian.com/blogs/tesmanian-blog/tesla-likely-to-achieve-level-4-autonomy-in-2022-says-elon-muskhttps://www.synopsys.com/automotive/autonomous-driving-levels.html

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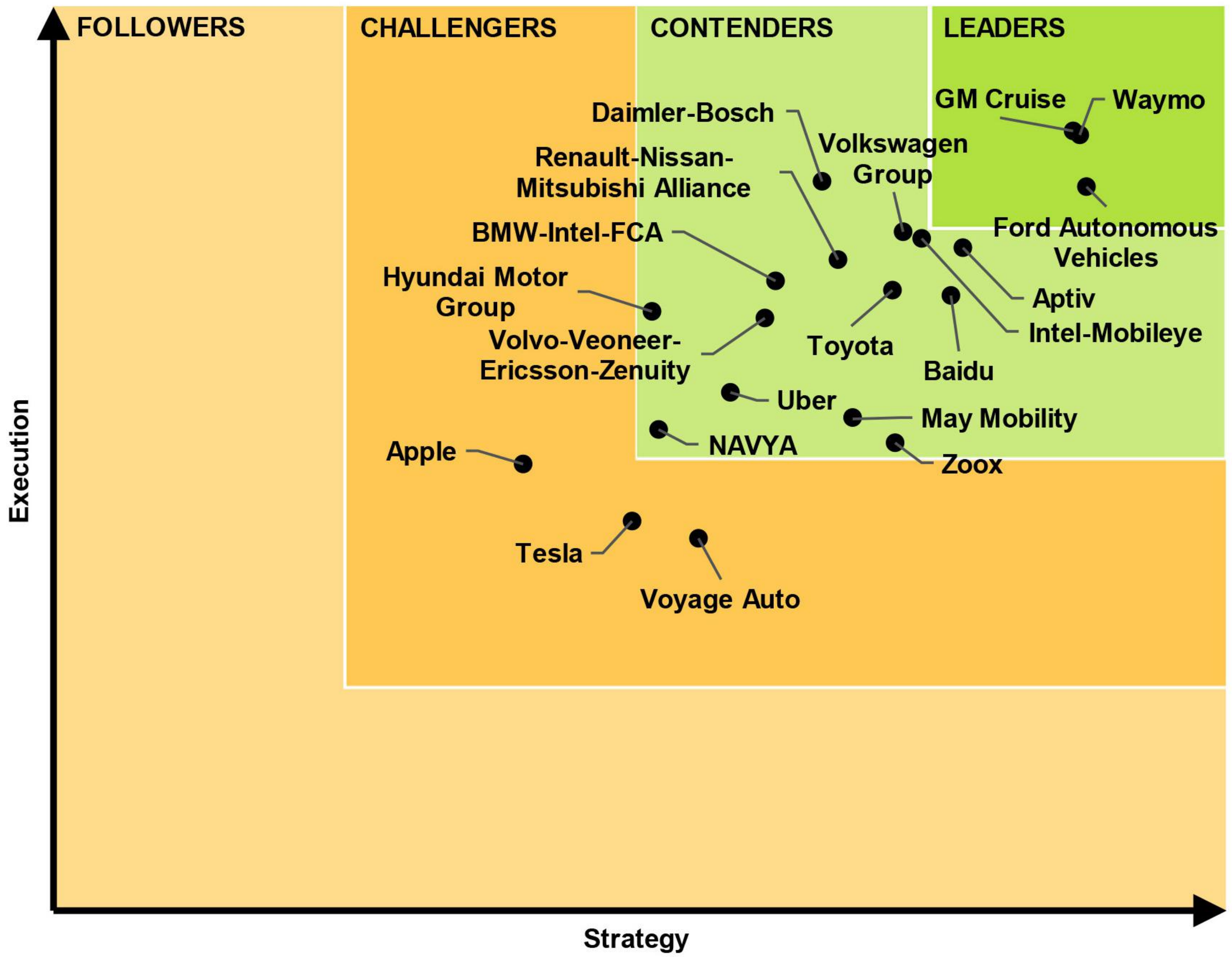
Company Scores (2019)

- Waymo (Google)
- GM Cruise
- Ford

Automated Driving Leaderboard. *Sae* [online]. [cit. 2020-01-25]. Dostupné z: https://www.sae.org/news/2019/03/2019-navigant-autonomous-leaderboard

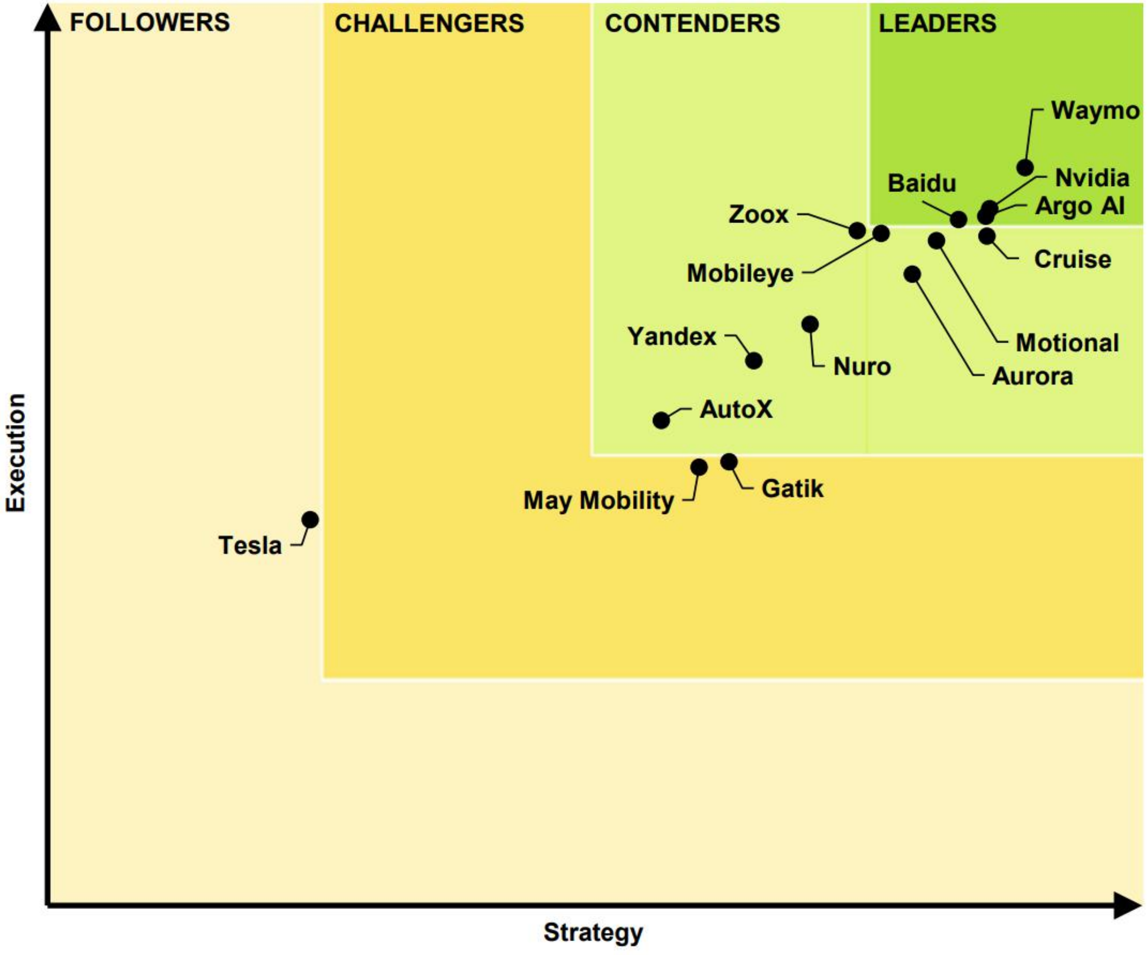
Company Scores (2019)

The Navigant Research Leaderboard Grid



Automated Driving Leaderboard. *Sae* [online]. [cit. 2020-01-25]. Dostupné z: https://www.sae.org/news/2019/03/2019-navigant-autonomous-leaderboard

Company Scores (2020)



