Driverless vehicles are here

The question is how quickly they become mainstream

Milton Keynes is a UK town about 75 kilometres to the northwest of London where many streets are reserved for pedestrians and bicycles. That made it a suitable place to test driverless cars, one of the great possibilities tied to the rise of artificial intelligence.

In what was declared a successful experiment, 'pods' with radar, lidar (that uses pulses of light to measure distance) and cameras feeding data into a central computer drove two passengers through the town during testing in 2016. The robocar travelled along the digitally pre-mapped two-kilometre route from the railway station to the town centre at a maximum speed of 15 kilometres an hour.[1]

The testing is part of a three-year government-funded program begun in 2015 run by the UKAutodrive consortium of businesses, governments and academics. The trials seek to overcome the technical, safety, legal, insurance and social challenges of using driverless or automated vehicles in cities.[2]

Such testing is happening the world over as driverless driving represents one of the most-touted aspects of artificial intelligence. Almost every developed country including Australia is hosting pilot studies on automated vehicles. The big technology companies such as Alphabet, Apple and Uber and the largest car companies including Ford, Honda, Tesla and Volvo are investing billions of dollars into driverless technology. US-based CB Insights tallies that 44 companies[3] are developing autonomous technology and many of them are road-testing prototypes. The US research company estimates that global investment just in auto-tech start-ups topped US$1 billion in 2016[4] and reached US$1.6 billion in the first six months of 2017, more than double that of a year earlier.[5] Those investing hope to profit from a leap in transportation as significant as the bound from horses to cars was a century ago.

The promise of driverless cars, delivery bots and self-propelled buses and trucks is safer, faster, cheaper and more comfortable travel, especially for the disabled, the elderly and those who never learnt to drive. Robocars are poised to revolutionise travel within cities by promoting car sharing (what's called transport as a service). Driverless proponents push the safety aspects the most because human error causes most of the world's 1.25 million road deaths a year.[6]

The technological advances in automated driving are as impressive as any of the artificial-intelligence revolution. The breakthrough to fully autonomous cars has been made, cars are including more autonomous features, robocars that require human backup are for sale, self-driving taxis (with a safety driver) have picked up passengers and automated driving with no safety driver on public roads has occurred.[7] Boston Consulting Group this year forecast that by 2030 a quarter of all miles driven in the US could be done in shared, self-driving (and electric) vehicles, and by that year more than 4.7 million autonomous vehicles will have displaced five million conventional cars.[8] Research firm IHS Automotive predicts the take-up of driverless cars to accelerate from 2030, such that 21 million robo-vehicles will be sold annually by 2035.[9] (In 2016, for context, about 92 million vehicles were sold worldwide.[10])

But driverless cars are a while away from meeting the expectations of their biggest advocates such as Elon Musk who said this year that by 2019 the technology would allow people to sleep while being driven[11] The largest obstacles to the mass uptake of driverless cars may prove to be challenges away from the technology. These issues include safety, legal and insurance liabilities, cybersecurity risks and making roads suitable. Above all this sits the unanswerable question of whether or not the public will feel safe being propelled at great speed by software. Enough people will surely be willing. Driverless vehicles are coming in some form – the technological advances so far, the amount of money being invested and the greater commercial viability of the technology will ensure a driverless world of some description. It might be years, however, before robo-vehicles appear

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[2] UKAutodrive. http://www.ukautodrive.com/. See frequently asked questions. http://www.ukautodrive.com/frequently-asked-questions/#
[3] To see the full list of companies and what they are doing, go to: CB Insights. "44 corporations working on autonomous vehicles." 18 May 2017. https://www.cbinsights.com/blog/autonomous-driverless-vehicles-corporations-list/
[4] CB Insights. "Auto tech startup financing tops $1 billion in 2016." 12 January 2017. https://www.cbinsights.com/blog/auto-tech-startups-2016-recap/
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[6] World Health Organisation. "Road traffic deaths." The toll is for 2013, the latest year for which it is available. http://www.who.int/gho/road_safety/mortality/en/
[7] Legally blind US citizen Steve Mahan rode solo in a Waymo car in Austin, Texas in 2016. "Google's self-driving car unit became Waymo." 13 December 2013. https://techcrunch.com/2016/12/13/googles-self-driving-car-unit-spins-out-as-waymo/
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[11] TED talk transcript. "Elon Musk on boring company, semi-truck, Mars." 1 May 2017. https://electrek.co/2017/05/01/elon-musk-on-boring-company-semi-truck-mars-ted-talk-transcript/. For another optimistic forecast, see also Recode. "Elon Musk: Self-driving cars are coming sooner than you think." 6 October 2015. https://www.recode.net/2015/10/6/11619270/elon-musk-self-driving-cars-are-coming-sooner-than-you-think

in enough numbers to challenge the road share of the world's 1 billion conventional cars and trucks.[12]

