SELF-DRIVING CARS by Dr James Martin

A type of product that will have massive sales as it matures will be the autonomous vehicle – such as cars that drive themselves. You may choose a destination, but you are not required to steer the car or press the accelerator pedal. An autonomous car is capable of sensing its environment and navigating without human input.[1]

In 2012 Nevada became the first U.S. state to license a driverless car. Florida and California and Florida soon followed. In 2012, the Governor of California signed an Autonomous-Vehicles Bill into law. Senate Bill, SB 1298, defines procedures and requirements for determining when autonomous cars are road-ready. It requires a human to be in each car as a safety measure. Sergey Brin the co-founder of Google, which spent much effort developing self-driving cars, said he hopes that they will be on public streets in five years or less after California making them legal.[i]

The first time a person gets into such a car and it drives off by itself this can be an alarming experience. Many people will want to take over the controls. As a person repeats the experience enough, the skittish feeling goes away. A human behind the wheel may be able to take control of the vehicle at any time, but must resist the impulse to do so. If you drive to work, instead of listening to the radio you might do your email.

To most of the public today, a driverless car is a shocking idea. Many drivers would say “You’ll take away my steering wheel over my dead body.” When autonomous cars become commonplace, many people will want a conventional car simply because they want to drive. Manufacturers will use the technology to make conventional cars safer, but there will inevitably come a time when human driving is prohibited in some areas, for example in cities like those described in the next chapter, because human drivers have accidents and autonomous cars don’t. There will be driving ranges where people go to drive for fun.

ROAD DEATHS

By far the most important reason for having autonomous cars is the appalling numbers of road accidents. The AAA (American Automobile Association) reports that nearly 43,000 people die on America’s roads each year. For each death, 18 times as many people are hospitalized. [ii] Several million are injured without being hospitalized.

In the USA, the number of people killed every month from road accidents is more than the number killed inside the Pentagon and the World Trade Center in the 9/11 terrorist attack. American road deaths are the equivalent of more than one 9/11 per month. Most of the public, utterly appalled by the death toll of 9/11, make no comment about the traffic death toll. The AAA President states, "The annual tally of motor vehicle-related fatalities barely registers as a blip in most people's minds." [iii]

Elly Martin, a spokeswoman for the U.S. National Highway Traffic Safety Administration, said a study by her group concluded that the cost to America of vehicle accidents was $230.6 billion in 2000 and it is probably much higher today.[iv] In the USA, approximately 39 percent of all traffic fatalities involve alcohol. In Texas the figure is 45 percent. 17,400 individuals in the USA lost their lives in alcohol-related accidents in 2001– over 6 times the number of deaths from 9/11 terrorists, that year.[v]

Interestingly, the first 3 states in the U.S. to license driverless cars, with appropriate legislation, were the 3 with the highest level of fatalities from alcohol-related crashes – Texas, Nevada and California. [vi]

SUPER CRUISE

Probably the first experience people will have being in a car that is driving itself will be on highways where the car has an advanced form of cruise control, which General Motors calls “Super Cruise”. “Super Cruise” allows the vehicle to do its own steering, lane centering and speed control, from highway speed down to a stop. GM has already begun road testing Cadillacs that have this capability. Dr Nady Boules, director of GM's Electrical and Control Integration Research Lab, comments that GM's management, when they try it, hands-free and foot-free at the same time, always come away wowed. "Letting go of the steering wheel really is a big deal."[vii]

GM, like other car manufacturers, will progress from semi-autonomous cars to fully autonomous cars. It is expanding "cruise" capability to "Super Cruise". Boules states that in GM's vision, fully autonomous driving is the only way to get cars that don't crash, but it will develop in stages. Once crashes stop happening, he says, cars can be built that are far lighter and more efficient.

HOW DO DRIVERLESS CARS OPERATE?

