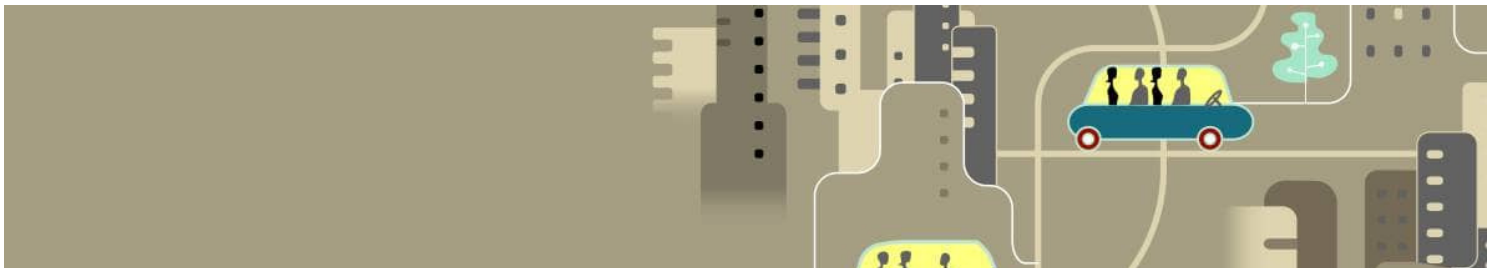


SCIENCE & TECHNOLOGY

IF AUTONOMOUS VEHICLES RULE THE WORLD
FROM HORSELESS TO DRIVERLESS

Overturning industries and redefining urban life, self-driving cars promise to be as disruptive and transformative a technology as the mobile phone

SHORTLY after Thomas Müller eases his Audi A7 into the flow of highway traffic heading towards Shanghai, a message on the dashboard indicates that "piloted driving" is now available. Mr Müller, an Audi engineer, presses a button on the steering wheel and raises his hands. The car begins to drive itself, the steering wheel eerily moving on its own as the traffic creeps over a bridge towards the city

centre.

This is, admittedly, a limited form of autonomy: the car stays on the same road, using cameras and a "LiDAR" scanner to follow the lane markings and maintain a constant distance from the vehicle in front. But this is how the world's carmakers see the future of self-driving technology: as driver-assistance features that gradually trickle down from luxury vehicles to mass-market cars, just as electric windows and power steering did before them. Autonomous driving will, in this view, make motoring less stressful—drivers "arrive more relaxed", says Mr Müller—but people will still buy and own cars just as they do today.

For a different vision of the driverless future, visit Heathrow airport outside London, and head to a "pod parking" area. Transfers between the car park and terminal are provided by driverless electric pods moving on dedicated elevated roadways. Using a touchscreen kiosk, you summon a pod and specify your destination. A pod, which can seat four people, pulls up, parks itself and opens its doors. Jump in, sit down and press the start button—the

only control—and it drives you to your destination, avoiding other pods and neatly parking itself when you arrive, before heading off to pick up its next passengers.

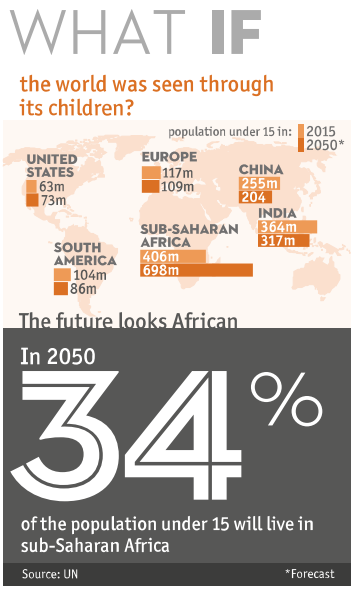
Like riding in the autonomous Audi, travelling by pod is thrilling for the first 30 seconds—but quickly becomes mundane. The difference is that self-driving vehicles that can be summoned and dismissed at will could do more than make driving easier: they promise to overturn many industries and redefine urban life. The spread of driver-assistance technology will be gradual over the next few years, but then the emergence of fully autonomous vehicles could suddenly make existing cars look as outmoded as steam engines and landline telephones. What will the world look like if they become commonplace?