Attaining 'level 5'

The world's first driverless vehicle could well be the one developed in 1977 by Sadayuki Tsugawa and colleagues at Japan's Tsukuba Mechanical Engineering Laboratory. Its novelty was that it could 'process' the road ahead. Others say it was the VaMoRs of 1987 developed by Ernst Dickmanns of West Germany's Bundeswehr University Munich. The vehicle with two cameras, sensors and software drove more than 20 kilometres at 90 kilometres per hour.[13] Another contender is the Navlab produced in 1984 by the Robotics Institute from the Carnegie Mellon University.[14] Whatever the truth of each claim, the point is that efforts to create driverless cars are long-standing, even for the tech giants. Waymo (then Google), for instance, started researching self-driving technology in 2009.[15]

The early robocars would fit on the lowest levels of the global spectrum of automated driving, as would the Milton Keynes pods. The J3016 spectrum has six levels, as defined in 2014 by SAE International, a global association of engineers.[16]

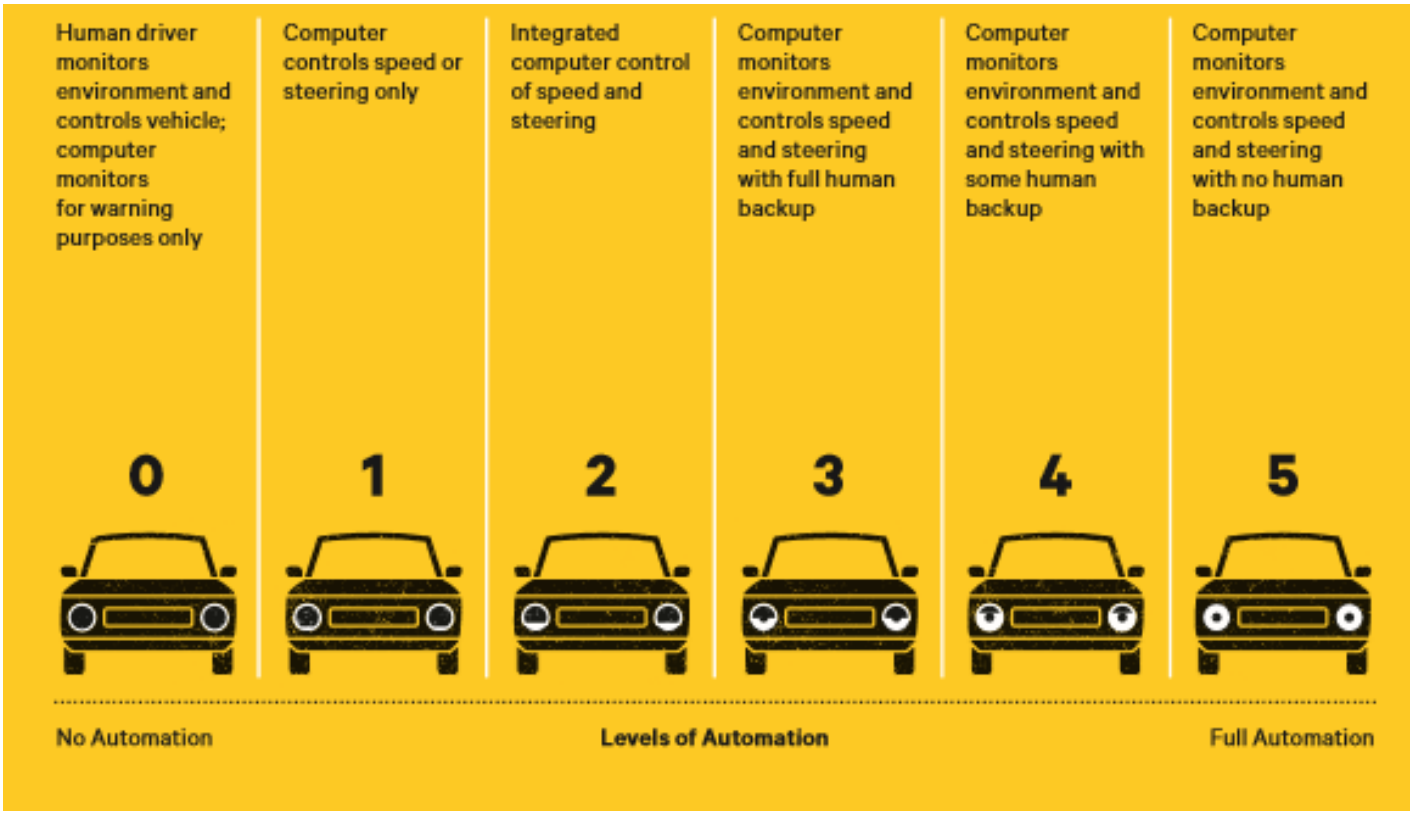
From levels 0 to 2, a human dominates. On level 0, the driver does all. On level 1, a computer controls the speed or the steering of the car. At level 2, the software controls the steering and speed of the car. With levels 3 to 5, software dominates. At level 3, a computer monitors the vicinity to control the speed and steering of the car but full human backup is required. At level 4, the human stand-by is partial. At level 5, no human fall-back is required. The software does all. Vehicles categorised at levels 4 and 5 are considered 'self-driving'. The most advanced driverless car for sale in 2017 is the Audi A8, which registers at level 3.[17]