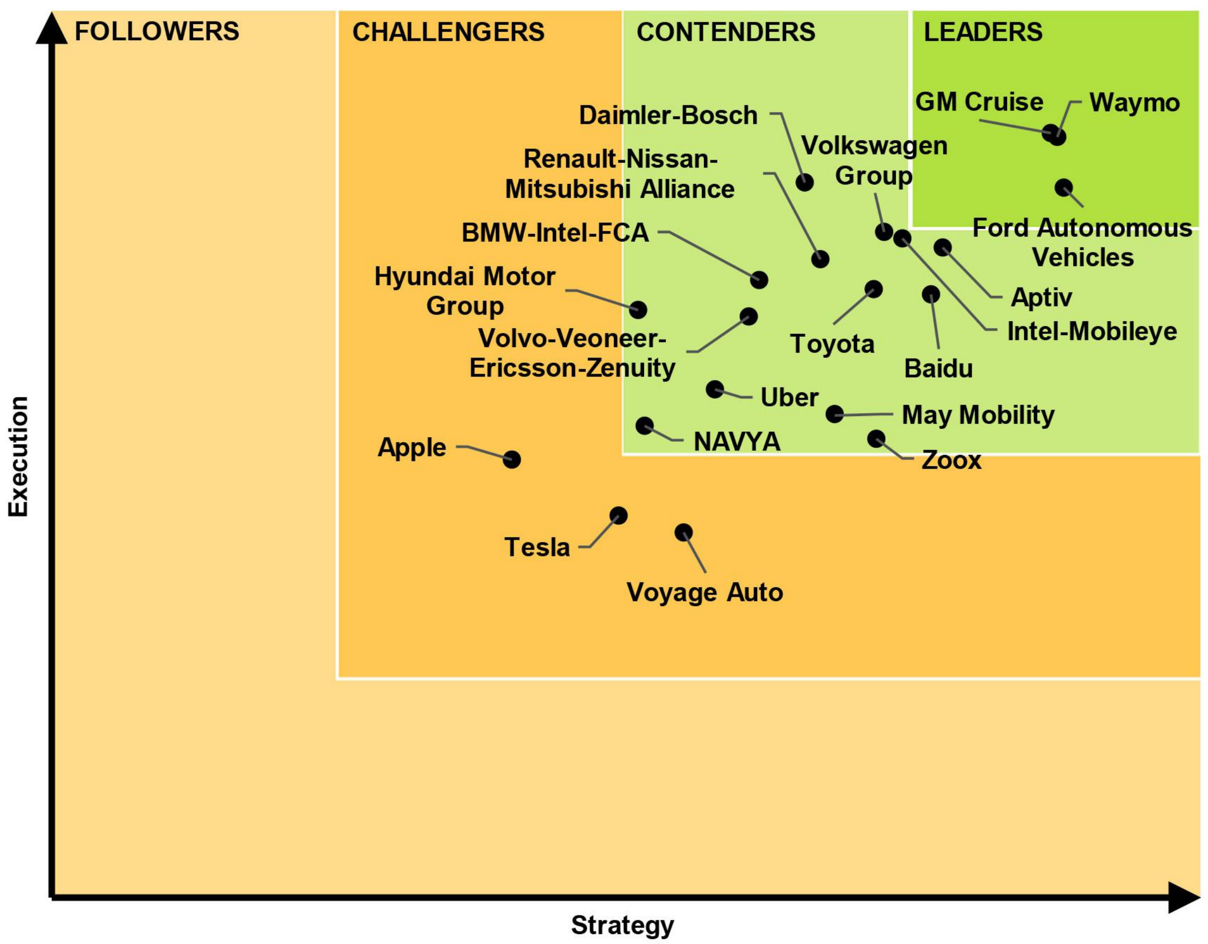
(Source: Guidehouse Insights)

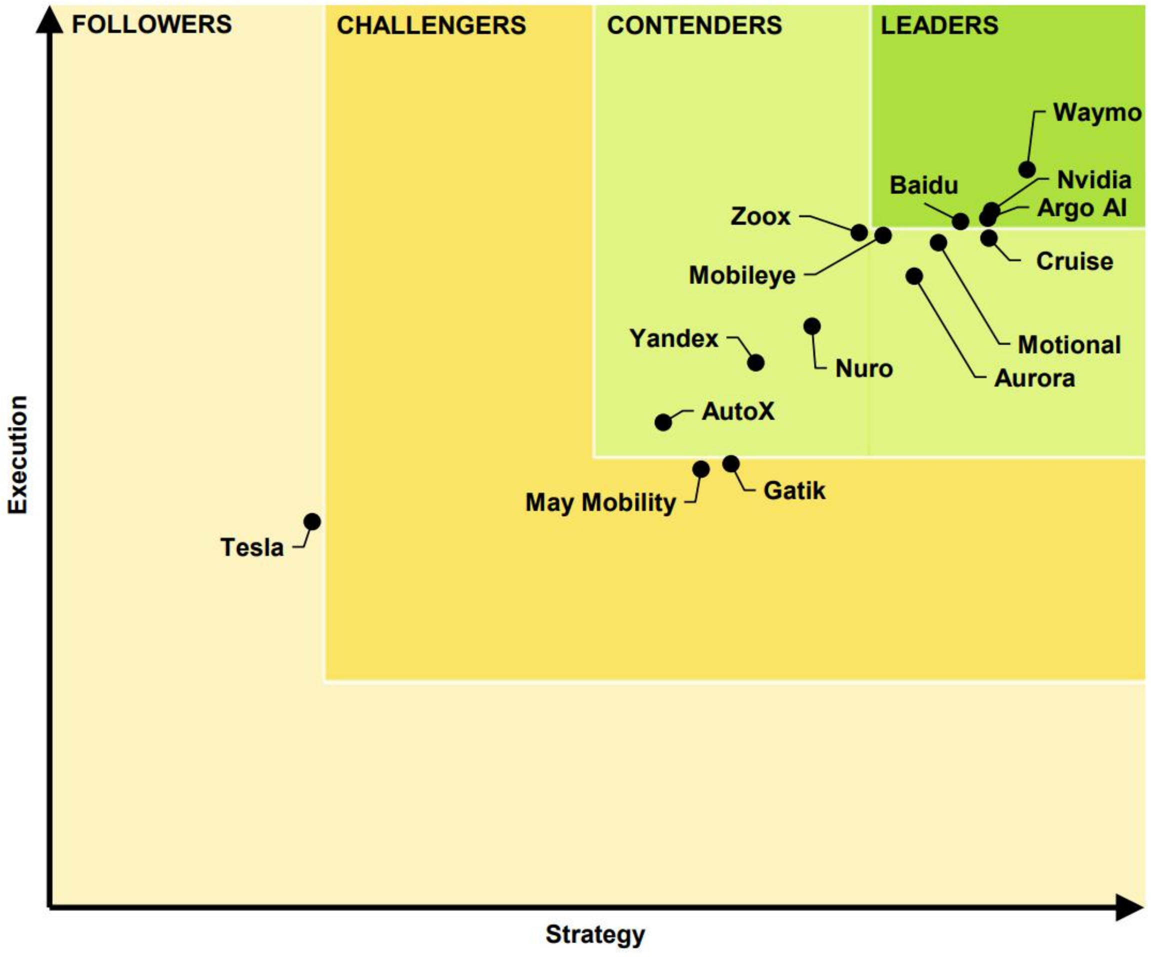
Chart 1-1 shows the ranking of each company. This year, four companies had scores that earned a place in the Leaders group: Waymo, Nvidia, Argo AI, and Baidu. Several others, including Cruise, Motional, Mobileye, Zoox, and Aurora, fell just outside of this group among the eight companies in the Contenders group. Notably, Tesla continues to rank at the bottom of this list despite getting significant press attention for its full self-driving (FSD) beta software release. Although several of the companies ranked this year have close affiliations with automakers, Tesla is the only automaker on the list and has made marketing FSD a key feature in selling vehicles. Tesla has made significant progress in strengthening several areas including staying power thanks to the runup in its stock price in the second half of 2020, but its technology is still lacking.

