

# The long road to autonomous vehicles

April 9 2017, by Mike Freeman, The San Diego Union-Tribune

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Credit: Steffen Thoma/Public Domain

Back in 1995, the NavLab 5 team at Carnegie Mellon University launched an autonomous vehicle on a trip from Pittsburgh to San Diego.

The vehicle navigated itself, without intervention from a human driver, for 98 percent of the 2,800 mile journey. It averaged speeds above 60 mph.

So if self-driving technology worked on a cross-country trip 22 years

ago, why aren't roads filled with autonomous cars today?

The reason is the technology remains closer to the research lab stage and is not ready for prime time, say experts. It's not good enough or affordable enough yet for widespread use.

Sensors must shrink, improve their range, particularly in bad weather, and become less expensive. Mobile networks must eliminate transmission delays so vehicles can communicate instantly - not only with nearby cars but also with the internet cloud to process data.

Costs for very precise, real-time, three-dimensional map technology to guide self-driving cars must come down. Artificial intelligence software must be nimble to handle the unexpected - ranging from predicting behavior of nearby drivers to figuring out when an object in the road is a harmless plastic bag or an undercarriage-crushing rock.

And perhaps most importantly, the driving public needs to come to grips with what it wants from [autonomous vehicles](#), which hold the promise of reducing accidents and fatalities but may not be perfect.

In May 2016, a man died when his Telsa crashed into a big rig while operating in the car maker's self-driving software mode known as Autopilot. U.S. regulators determined that Telsa's software functioned properly in the Florida accident but Autopilot requires full-driver attention at all times.

In March, Uber briefly suspended autonomous car testing after a crash in Arizona, which officials said wasn't the fault of the self-driving [vehicle](#). It occurred when a nearby motorist failed to yield.

"We really expect our autonomous cars to do much better than us, otherwise we are not going to use them," said Gabriel Rebeiz, an

electrical and computer engineering professor at the University of California at San Diego. "That is a very high bar."

These hurdles don't mean that the march toward self-driving cars has stalled. If anything, it's gaining momentum.

Nearly all automakers are working on autonomous vehicles programs. Google and Uber are testing robotic car technologies on the road. Big technology companies including Qualcomm and Intel have targeted automotive technology as a major growth market. It is part of the rationale behind Qualcomm's pending \$38 billion acquisition of automotive chip outfit NXP Semiconductors and Intel's recent \$15 billion buyout of automotive sensor and software outfit Mobileye.

Work on autonomous vehicles has been going on since the early 1980s, said Takeo Kanade, a computer vision professor and winner of the 2016 Kyoto Prize for Advanced Technology, during a recent event in San Diego. The cross-country trip between Pittsburgh and San Diego was a milestone achievement for Robotics Institute at Carnegie Mellon and the advancement of self-driving vehicles.

One advantage to automation is the potential to reduce accidents and save lives. Vehicle crashes kill more than one million people globally each year and injure millions more. Cutting the number of wrecks would bring down medical and insurance costs.

"What happens when a child chases a ball onto the road? As a human you can slam on the brakes and stop car. But machines will react much faster than humans," said Chris Mi, chair of electrical and computer engineering department at San Diego State University.

Coupled with connected smart infrastructure, autonomous vehicles also could traverse highways and streets more efficiently, limiting traffic

jams and reducing carbon emissions.

And [self-driving cars](#) free up time for motorists to do other things on their way to the office, boosting productivity.

To get there, data from on-board cameras, radar and lidar sensors is being fused together to create a picture of what's around the car. Lidar, which can cost \$60,000 or more, works like radar but uses light instead of radio waves.

At International CES in January, Ford demonstrated a pickle-jar sized laser lidar, mounted near the side-view mirror on a prototype self-driving sedan. (Not long ago, lidar systems were the size of a suitcase.) It pinpointed people and objects around the car - creating a very detailed dynamic view of its surroundings.

But it also required a trunk full of powerful computer servers to process the data - which probably isn't practical for real life self-driving vehicles.

High-speed 5G mobile networks could be critical for autonomous vehicles - providing a way to off-load the hefty computer processing demands to the internet cloud.

5G also is expected to reduce transmission delays - known as latency - in wireless networks, paving the way for connected cars to make split second decisions required on the road. 5G networks could roll out as early as 2019.

There are other roadblocks facing autonomous vehicles, such as legal questions of who is responsible if a self-driving car causes an accident. Cybersecurity experts worry about connected cars being hacked and wrecking havoc.

But advocates of autonomous technology believe these barriers eventually will be pushed aside. With today's self-driving prototypes, a driver is obligated to be ready to take control at any moment. But in about a decade, autonomous cars where a human driver's attention is not required could begin showing up on the road.

The arrival of these [autonomous cars](#) might be different than we expect, said consultant Sven Beiker, a former BMW technologist and ex-director of the Center for Automotive Research at Stanford.

"There is lot of work on these automated robo-taxis, where it operates within 20 city blocks - maybe to the airport - but you can't take it to the next city," said Beiker. "So it might not be the Toyota or Chevrolet or Volkswagen that I buy, push a button and it drives me home automatically. Maybe it's I wait for my Uber, and when it arrives there is no driver."

In the meantime, Advanced Driver Assistance Systems will incrementally boost automation and safety in cars. Already, lane monitoring technology in some vehicles will automatically correct drifting. Several automakers offer automatic braking in new models. Adaptive Cruise Control will automatically adjust speed to maintain a safe distance between vehicles. At CES, BMW demonstrated a sedan that parked itself.

"It is going to take time," said Rebeiz, the UCSD professor. "But we have the electronics. We have the know-how. It's just going to take time before we integrate it all together."

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Citation: The long road to autonomous vehicles (2017, April 9) retrieved 27 April 2024 from

<https://phys.org/news/2017-04-road-autonomous-vehicles.html>

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