Interwoven into this spectrum are developments like cruise control and parking assistance (level 1), automatic lane change and merge (level 2), automated cruising (level 3) and automated parking (level 4).

The concept of how driverless cars work is straightforward; they use wireless technology to see the road ahead and move there safely. To enable autonomous vehicles to do that, roads need to be pre-mapped ('geo-fenced'), signage and road markings made more visible and devices that communicate with car technology installed (and maintained) on roads. The digital maps mark the permanent features on roads such as lane markings, kerbs and street signs, and note speed limits and traffic controls.

Having a grasp of the fixed features ahead and confirmation of them from the road-based devices, robocars use global positioning technology, radar, lidar lasers, cameras and laser sensors to cope with fleeting items on the roads such as other vehicles, pushbikes, pedestrians, animals, accidents and roadworks. The central

The spectrum of automated driving



Source: The Aspen Institute. "Taming the autonomous vehicle. A primer for cities." 2017.

[12] The Aspen Institute. "Taming the autonomous vehicle. A primer for cities." March 2017. Page 6 https://www.bbhub.io/dotorg/sites/2/2017/05/TamingtheAutonomousVehicleSpreadsPDFreleaseMay3rev2.pdf

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[17] CAR magazine (of the UK). "How did Audi make the first car with level 3 autonomy?" 12 July 2017. http://www.carmagazine.co.uk/car-news/tech/audi-a3-level-3-autonomy-how-did-they-get-it-to-market/

computer analyses the incoming data to steer, accelerate, brake and signal the intentions of the vehicle, no matter the weather, light conditions and threats.

One test for autonomous-driving software is how far a robocar can travel before a human needs to seize the wheel to avoid an incident. Waymo holds the best safety record. During 960,000 kilometres of testing around California, the safety driver only needed to assume control every 8,000 kilometres or so.[18]

The promise of robocars

The rise of autonomous driving could herald the advent of massive disruption of transport, especially if people hail driverless taxis rather than own a car. US think tank, RethinkX, says that by 2030 about 95% of distance travelled in the US is likely to be in self-driving shared (electric) vehicles. This development will be akin to one of the "fastest, deepest and most consequential disruptions of transportation in history", it says.[19]

Summoning (electric) robo-taxis by mobile will save US families US$1 trillion in transport costs a year, RethinkX says. Such a saving would trigger a major shift in consumer-spending patterns, while upending industries such as auto sales, car repairs, car servicing, motels, truck haulage and fast-food outlets that rely on drive-throughs (while the expected shift to electric would batter the oil industry).

While many jobs might become redundant, others will be created. People will want to make use of their time while travelling in pedal-free and steering-wheel-less cars. An Intel-backed study forecasts that autonomous cars will create a "passenger economy" worth US$7 trillion by 2050 as pilotless vehicles free more than 250 million hours of time in the world's most congested cities and save more than 585,000 lives from 2035 to 2045.[20] Instead of driving, people will dine, read, watch TV, use devices, even sleep.

Just as the US interstate highways of the 1950s changed daily life by creating suburbia, the adjustment from car-owning to car-sharing could transform everyday living. The change to car-sharing could reduce the need for garages and driveways and diminish the number of parked cars on streets, which would free up living and playing space. Local government might forego car-parking revenue but councils might no longer need to build parking lots. Public transport could become even more uneconomical if it faces competition from robo-shuttles. Drink-driving would become a less common crime.

Autonomous driving promises more fluid traffic. Computer simulations show that cars could travel closer together, speed through intersections faster, face fewer traffic jams and suffer fewer accident-caused delays. A study by the University of California said that toll roads might be able to double their traffic capacity from about 2,200 vehicles per lane per hour, much to the benefit of toll-road operators.[21] But less congestion only encourages people to use cars.