Guidehouse Insights Leaderboard report. *Guidehouseinsights* [online]. [cit. 2022-02-25]. Dostupné z: https://guidehouseinsights.com/reports/guidehouse-insights-leaderboard-automated-driving-systems

Company Scores (2019 vs 2020)

The Navigant Research Leaderboard Grid





(Source: Guidehouse Insights)

Automated Driving Leaderboard. *Sae* [online]. [cit. 2020-01-25]. Dostupné z: https://www.sae.org/news/2019/03/2019-navigant-autonomous-leaderboard

Guidehouse Insights Leaderboard report. *Guidehouseinsights* [online]. [cit. 2022-02-25]. Dostupné z: https://guidehouseinsights.com/reports/guidehouse-insights-leaderboard-automated-driving-systems

Identifying the Waymo Fully Self-Driving Vehicle

The Waymo fully self-driving Chrysler Pacifica Hybrid minivans can be easily identified by the white color with Waymo logos, roof assembly, front fender additions, or rear roof additions below.

During driverless testing and operation, Waymo's vehicles are fully self-driving at all times, and will not have any person in the driver's seat either steering or otherwise controlling the vehicle.

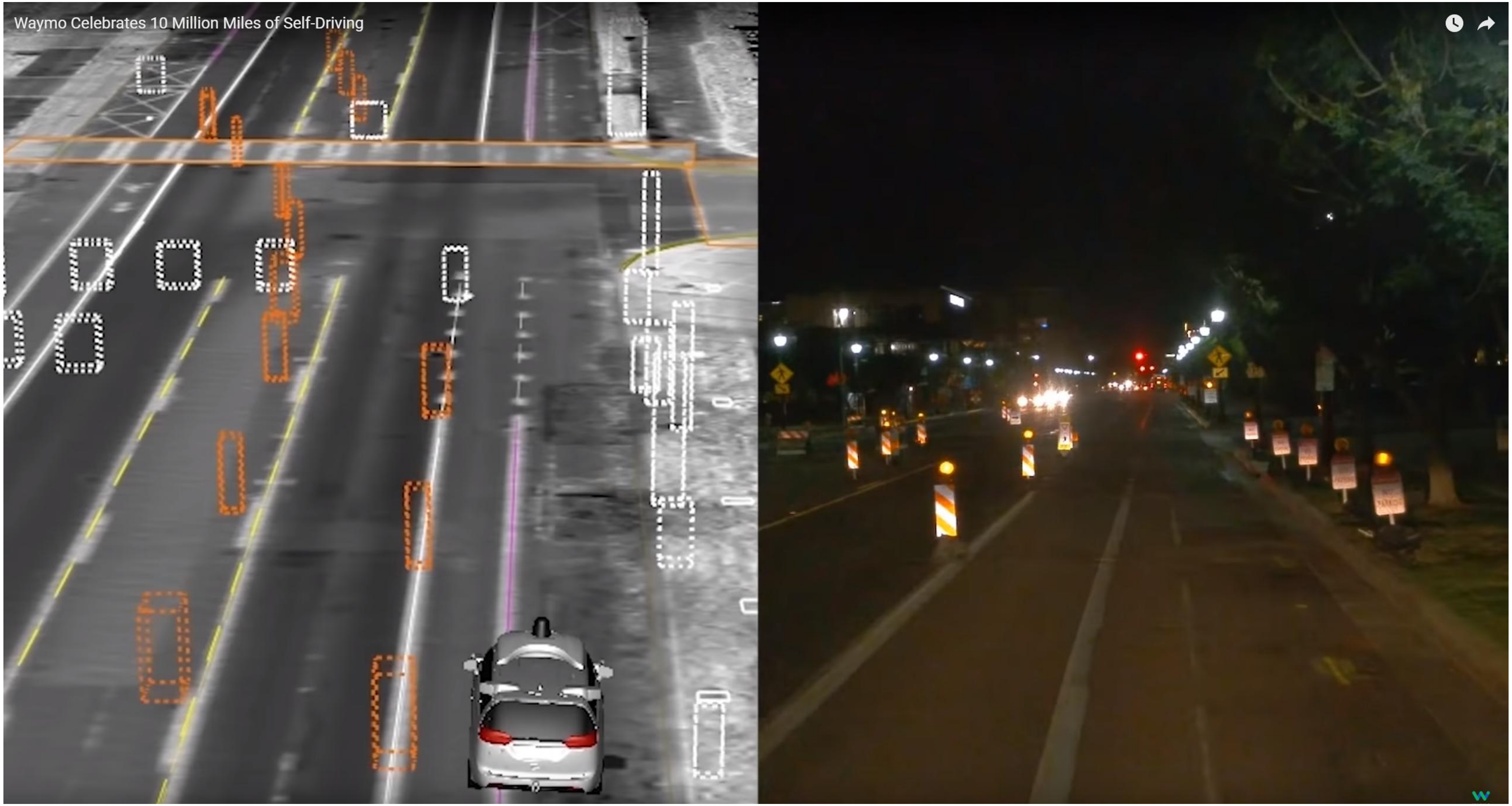
Waymo Fully Self-Driving. *Thedrive* [online]. [cit. 2022-02-25]. Dostupné z: https://s3.amazonaws.com/the-drive-staging/message-editor%2F1540065806515-waymo1.jpg

Waymo Fully Self-Driving. *Thedrive* [online]. [cit. 2020-01-25]. Dostupné z: https://guidehouseinsights.com/reports/guidehouse-insights-leaderboard-automated-driving-systems

https://waymo.com

https://www.youtube.com/watch?v=DJlcdH6iuAk

https://www.youtube.com/watch?v=O8TSA-X9UlU

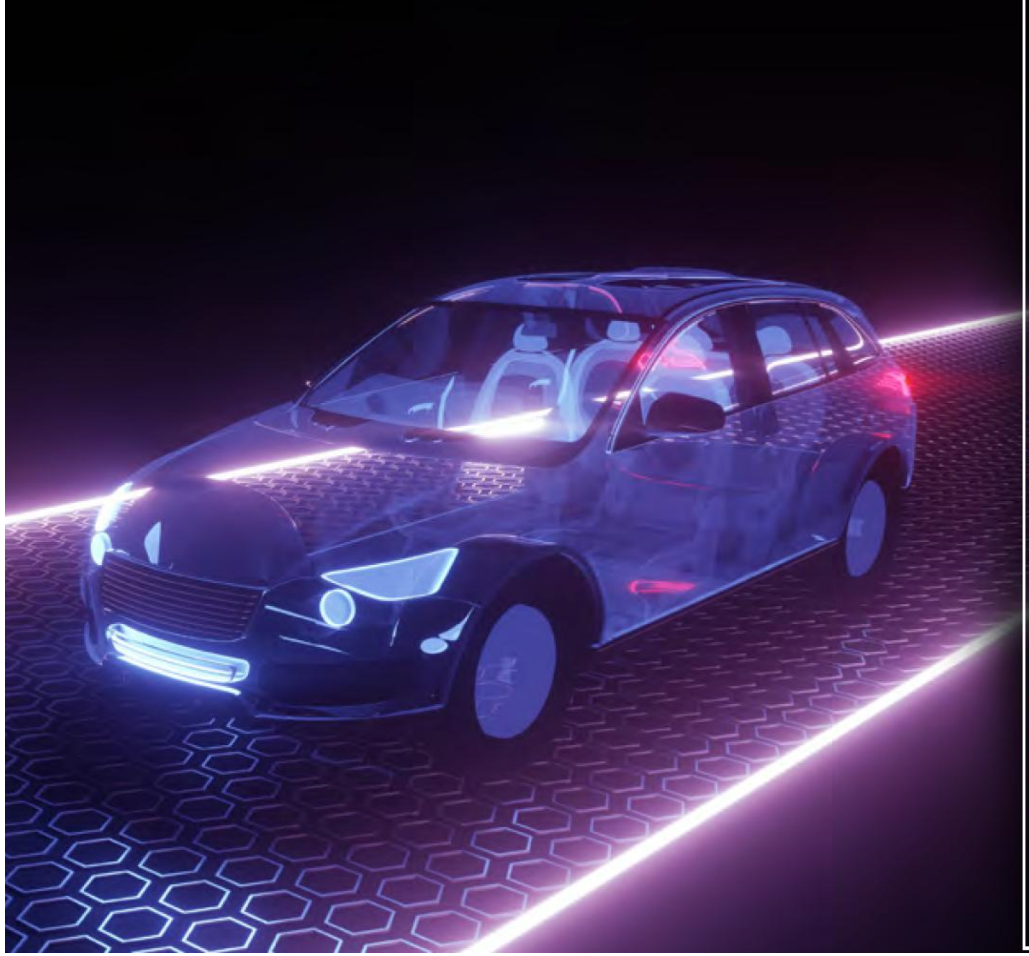


Waymo Celebrates 10 Million Miles of Autonomous Driving [online]. [cit. 2020-01-25]. Dostupné z: https://www.youtube.com/watch?v=ROAwXEqDk7k&t=32s