Autonomous vehicles use a variety of fast-acting sensors to determine the distance and motion of objects around the vehicle, and "drive" the vehicle accordingly. Lidar (Light Detection and Ranging) devices send out laser light and analyze the light scattered back. Self-driving vehicles also use other sensors, for example tiny video cameras aimed at the surrounding area to provide computer vision, and GPS technology to help navigate. Electronic controls and software use this sensory information to establish appropriate navigation paths, and take very rapid action to avoid collisions. There is vehicle-to-vehicle communication. Some autonomous vehicles can update maps based on sensory input. The controls of an autonomous car will be designed to be very reliable and will have redundant backup, in case a failure occurs

The U.S. Department of Transportation is sponsoring work to put technology in traffic lights that can communicate with smart vehicles. Traffic lights will have not only today's red, yellow and green lights but will also transmit the same information electronically. Road signs will also transmit their information by wireless. Such information will be used by vehicles before autonomous vehicles are fully here. There will be a step-by-step transition from traditional vehicles to autonomous vehicles.

Self-drive cars today are designed to operate on existing roads; they can see traffic lights and read road signs. But roads of the future may have no traffic lights; instead they will have sensors that communicate with each car. Some of the "intelligent" features of robotic cars will be introduced before cars are fully robotic, with the goal of reducing accidents. The first robotic cars will have to operate on today's roads, but electronic features will be built into roads in some cities.

Robotic cars will be cheaper and better when they are designed for roads specially made for them. Some cities of the future will be designed for autonomous cars, and human operated cars will not be allowed on the roads.

It will become clear that the only collisions that normally occur involve human-driven vehicles. If there are no human drivers, traffic lights will be part of an obsolete past. Sensors at intersections will interact directly with the cars. The city of the past has been dominated by the car, and is often made unpleasant for pedestrians. In the city of the future, traffic areas will be separate from pedestrian areas, designed so that people will not wander in front of the cars. Pedestrian areas will be attractive and quiet, with open-air cafés, orchestras and gathering areas. There will be 3-dimensional pedestrian areas instead of 2-dimensional areas designed for the car. If you want to go to a restaurant, an autonomous car will find its own way there and when you get out at the entrance the car can be sent to park itself. When you are ready to leave you will summon it, and not worry because you have been drinking.

Today's cars are made in such large quantities that you can own an amazing amount of equipment for, say, $20,000. The first autonomous cars will be expensive, but they will rapidly drop in cost. VisLab**,** the artificial vision research laboratory of University of Parma, in Italy, tested autonomous cars in normal traffic conditions, built with low cost off-the-shelf technology, such as a Pentium 200 MHz PC and low-cost video-phone cameras. The software for autonomous cars will become very complex and will be repeatedly improved, based on the experience of cars driving themselves in all conditions, but once software exists and is fully tested, millions of copies can be created at almost no production cost.

It is sometimes stated on some of the buffoon-blogs that automated cars will cause accidents, but in fact the opposite is the case. Automated cars respond to what is around them with an extremely fast response time, and are designed to do so with extreme reliability. A ladar scanner can take more than 1.5 million measurements every second.

Google states, as I am writing this, that its autonomous cars have driven more than 300,000 miles and have had no accidents except for one that took place while a human was in control.[viii] Google's modified Prius was being *manually* driven when it caused a five-car chain reaction of fender benders. The car was not in auto pilot mode when this happened.

V2V

A vital capability of future cars is vehicle-to-vehicle communication, referred to as V2V. Standards are needed so that cars of all manufacturers and countries can communicate. When V2V communication is universal, autonomous driving will be less expensive because cars will need fewer sensors. Cars will inform each other of their position and trajectory, so it will not need to be sensed separately. This will help cars to take evasive action to avoid crashes.

An international standard for short-range wireless now exists for communication among vehicles, called DSRC (Dedicated Short-Range Communications), and uses a frequency of 5.9GHz. This provides one-way or two-way short-range communication channels specifically designed for automotive use, along with a corresponding set of protocols and standards. [ix] It is currently used in Europe and Japan for electronic collection of tolls. It can be used to enable traffic lights and road signs to communicate with cars. Many suppliers of equipment to the auto industry use this standard. It will presumably be adapted as a worldwide standard. Use of V2V is being encouraged by insurance companies because it will help provide lower accident costs.