Tech snags

The possibilities that automated vehicles herald are great. So too are the challenges. The technology needed to enable millions of cars at any one time to speed safely around the world's roads are daunting, if not mind-boggling. The Economist indirectly quoted one Detroit executive as saying that "it is 10,000 times harder to build an autonomous vehicle that works on real roads rather than on a Californian test track".[22]

The infrastructure needed to enable autonomous driving will be expensive and involve public money, which will make it political.[23] Signs, pavements and road markings will need to be made more visible and sensor-friendly and short-range communication devices must be installed,[24] as 3M is doing on a three-kilometre stretch in Michigan to enable testing.[25] Road markings, for instance, now include metal mesh that sensors can track. Much pre-mapping needs to be done. New South Wales alone has 207,000 kilometres of road[26] so the task to digitally map Australia will be expensive. As with any software, the technology could be vulnerable to cyberattack.

Another technical challenge is eradicating glitches that could immobilise robocars or annoy users. The latest survey by J.D. Power, the bellwether report for the auto industry, found that people are struggling with cruise controls, lane-departure warnings, collision-avoidance systems and blind-spot warnings. "Consumers will need to be convinced that these systems are foolproof before they will give up driving control to autonomous vehicles," it warns.[27]

On top of this, there are hard-to-surmount quirks. The small size, speed and different shapes of bicycles confuses self-driving software as does cyclists to-and-froing at lights.[28] Volvo says the hopping of kangaroos bewilders its animal-detection system – though the system can cope with deer, elk and caribou.[29] Another challenge is how robocars will deal with erratic human drivers, including pranksters who force them to stop.

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Convincing the public

A big hurdle for the driverless industry is getting laws changed so robocars can be driven on public roads. It's tricky to legislate and test the safety of a concept. If lawmakers judge that driverless cars are safe with a human backup driver, they will have to decide whether or not to allow a vehicle to have no potential driver. If not, then the benefits of autonomous driving for the elderly, the young, the disabled and the unlicensed could fail to materialise.

Dealing with collisions will prove tricky because it might be hard to judge who might be at fault, especially if two driverless cars crash. That complicates who would pay for repairs. A core problem is that no easily identifiable person would be responsible if a driverless car were to go awry. Some anonymous coders might have made an error. Lawmakers need to understand what ethical decisions coders have pre-programmed – the software is likely to favour the safety of a car's passengers over pedestrians and people in other cars.

Laws are changing to promote driverless driving. More than 20 US states allow testing of autonomous vehicles and the driverless industry is pushing for federal oversight for consistency, which they are on track to achieving.[30] To help surmount the legal issues and win public support, Ford, Luft (General Motors), Uber, Volvo and Waymo have formed the 'Self-driving coalition for safer streets' to lobby US lawmakers and regulators.[31]

To promote the driverless industry, advocates are pushing the greatest promise of autonomous cars; fewer accidents, fewer deaths and fewer injuries. Fatalities, however, will still occur. A self-driving Tesla car killed its safety driver in 2016 when neither the driver nor the software spotted the trailer behind a truck crossing its path.[32]

While the road death toll is too high, looked at another way – by deaths per million vehicle kilometres driven – perhaps, cars don't look as lethal. In Australia in 2014 (the latest year for which figures are available), there were 0.48 deaths per million vehicle kilometres travelled. This result made Australia eighth out of 13 developed countries surveyed and was just above the 0.46 median result for OECD countries.[33] (See table.) The vested interest pushing driverless cars will need to prove they can lower this ratio.

Ultimately, the public must be willing to ride in driverless vehicles for the concept to succeed. Surveys suggest the public are wary. A London School of Economics study in 2010 found only 25% of the 12,000 people from 11 European countries asked were 'comfortable' with the idea of robocars, while 44% were 'uncomfortable' with the concept.[34]

A study in 2016 by the Humboldt University of Berlin found that 62% of respondents would "not want to hand over the complete vehicle operation".[35] Even if people's confidence were won, fatal accidents could dent their enthusiasm.

Other issues determining public acceptance of driverless cars will be their affordability and how easy they are to operate. Car costs can be reduced if the safety features crammed into today's vehicles can be minimised but the autonomous technology promises to be expensive. Time will tell how human drivers interact with driverless cars. Some say that erratic driving by humans could lead to segregated highways. Others worry that people's driving skills may atrophy and they won't react fast enough in emergencies. People could be prone to panic.

Those testing robocars in Milton Keynes and the rest of the world have much to solve before a driverless world eventuates.

By Michael Collins, Investment Specialist.

Table of road deaths per 100 million vehicle kilometres travelled selected OECD countries, 2014.

COUNTRY	DEATH PER MILLION VEHICLE KM TRAVELLED
Iceland	0.12
Norway	0.33
Sweden	0.34
Denmark	0.36
Switzerland	0.39
Finland	0.41
Germany	0.46
OECD median	**0.46**
Australia	**0.48**
Israel	0.53
France	0.59
Japan	0.62
US	0.67
New Zealand	0.71

* Sources: Bureau of Infrastructure Transport and Regional Economics, Australian Road Deaths Database, International Traffic Safety Data and Analysis Group, OECD.

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