Full Self-Driving: Tesla [online]. [cit. 2020-01-25]. Dostupné z: https://www.youtube.com/watch?time_continue=1&v=tlThdr3O5Qo

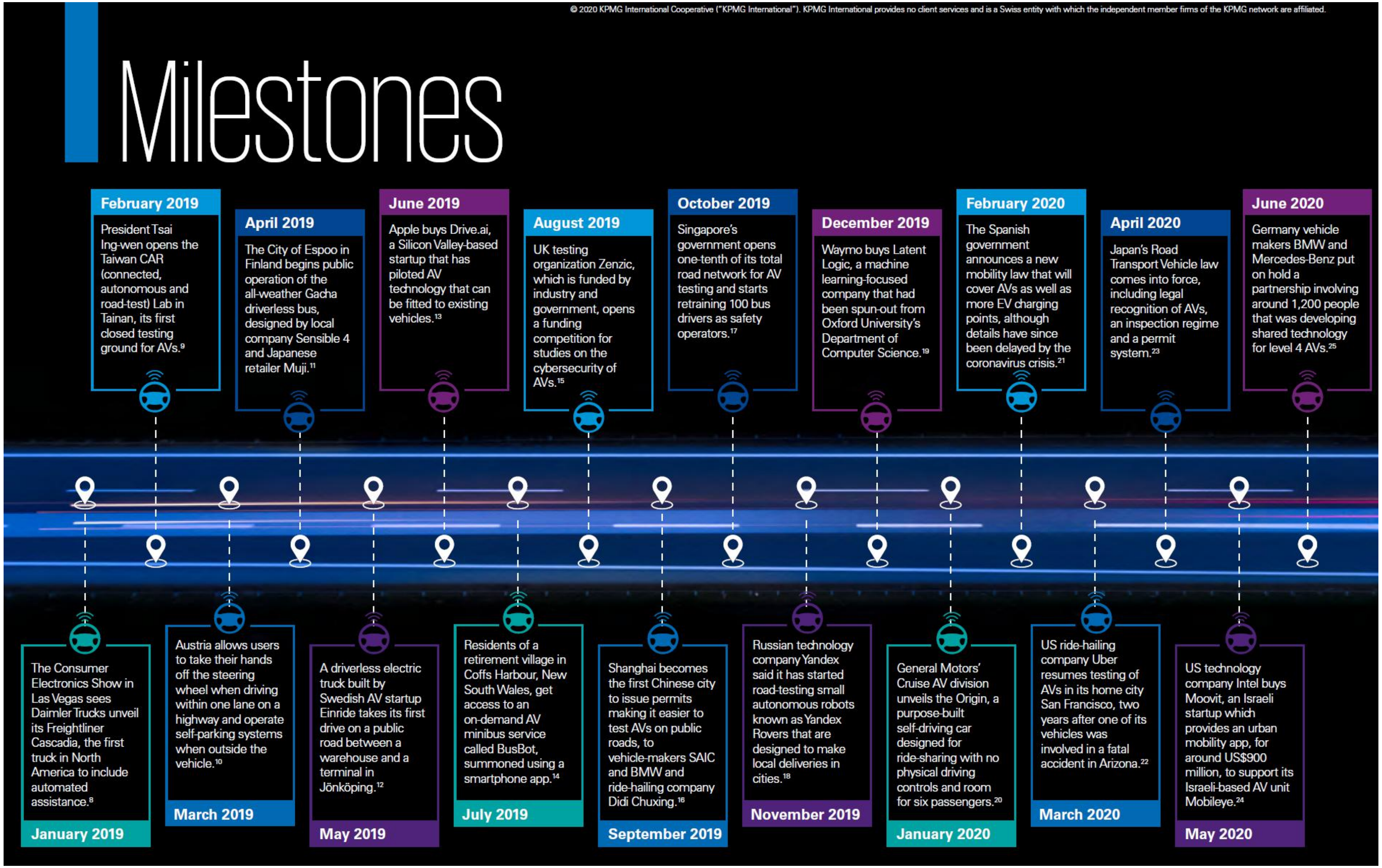
The Autonomous Vehicles Readiness Index

Index results



Country or jurisdiction	Rank 2020	Rank 2019	2020 score
Singapore	1	2	25.45
The Netherlands	2	1	25.22
Norway	3	3	24.25
United States	4	4	23.99
Finland	5	6	23.58
Sweden	6	5	23.17
South Korea	7	13	22.71
United Arab Emirates	8	9	22.23
United Kingdom	9	7	21.36
Denmark	10	n/a	21.21
Japan	11	10	20.88
Canada	12	12	20.68
Taiwan	13	n/a	19.97
Germany	14	8	19.88
Australia	15	15	19.70
Israel	16	14	19.40
New Zealand	17	11	19.19
Austria	18	16	19.16
France	19	17	18.59
China	20	20	16.42
Belgium	21	n/a	16.23
Spain	22	18	16.15
Czech Republic	23	19	13.99
Italy	24	n/a	12.70
Hungary	25	21	11.66
Russia	26	22	11.45
Chile	27	n/a	11.28
Mexico	28	23	7.42
India	29	24	6.95
Brazil	30	25	5.49

Autonomous Vehicles Readiness Index: AVRI [online]. [cit. 2020-01-25]. Dostupné z: https://home.kpmg/xx/en/home/insights/2020/06/autonomous-vehicles-readiness-index.html



Autonomous Vehicles Readiness Index: AVRI [online]. [cit. 2020-01-25]. Dostupné z: https://home.kpmg/xx/en/home/insights/2020/06/autonomous-vehicles-readiness-index.html

https://www.daimlertruck.com/innovation/safe-automated/autonomous-driving-daimler-trucks.html

Autonomous Vehicles Readiness Index: AVRI [online]. [cit. 2020-01-25]. Dostupné z: https://home.kpmg/xx/en/home/insights/2020/06/autonomous-vehicles-readiness-index.html

https://en.wikipedia.org/wiki/Einride
Autonomous Vehicles Readiness Index: AVRI [online]. [cit. 2020-01-25]. Dostupné z: https://home.kpmg/xx/en/home/insights/2020/06/autonomous-vehicles-readiness-index.html

https://www.youtube.com/c/Einride

Autonomous Vehicles Readiness Index: AVRI [online]. [cit. 2020-01-25]. Dostupné z: https://home.kpmg/xx/en/home/insights/2020/06/autonomous-vehicles-readiness-index.html

https://www.youtube.com/watch?v=Vf44Pw3BqUI

Autonomous Vehicles Readiness Index: AVRI [online]. [cit. 2020-01-25]. Dostupné z: https://home.kpmg/xx/en/home/insights/2020/06/autonomous-vehicles-readiness-index.html

Executive summary

Methodology

The 2020 edition of the AVRI assesses 30 countries and jurisdictions. This includes the addition of five new countries and jurisdictions to the roster from 2019, and can explain some of the downward movement of some countries as a result. The AVRI uses 28 different measures, organized into four pillars: policy and legislation, technology and innovation, infrastructure and consumer acceptance. Four of the variables are scored for this index by KPMG International and ESI ThoughtLab and 24 draw on existing research by KPMG International and other organizations. Full details are in the Appendix.

P. 12 Singapore (1st)

- For the first time Singapore leads the AVRI, overtaking the Netherlands for the top-ranked position and leading on both the consumer acceptance and policy and legislation pillars.
- The city-state has expanded AV testing to cover all public roads in western Singapore and aims to serve three areas with driverless buses from 2022.
- The number of charging points will increase from 1,600 to 28,000 by 2030 with incentives for buying EVs, although the government is also phasing in a usage tax to compensate for loss of fuel excise duties. Given they will be mostly electric, such moves are vital in enabling AV implementation.