To avoid issues with privacy as cars broadcast their positions, DSRC data is coded so that it is anonymous.

The National Highway Traffic Safety Administration (NHTSA) is currently working with the auto industry to help accelerate the introduction of advanced vehicle-to-vehicle connectivity such as crash warning systems and lane departure alerts. Volkswagen has created a system called TAP (Temporary Auto Pilot) to progress towards self-driving cars with technology designed for production cars, and hence be relatively inexpensive. This will include equipment such as radar, cameras and ultrasonic sensors supplemented by a laser scanner.

Such equipment will be phased into cars before the car is fully automated, with hope of making the car safer. However, real safety will come when the car is fully autonomous.

TYPES OF CARS

There will be a variety of different robotic vehicles, some looking like today's cars or trucks and some of them smaller vehicles.

Most of the initial work on driverless cars added new equipment to existing cars; Google's fleet of vehicles started with Toyota Prius Hybrids for example and then an SUV. The Oxford Martin School added equipment to a Range Rover. Some car manufacturers designed fundamentally new concept cars. In October 2011 General Motors announced its decision to develop a fashionable, glamorous-looking, 2-seat urban electric "car" was shown in the second photograph below.

A conventional car (a Lexus RX 450h) modified by Google to become an autonomous car, with no human driver.

The Chevrolet EN-V (Electric Networked Vehicle) is a small-footprint 2-person vehicle that can be driven manually or autonomously.

The Chevrolet EN-V (pronounced “envy” but short for Electric Networked Vehicle) is powered by two electric motors, one on each wheel, and a lithium-ion phosphate battery. It has a top speed of 25 mph and a maximum range of 25 miles. It has a small footprint and high maneuverability. It can be driven manually or autonomously. Its field testing began in the city of Tianjin, in China.

The Segway, introduced in 2001, is a remarkable two-wheeled self-balancing vehicle that looks a little like a large scooter. It used gyroscopic sensors and fluid-based leveling sensors to keep it upright, and respond to its owner’s motion. The Chevrolet EN-V also has two wheels and the self-balancing technology developed by Segway Inc. The EN-V can detect other vehicles and avoid obstacles. It can park itself, and come when called by phone. If an EN-V detects another autonomous vehicle nearby, it can check what that other is intending to do and agree on how to pass it safely.

If an accident occurs with a robotic vehicle it will probably be because a human driver has taken over, or a human-driven vehicle was involved. Most developers of autonomous cars say that if there are no cars driven by humans there will be no accidents. However, for many years there will be human-driven cars on most roads. It will be clear that cities with no human-driven cars will be much safer than those where some human driving is permitted. In some areas of cities vehicles with human drivers may be banned. Some new cities will be attractively designed for autonomous cars and new types of people movers. Future traffic statistics will show that to keep death off the road, you need to stop humans driving, but the transition period will be lengthy in most places.

LEGAL QUESTIONS

Technology is now changing so fast and fundamentally, that in many areas the law cannot keep up. As self-driving cars become more common, there will be a flood of new legal questions. If a self-driving car gets into an accident, the human on board will normally be faultless. The car itself will probably be faultless. If you are hit by a self-driving car, who would you sue? The owner of the car, the car’s manufacturer, or a city with faulty road design? Autonomous cars will need insurance. New laws will have to be developed to deal with such issues.

When California passed its Senate Bill allowing driverless cars, Sergey Brin, the co-founder of Google, was asked who would get the ticket when a driverless car runs a red light, Brin replied, "Self- driving cars do not run red lights." [x]

There are many legal problems and software problems that will need to be worked out as part of the technology of autonomous traffic evolves, and it will evolve very rapidly. All state laws now presume that any road vehicle is operated by a human. Some existing traffic laws date back to the era of horse-drawn carriages. Some critical aspects of semi-autonomous driving, such as Super Cruise control, require no legislative changes.[xi]

BLACK BOXES

Roughly 200 Americans people per year die in plane crashes, whereas over 40,000 die in car crashes. A plane crash gets great media attention whereas most car crashes do not, but the number of people injured in road accidents is many thousands of times the number injured in plane accidents.