IF 90% OF CARS ON AMERICAN ROADS WERE AUTONOMOUS, ACCIDENTS WOULD FALL FROM 5.5M A YEAR TO 1.3M

motor cars provides an instructive analogy. Cars were originally known as “horseless carriages”—defined, like driverless cars today, by the removal of a characteristic. But having done away with horses, cars proved to be entirely different beasts, facilitating suburbanisation and becoming symbols of self-

definition. Driverless vehicles, too, will have unexpected impacts. They will look different. Early cars resembled the carriages from which they were derived, and car design took some years to escape its horse-drawn past. By the same token, autonomous vehicles need look nothing like existing cars. Already, Google's futuristic pods are on the public roads of California, and some concept designs, liberated from the need to have steering wheels and pedals, have seats facing each other around a table.

Autonomous vehicles will also challenge the very notion of car ownership. Cars are among the most expensive things most people own, yet they sit idle, on average, 96% of the time. That is justified by the convenience of having access to a car whenever you need it. These days, however, you can summon a car at will using a smartphone app for a taxi service, car-sharing scheme or rental provider. Google reckons that shared, self-driving taxis could have utilisation rates of more than 75%. If so, a much smaller number of cars would be needed to move the same number of people



around. “There will be fewer cars on the road —perhaps just 30% of the cars we have today,” predicts Sebastian Thrun, a computer scientist at Stanford University and a former leader of Google’s self-driving-car project.

The idea that autonomous vehicles will be owned and used much as cars are today is a “tenuous assumption”, says Luis Martinez of the International Transport Forum, a division of the OECD, a think-tank. Fleets of self-driving vehicles could, he says, replace all car, taxi and bus trips in a city, providing as much mobility with far fewer vehicles. An OECD study modelling the use of self-driving cars in Lisbon found that shared “taxibots” could reduce the number of cars needed by 80-90%. Similarly, research by Dan Fagnant of the University of Utah, drawing on traffic data for Austin, Texas, found that an autonomous taxi with dynamic ride-sharing could replace ten private vehicles. This is consistent with the finding that one extra car in a car-sharing service typically takes 9-13 cars off the road. Self-driving vehicles could, in short, reduce urban vehicle numbers by as much as 90%.

Driven to tears

All this would be transformational for carmakers. They would end up selling autonomous vehicles to fleet operators, rather than to individual drivers. The value in carmaking will shift from hardware to software and from products to services, says Mr Martinez. That would shake existing carmakers, just as smartphones upended Nokia and Kodak. Already, high-tech newcomers such as Google, Uber and Tesla are muscling in.

Yet car-industry executives gamely insist that many people will still want to own their own vehicles and that the popularity of leasing means the industry has already moved to a service model. It sounds a lot like wishful thinking, if not denial.

Carmaking is not the only industry that faces upheaval. So does car insurance—worth $198 billion a year in America alone—as cover switches from millions of consumers to a handful of fleet operators. In February three big American insurers, Cincinnati Financial, Mercury General and Travelers, noted in their SEC filings that driverless cars threaten to

disrupt their business. Similarly, LKQ, a car-parts firm, pointed out in its filing that fewer cars on the road, and fewer accidents, could reduce its sales.

Automation would, more obviously, be bad news for taxi drivers. A study by Columbia University found that a fleet of 9,000 autonomous vehicles could replace all 13,000 taxis in New York. Passengers would spend less time waiting, and would pay less per mile, because paying drivers is the biggest cost for taxi operators. No wonder Uber is keen on driverless vehicles. “When there is no other dude in the car, the cost of taking an Uber anywhere becomes cheaper than owning a vehicle,” observed its boss, Travis Kalanick, last year. Uber’s first test vehicle was recently spotted on the streets of Pittsburgh.