P. 13 The Netherlands (2nd)

- The Netherlands retains top ranking on the infrastructure pillar, leading on EV charging stations per capita and second only to Singapore on road quality.
- An extensive series of pilots means that 81 percent of people live near AV testing sites. However, tests on truck platooning in July 2019 found challenges in keeping vehicles connected at all times.
- 2019 saw the Netherlands extending its use of smart road furniture, including traffic lights that send their statuses wirelessly to AVs in 60 new areas of the country.

P. 14 Norway (3rd)

- Norway extended its use of AVs in 2019, with several bus routes in Oslo now driverless, and the speed limit for driverless vehicles on roads increasing from 16kph to 20kph.
- A majority of passenger vehicles bought in Norway in 2019 were battery or plug-in hybrids, as a result of high taxes on internal combustion vehicles and fuels and subsidies for EVs.
- The country is testing AVs in extreme weather, with pilots of driverless trucks, cars and buses on the snow-bound Svalbard islands in the Arctic Circle.

Autonomous Vehicles Readiness Index: AVRI [online]. [cit. 2020-01-25]. Dostupné z: https://home.kpmg/xx/en/home/insights/2020/06/autonomous-vehicles-readiness-index.html

Also noted

— South Korea climbs six places to 7th in this edition of the AVRI, the biggest rise of any country. The government published a national strategy for AVs in October 2019, with the goal of reducing road deaths by three-quarters.

— The UK leads on a new AVRI measure of cybersecurity, with AV testing body Zenzic funding seven projects in this field.

— Israel retains its leadership of the technology pillar, leading on both AV-related companies and investments scaled by population.

New to AVRI

— Denmark is the highest-rated of the five countries and jurisdictions joining this edition of the AVRI, occupying the 10th spot. It allows AV tests on any public road and its first driverless bus service started running in March 2020 in Aalborg.

— Taiwan, the second highest at 13th, has a focus on testing AVs on its challenging mixed-use roads. Taipei is planning to start a night-time trial of driverless buses partly to tackle a shortage of drivers.

— Belgium, entering at 21st, ran its first demonstration of an AV bus at Brussels airport in May 2019, operated by Flemish regional transport authority De Lijn.

— Italy, placed 24th, introduced rules and an observatory for AV testing in 2018, with tests beginning in Parma and Turin in 2019.

— Chile, at 27th, has made use of AVs in mining for several years and in January 2020 started Latin America's first public pilot in a park in central Santiago.

P. 15 United States

— The US is second only to Israel on technology and innovation, with 420 AV company headquarters, 44 percent of all of those tracked in this research.

— American technology companies, including Apple and Google's Waymo unit, and vehicle makers such as General Motors and Ford, continue to dominate AV development. GM's Cruise division unveiled the Origin, a purpose-built self-driving car designed for ride-sharing.

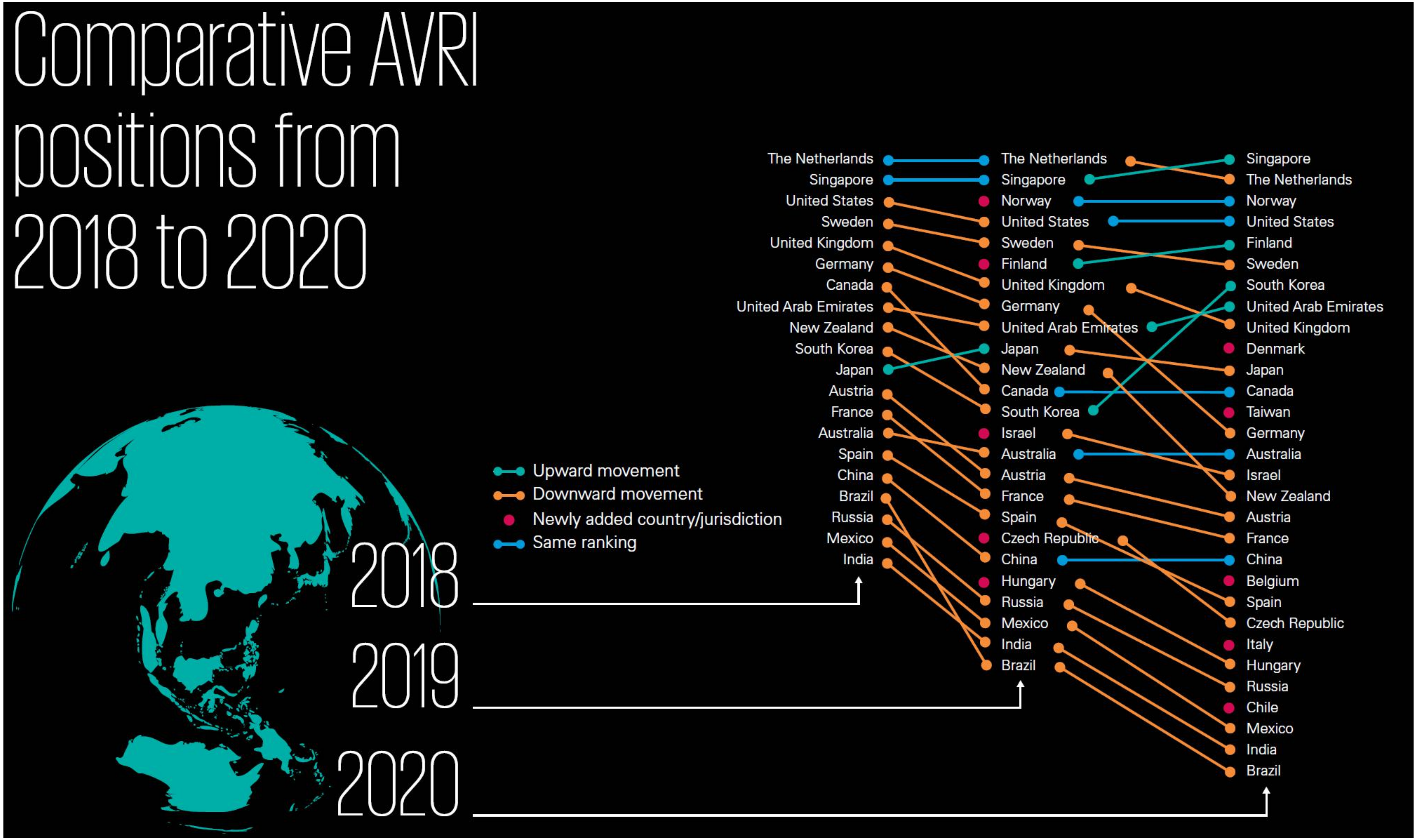
— Cities including Detroit and Pittsburgh are undertaking innovative work to introduce and promote AVs (both are profiled in the Cities to watch section).

P. 16 Finland

— Finland has the highest ratings for AV-specific regulations and for the efficiency of its legal system in challenging regulations, and its entire road network is open for AV trials.

— Helsinki (profiled in Cities to watch) and its neighbor Espoo both run public AV bus services, with the latter using an all-weather vehicle designed by local company Sensible 4.

— Finland also leads on measures of digital skills, benefiting from a breadth of talented engineers, many of whom have notable experience having been part of Nokia's legacy. It also makes the greatest use of ride-hailing services.



Autonomous Vehicles Readiness Index: AVRI [online]. [cit. 2020-01-25]. Dostupné z: https://home.kpmg/xx/en/home/insights/2020/06/autonomous-vehicles-readiness-index.html

23 | Czech Republic

22	25	24	22
Policy and legislation	Technology and innovation	Infrastructure	Consumer acceptance

The Czech Republic is one of the five countries receiving the top rating for government-funded AV pilots, and testing is the country's main area of strength. 2020 should see construction start on German vehicle maker BMW's EUR300 million (US$340 million) AV test site at Sokolov, around 300km (190 miles) from the company's main development site in Munich. BMW plans to open the site, which will have around 100km of road allowing tests of city, highway and rural roads, in the second half of 2022. It will create around 700 jobs and has established a cooperation agreement with the University of West Bohemia.[103]

The country has several other test facilities under development. Czech investment group Accolade is planning to build on a site near Stříbro, which is similarly near the German border, to be used by companies developing AV technologies. It plans to open in 2022 at a cost of EUR180 million (US$200 million), which will also offer a range of road environments including European cities that do not use right-angled grids of roads.[104] Czech-based vehicle maker Skoda, part of Germany's Volkswagen, is working on a site while German safety company TÜV and French vehicle part maker Valeo Group are both looking to convert disused airfields.

"Our strength is that the automotive industry is already here," says Pavel Kliment, Partner, KPMG in the Czech Republic, with the country making vehicles for a number of companies. "That's why there is the focus on test sites." There is less research and development work, although there are good examples, such as German vehicle maker Porsche, another Volkswagen unit, and Italian parts maker Marelli have research partnerships with the Czech Technical University in Prague.[105]

Aside from testing, Kliment says that the Czech Republic lacks a legal framework for the use of AVs. The technology attracts attention when there is a significant announcement, such as when BMW detailed its test site plans in January 2020. "There are a lot of positive things happening, but it's not a strategic issue," he says. "I expect the importance will gradually grow over time, particularly when the test sites are completed."

Government-funded AV pilots

Top performing countries and jurisdictions

- Canada
- Czech Republic
- Singapore
- South Korea
- Taiwan

Source: KPMG International (2020)

> "Our strength is that the automotive industry is already here. That's why there is the focus on test sites."

Pavel Kliment
Partner
KPMG in the Czech Republic

The Autonomous Vehicles Readiness Index

- Policy and legislation
- Technology and innovation
- Infrastructure
- Consumer acceptance

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Policy and legislation pillar scores breakdown by variable

	Position	AV Regulations	Government-funded AV Pilots	AV-focused agency	Future orientation of government	Efficiency of legal system in challenging regulations	Government readiness for change	Data-sharing environment	Pillar 1 score (unadjusted)
1	**Singapore**	1.000	1.000	1.000	1.000	0.673	1.000	0.411	**6.084**
2	**United Kingdom**	0.929	0.857	0.857	0.534	0.668	0.780	1.000	**5.626**
3	**The Netherlands**	1.000	0.929	0.714	0.639	0.825	0.780	0.688	**5.576**
4	**Finland**	1.000	0.857	0.714	0.718	1.000	0.780	0.451	**5.521**
5	**New Zealand**	0.929	0.714	0.929	0.573	0.792	0.829	0.743	**5.509**
6	**United States**	0.857	0.929	0.714	0.763	0.792	0.634	0.771	**5.461**
7	**Germany**	0.786	0.857	0.857	0.604	0.747	0.829	0.621	**5.301**
8	**United Arab Emirates**	0.857	0.714	0.929	0.880	0.865	0.951	0.081	**5.278**
9	**Canada**	0.786	1.000	0.714	0.502	0.614	0.756	0.870	**5.242**
10	**Norway**	0.929	0.857	0.643	0.575	0.629	0.854	0.674	**5.161**
11	**Austria**	0.857	0.857	0.929	0.502	0.568	0.610	0.629	**4.952**
12	**Denmark**	0.714	0.643	0.857	0.589	0.666	0.829	0.633	**4.931**
13	**Taiwan**	0.857	1.000	0.786	0.334	0.425	0.659	0.860	**4.920**
14	**France**	0.786	0.857	0.714	0.481	0.615	0.585	0.815	**4.854**
15	**Sweden**	0.714	0.714	0.714	0.564	0.624	0.878	0.625	**4.834**
16	**South Korea**	0.857	1.000	0.857	0.488	0.346	0.463	0.766	**4.777**
17	**Australia**	1.000	0.571	0.714	0.409	0.516	0.707	0.765	**4.683**
18	**Japan**	0.571	0.857	0.571	0.505	0.642	0.659	0.691	**4.496**
19	**Israel**	0.714	0.786	0.643	0.532	0.603	0.488	0.331	**4.097**
20	**Belgium**	0.929	0.714	0.714	0.271	0.565	0.512	0.319	**4.024**
21	**China**	0.786	0.929	0.643	0.490	0.535	0.561	0.000	**3.944**
22	**Czech Republic**	0.857	1.000	0.714	0.186	0.222	0.512	0.309	**3.800**
23	**Spain**	0.857	0.571	0.714	0.163	0.322	0.317	0.668	**3.614**
24	**Chile**	0.429	0.571	0.429	0.435	0.435	0.439	0.346	**3.083**
25	**Hungary**	0.643	0.857	1.000	0.266	0.000	0.244	0.046	**3.056**
26	**Russia**	0.571	0.286	0.857	0.367	0.240	0.293	0.360	**2.973**
27	**Italy**	0.857	0.643	0.643	0.000	0.056	0.293	0.452	**2.943**
28	**India**	0.000	0.000	0.000	0.536	0.514	0.341	0.288	**1.679**
29	**Mexico**	0.143	0.143	0.143	0.168	0.194	0.098	0.670	**1.557**
30	**Brazil**	0.286	0.143	0.143	0.011	0.119	0.000	0.488	**1.190**

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Technology and innovation pillar scores breakdown by variable

	Position	Industry partnerships	AV technology firm headquarters	AV-related patents	Industry investments in AV	Availability of the latest technologies	Innovation capability	Cybersecurity	Assessment of cloud computing, AI and IoT	Market share of electric cars	Pillar 2 score (unadjusted)
1	**Israel**	0.750	1.000	0.052	1.000	0.946	0.716	0.679	0.551	0.029	**5.722**
2	**United States**	1.000	0.122	0.298	0.370	0.931	0.939	0.989	1.000	0.033	**5.681**
3	**Japan**	0.917	0.022	1.000	0.055	0.843	0.808	0.889	0.707	0.017	**5.258**
4	**Germany**	1.000	0.078	0.849	0.124	0.751	1.000	0.822	0.574	0.052	**5.250**
5	**Norway**	0.917	0.053	0.012	0.000	0.971	0.576	0.915	0.764	1.000	**5.209**
6	**Sweden**	0.833	0.203	0.352	0.051	0.937	0.826	0.737	0.805	0.201	**4.946**
7	**South Korea**	1.000	0.026	0.856	0.023	0.633	0.826	0.874	0.551	0.043	**4.832**
8	**Finland**	0.833	0.171	0.017	0.035	1.000	0.752	0.837	0.705	0.123	**4.475**
9	**United Kingdom**	0.833	0.104	0.113	0.011	0.855	0.806	1.000	0.676	0.057	**4.456**
10	**The Netherlands**	0.667	0.066	0.032	0.103	0.907	0.763	0.900	0.701	0.265	**4.403**
11	**Singapore**	0.833	0.133	0.020	0.004	0.771	0.738	0.928	0.717	0.085	**4.230**
12	**France**	0.833	0.043	0.116	0.029	0.735	0.783	0.972	0.567	0.049	**4.127**
13	**Canada**	1.000	0.085	0.012	0.073	0.782	0.711	0.915	0.488	0.047	**4.114**
14	**Taiwan**	0.833	0.007	0.094	0.000	0.551	0.851	0.856	0.736	0.018	**3.946**
15	**Denmark**	0.667	0.015	0.011	0.000	0.740	0.761	0.829	0.800	0.074	**3.896**
16	**Austria**	0.667	0.087	0.036	0.044	0.685	0.722	0.772	0.450	0.065	**3.527**
17	**Australia**	0.500	0.034	0.045	0.007	0.576	0.609	0.911	0.545	0.020	**3.248**
18	**Belgium**	0.417	0.032	0.007	0.001	0.808	0.652	0.746	0.521	0.057	**3.242**
19	**New Zealand**	0.667	0.019	0.010	0.000	0.743	0.409	0.692	0.567	0.048	**3.155**
20	**China**	1.000	0.002	0.045	0.014	0.023	0.503	0.777	0.446	0.103	**2.913**
21	**Italy**	0.833	0.008	0.012	0.000	0.330	0.519	0.796	0.360	0.016	**2.875**
22	**United Arab Emirates**	0.833	0.008	0.000	0.005	0.787	0.221	0.731	0.193	0.085	**2.864**
23	**Spain**	0.500	0.015	0.013	0.000	0.462	0.492	0.924	0.338	0.025	**2.769**
24	**Hungary**	0.667	0.037	0.006	0.026	0.371	0.111	0.742	0.103	0.033	**2.095**
25	**Czech Republic**	0.583	0.007	0.008	0.000	0.543	0.325	0.215	0.335	0.009	**2.025**
26	**Russia**	0.333	0.004	0.007	0.001	0.000	0.235	0.794	0.058	0.001	**1.432**
27	**Chile**	0.333	0.004	0.001	0.000	0.554	0.000	0.000	0.190	0.001	**1.084**
28	**India**	0.167	0.001	0.001	0.000	0.122	0.190	0.540	0.000	0.000	**1.020**
29	**Mexico**	0.000	0.000	0.001	0.000	0.269	0.025	0.345	0.122	0.001	**0.763**
30	**Brazil**	0.167	0.001	0.001	0.000	0.046	0.144	0.232	0.144	0.001	**0.736**