Other workers stand to lose as well. Rio Tinto, a mining giant, is already using 53 self-driving lorries across three of its sites in Australia. The first self-driving truck licensed for testing on public highways, built by Daimler, hit the road in May. America’s 3.5m truck drivers sustain workers in other businesses, too, such as motels and restaurants. The current arguments

over Uber, Lyft and other ride-hailing services (which at least still require drivers) may seem like a picnic compared with the opposition to driverless vehicles.

Safety first

But self-driving cars would also have enormous benefits. Today 94% of car accidents are due to human error, according to America's National Highway Traffic Safety Administration, and the three leading causes are alcohol, speeding or distraction. Accidents kill around 1.2m people a year, reports the World Health Organisation, equivalent to a 9/11 attack every day.

Driverless cars cannot drink alcohol, break the speed limit or get distracted by a text message, so accidents should occur much less often. Google's driverless vehicles have driven 1.8m miles (2.9m kilometres) in the past six years, and have been involved in 12 minor accidents, none of which caused injury and none of which was the car's fault. A study by the Eno Centre for Transportation, a non-profit group, estimates that if 90% of cars on American roads were autonomous, the number of

accidents would fall from 5.5m a year to 1.3m, and road deaths from 32,400 to 11,300.

Once self-driving vehicles become available, some places will probably ban ordinary cars on safety grounds, starting with city centres, resorts, business parks and campuses. A report on self-driving cars from Morgan Stanley predicts that attitudes will quickly shift from "I don't want to share the road with robots" to "I don't want to share the road with other human drivers". People in Google's home town of Mountain View, California, are now used to seeing its prototype vehicles on the streets. Some even complain that they drive too timidly, waiting for pedestrians to finish crossing, for example, to the annoyance of drivers revving behind them. Strikingly, nobody seems to be scared of them.

As well as being safer, self-driving vehicles would make traffic flow more smoothly, because they would not brake erratically, could be routed to avoid congestion and could travel close together to increase road capacity. A study by the University of Texas estimates that 90% penetration of self-driving cars in America would be equivalent to a doubling of

road capacity and would cut delays by 60% on motorways and 15% on suburban roads. And riders in self-driving vehicles would be able to do other things. Morgan Stanley calculates that the resulting productivity gains would be worth $1.3 trillion a year in America and $5.6 trillion worldwide. Children, the elderly and the disabled could gain more independence (one of Google's videos shows a blind man doing errands in an autonomous car).

With cars in constant use, much less parking space would be needed. Parking accounts for as much as 24% of the area of American cities, and some urban areas have as many as 3.5 parking spaces per car; even so, people looking for parking account for 30% of miles driven in urban business districts. By liberating space wasted on parking, autonomous vehicles could allow more people to live in city centres; but they would also make it easier for workers to live farther out. If you can sleep on the journey a longer commute becomes feasible, notes Mr Fagnant, who foresees a "simultaneous densification of cities, and expansion of the exurbs".

The bumpy road ahead

Even though they will have fewer crashes, self-driving cars are sure to be held to a higher standard than human drivers when they are involved in accidents. They will present "new types of crash scenarios", says Mr Martinez. When faced with an unavoidable impact, should self-driving vehicles try to minimise injuries to their own passengers, or minimise harm overall? Autonomous vehicles bring to life questions from the domain of experimental philosophy, or "trolleyology": its theoretical ethical dilemmas involving runaway vehicles seem suddenly all too relevant.

At the very least, says Mr Martinez, regulators will demand that the algorithms that make such judgments should be audited, and their decision processes rendered transparent. Some self-driving vehicles are already fitted with "black boxes" to facilitate investigation of accidents. Regulators will face difficult questions about the legal liability of carmakers and fleet operators.

Car-lovers will doubtless mourn the passing of machines that, in the 20th century, became icons of personal freedom. But this freedom is

illusory. The empty roads seen in car advertisements are not most people's experience of driving. In a driverless future, people will come to wonder why they tolerated such a high rate of road deaths, and why they spent so much money on machines that mostly sat unused. A world of self-driving vehicles may sound odd, but coming generations will consider the era of car ownership to have been much stranger.

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