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Infrastructure pillar scores breakdown by variable

	Position	EV charging stations	4G coverage	Quality of roads	Technology infrastructure change readiness	Mobile connection speed (0.5 weight)	Broadband (0.5 weight)	Pillar 3 score (unadjusted)
1	**The Netherlands**	1.000	0.832	0.993	0.622	0.755	0.792	**4.221**
2	**South Korea**	0.060	1.000	0.838	0.689	0.959	0.917	**3.525**
3	**Norway**	0.808	0.929	0.448	0.467	0.728	0.958	**3.495**
4	**United Arab Emirates**	0.010	0.636	0.869	1.000	1.000	0.833	**3.431**
5	**Singapore**	0.095	0.739	1.000	0.756	0.578	1.000	**3.379**
6	**Japan**	0.078	0.957	0.894	0.689	0.272	0.958	**3.233**
7	**Austria**	0.166	0.611	0.871	0.844	0.498	0.708	**3.095**
8	**Sweden**	0.290	0.771	0.669	0.578	0.473	0.958	**3.023**
9	**United States**	0.070	0.839	0.714	0.600	0.393	0.917	**2.878**
10	**Denmark**	0.158	0.682	0.744	0.556	0.491	0.875	**2.823**
11	**Finland**	0.068	0.714	0.653	0.644	0.483	0.833	**2.738**
12	**Australia**	0.010	0.743	0.557	0.578	0.693	1.000	**2.735**
13	**Canada**	0.074	0.689	0.587	0.378	0.788	0.917	**2.580**
14	**Taiwan**	0.024	0.588	0.754	0.533	0.453	0.865	**2.558**
15	**Spain**	0.062	0.639	0.782	0.533	0.327	0.750	**2.555**
16	**United Kingdom**	0.141	0.543	0.538	0.689	0.313	0.750	**2.442**
17	**France**	0.150	0.364	0.704	0.533	0.467	0.792	**2.381**
18	**Belgium**	0.192	0.746	0.399	0.333	0.516	0.708	**2.283**
19	**Germany**	0.165	0.264	0.666	0.600	0.328	0.667	**2.192**
20	**New Zealand**	0.021	0.250	0.420	0.711	0.522	0.917	**2.121**
21	**Hungary**	0.023	0.782	0.293	0.333	0.433	0.542	**1.919**
22	**China**	0.079	0.581	0.456	0.267	0.751	0.250	**1.884**
23	**Italy**	0.024	0.339	0.406	0.622	0.318	0.625	**1.863**
24	**Czech Republic**	0.033	0.754	0.261	0.289	0.496	0.542	**1.856**
25	**Israel**	0.108	0.000	0.537	0.578	0.146	0.833	**1.712**
26	**Chile**	0.002	0.257	0.638	0.422	0.117	0.542	**1.648**
27	**Russia**	0.001	0.157	0.136	0.622	0.117	0.625	**1.287**
28	**Mexico**	0.007	0.368	0.434	0.200	0.218	0.333	**1.284**
29	**India**	0.000	0.764	0.437	0.000	0.000	0.000	**1.202**
30	**Brazil**	0.001	0.089	0.000	0.311	0.171	0.417	**0.695**

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Consumer acceptance pillar scores breakdown by variable

	Position	Population living near test areas	Civil society technology use	Consumer ICT adoption	Digital skills	Individual readiness	Online ride-hailing market penetration	Pillar 4 score (unadjusted)
1	Singapore	1.000	0.514	0.906	0.910	0.715	0.828	**4.873**
2	Finland	0.364	0.886	0.796	1.000	0.673	1.000	**4.718**
3	Sweden	0.353	1.000	0.918	0.941	0.641	0.524	**4.377**
4	United Arab Emirates	0.210	0.543	0.985	0.814	1.000	0.719	**4.271**
5	Norway	0.342	0.857	0.840	0.805	0.705	0.528	**4.078**
6	United States	0.324	0.914	0.695	0.818	0.636	0.682	**4.069**
7	The Netherlands	0.811	0.814	0.728	0.926	0.624	0.131	**4.034**
8	Denmark	0.574	0.729	0.843	0.849	0.734	0.199	**3.927**
9	Australia	0.365	0.786	0.684	0.705	0.719	0.412	**3.670**
10	South Korea	0.216	0.514	1.000	0.694	0.690	0.483	**3.597**
11	Israel	0.562	0.643	0.585	0.880	0.472	0.412	**3.553**
12	United Kingdom	0.305	0.714	0.674	0.674	0.541	0.607	**3.515**
13	Canada	0.477	0.729	0.629	0.724	0.444	0.453	**3.457**
14	New Zealand	0.342	0.757	0.751	0.672	0.583	0.315	**3.420**
15	Taiwan	0.465	0.171	0.827	0.748	0.749	0.435	**3.396**
16	China	0.043	0.571	0.764	0.573	0.419	0.993	**3.364**
17	Spain	0.000	0.329	0.759	0.457	0.676	0.539	**2.761**
18	Japan	0.302	0.286	0.891	0.490	0.709	0.000	**2.678**
19	France	0.284	0.386	0.685	0.512	0.407	0.348	**2.622**
20	Russia	0.000	0.329	0.740	0.678	0.394	0.442	**2.583**
21	Germany	0.096	0.529	0.624	0.722	0.483	0.127	**2.581**
22	Czech Republic	0.000	0.500	0.598	0.617	0.364	0.416	**2.494**
23	Belgium	0.000	0.657	0.575	0.635	0.485	0.116	**2.468**
24	Austria	0.000	0.457	0.552	0.617	0.504	0.333	**2.463**
25	Chile	0.000	0.257	0.511	0.429	0.612	0.367	**2.176**
26	Italy	0.125	0.271	0.534	0.396	0.464	0.000	**1.790**
27	Mexico	0.000	0.100	0.377	0.245	0.375	0.464	**1.561**
28	Hungary	0.000	0.114	0.529	0.322	0.221	0.266	**1.451**
29	Brazil	0.104	0.000	0.428	0.000	0.306	0.476	**1.314**
30	India	0.000	0.157	0.000	0.490	0.000	0.427	**1.074**

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Where to go next?

https://pytorch.org/vision/stable/models.html

Docs > Models and pre-trained weights

Object Detection, Instance Segmentation and Person Keypoint Detection

The pre-trained models for detection, instance segmentation and keypoint detection are initialized with the classification models in torchvision. The models expect a list of `Tensor[C, H, W]`. Check the constructor of the models for more information.

WARNING

The detection module is in Beta stage, and backward compatibility is not guaranteed.

Object Detection

The following object detection models are available, with or without pre-trained weights:

- Faster R-CNN
- FCOS
- RetinaNet
- SSD
- SSDlite

Here is an example of how to use the pre-trained object detection models:

Where to go next?

https://pytorch.org/vision/stable/models.html

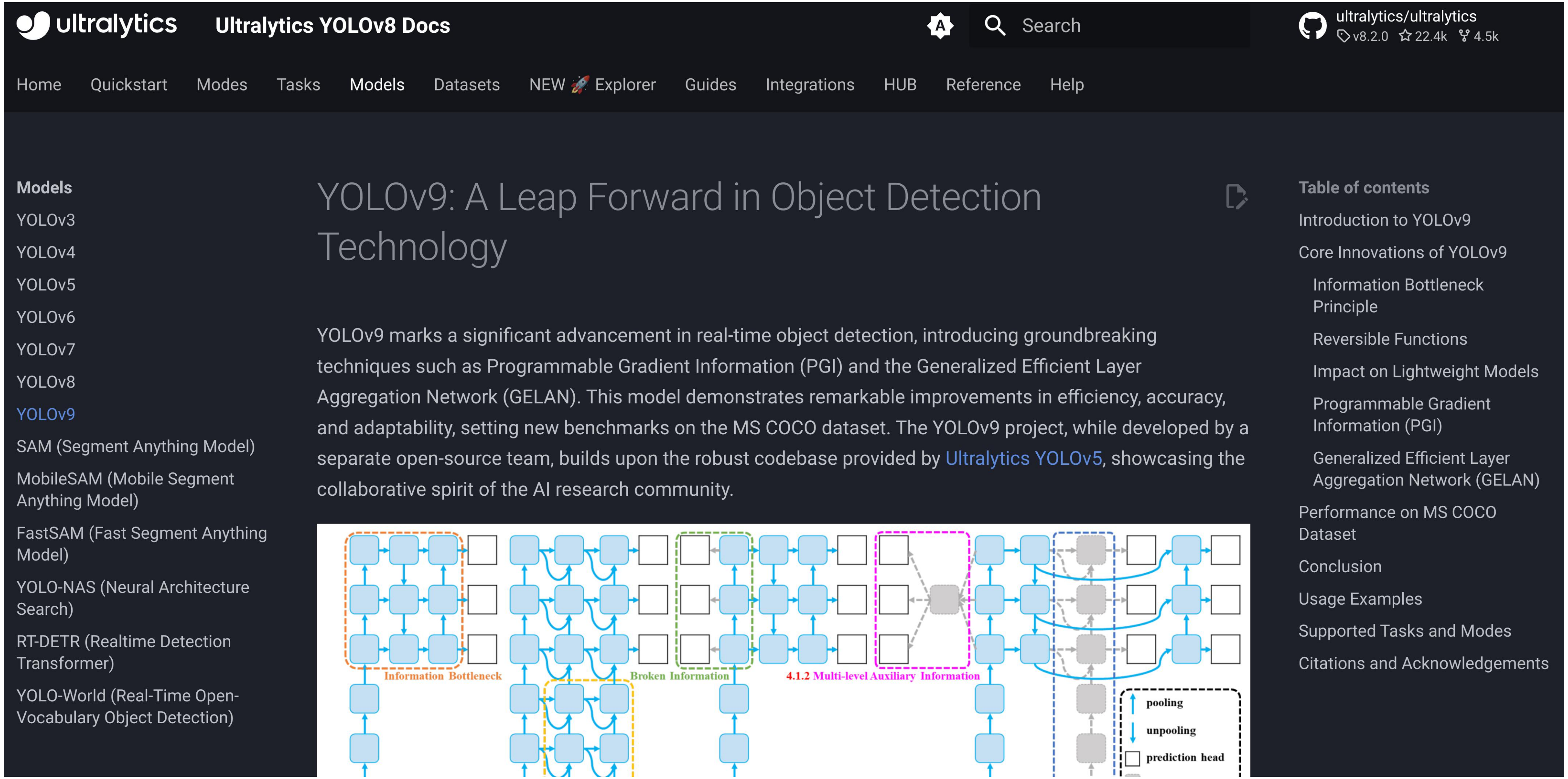
```
from torchvision.io.image import read_image
from torchvision.models.detection import fasterrcnn_resnet50_fpn_v2,
FasterRCNN_ResNet50_FPN_V2_Weights
from torchvision.utils import draw_bounding_boxes
from torchvision.transforms.functional import to_pil_image

img = read_image("test/assets/encode_jpeg/grace_hopper_517x606.jpg")

# Step 1: Initialize model with the best available weights
weights = FasterRCNN_ResNet50_FPN_V2_Weights.DEFAULT
model = fasterrcnn_resnet50_fpn_v2(weights=weights, box_score_thresh=0.9)
model.eval()

# Step 2: Initialize the inference transforms
preprocess = weights.transforms()

# Step 3: Apply inference preprocessing transforms
batch = [preprocess(img)]

# Step 4: Use the model and visualize the prediction
prediction = model(batch)[0]
labels = [weights.meta["categories"][i] for i in prediction["labels"]]
box = draw_bounding_boxes(img, boxes=prediction["boxes"],
                          labels=labels,
                          colors="red",
                          width=4, font_size=30)
im = to_pil_image(box.detach())
im.show()
```

Where to go next?

https://github.com/ultralytics/ultralytics

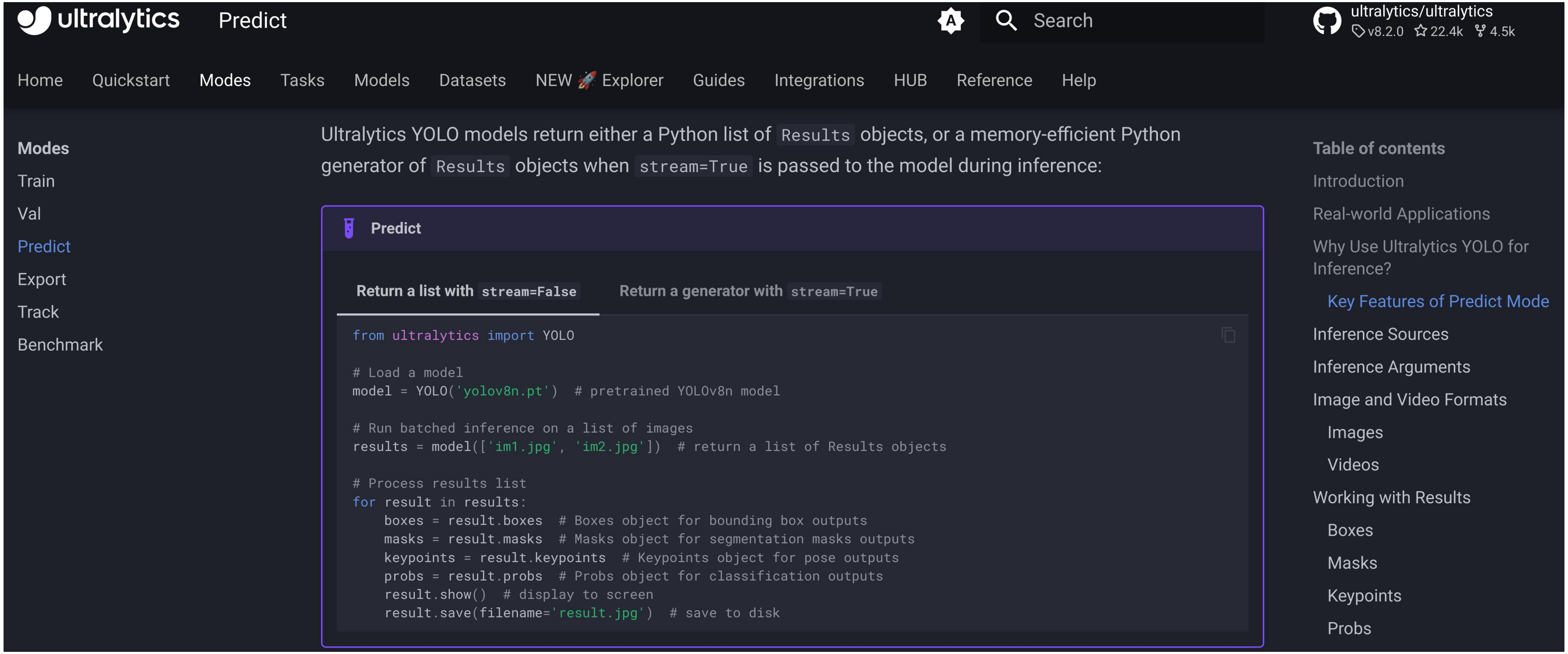
Where to go next?

https://docs.ultralytics.com/models/yolov9/



Where to go next?

https://docs.ultralytics.com/modes/predict/#key-features-of-predict-mode



Where to go next?

follow-up courses

http://mrl.cs.vsb.cz/

mrl

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Education

We are offering these courses at the Department of Computer Science.

- Second year
  - Scripting Programming Languages and their Applications (SPJA)
  - User Interfaces (URO)
- Third year
  - Fundamentals of Computer Graphics (ZPG)
- Fourth year
  - Digital Image Processing (DZO)
  - Computer Graphics I (PG I)
  - Image Analysis I (ANO I)
  - Computer Graphics II (PG II)
- Fifth year
  - Algorithmisation of Geometrical Problems (AGU)
  - Image Analysis II (ANO II)
  - Data Visualization (VD)
  - Multimedia Data Processing (ZMD)
  - Geographic Information Systems (GIS)