In cities designed for autonomous cars, where traffic and human walking are separated, there will normally be no car crashes, but if one does happen it will need to be very important to find out why. There may possibly be changes required in the software or the design of the vehicle. Autonomous vehicles may be legally required to have a crash-proof, tamper-proof, black box, like an airplane. The goal will be to investigate any crash very thoroughly, and reduce the number to crashes to zero.

TRAFFIC CONGESTION

The National Highway Traffic Safety Administration, estimates that traffic congestion costs America $67.6 billion each year. This expense can be lessened in various ways with autonomous cars.

Cars that drive themselves can lessen traffic congestion by chaining together with close spacing. On highways there may be convoys of vehicles close together. There are various ways in which autonomous vehicles and using highways more efficiently. Vehicles can be linked into computerized management of traffic flow. Accidents cause congestion, and a goal of autonomous cars is to stop accidents, as far as possible. Cars won't accelerate through red lights, as people do. Vehicle-to-vehicle communication can both reduce congestion and help to cut accidents. It is an infuriating waste of time to drive around a congested city looking for a parking space. Many people are late for the theater because they can't park. The car of the future will know where there are parking spaces and drive its owner to them. Often cars won't be parked in the city center. They will deliver their occupant there and then leave.

Today most cars are idle most of their time, often parked in expensive places, and often adding to congestion. Private cars with drivers could be traded for public cars that don't have drivers. A public, or multi-owner car could be summoned when needed. Because it is shared it could be in use most of the time – a much more efficient use of a resource.

In the era of autonomous cars, many people will choose not to own a car. They will ask for one when they want it, and a car will come. Self-driving cars would be able to drop you off at work and then pick up another person instead of being idle all day in a parking lot. If you do own a car, it could park itself in the most efficient way possible.

Many attractive European villages have narrow roads and their beauty of the village is destroyed by having cars parked on the road outside each house. If the cars were self-driving they could be told to park themselves in a parking lot away from the village. The owner could summon them five minutes before he or she wanted to leave home.

FUEL SAVING

Autonomous cars can help save fuel. If autonomous cars don't crash, they can be made lighter and more efficient, and so use less fuel. When a lady of weighing 100 pounds goes to the grocery store, a car weighing 1.5 tons goes too. She could have an autonomous car a quarter of that weight, like the General Motors' EN-V concept vehicle.

Vehicle-to-vehicle communication, which allows vehicles to travel on highways very close together at consistent speeds, could also reduce fuel consumption. If a truck in a convoy brakes, it sends a signal slowing down the following trucks instantaneously. A spacing of four meters reduces wind resistance for the following trucks, and could reduce fuel consumption by 10 to 15 percent.

Cars that park themselves can save fuel by delivering their owner directly to his destination, and not circling the area looking for a parking spot. When it's time for the person to leave she notifies the car with a smart phone, and it comes. The biggest savings will come with full automation.

THE ROAD SAFETY IMPERATIVE

We look back in horror now at the world before the abolition of slavery. Future generations will look back in horror at the world before the abolition of car crashes.

Approximately 1.3 million people die on the *world's* roads each year, and between 20 and 50 million sustain non-fatal injuries.[xii] The death toll is forecast to go up to 2.4 million deaths a year by 2030, as the number of cars increase in countries like China and India.These figures are from the "*Global Status Report on Road Safety*" of the World Health Organization. Road traffic injuries are the leading cause of death among young people, aged between 15 and 29. For many years countries have tried to improve road safety programs, but the numbers of deaths and injuries worldwide have increased because of the increased numbers of cars.

It would be grossly immoral not to take action to drastically reduce road deaths in the future, now that it is becoming feasible to do so. There should be a global manifesto to stop road deaths.

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[i] "Self-driving cars now legal in California" By Heather Kelly, CNN, October 30, 2012
[ii] National Highway Traffic Safety Administration report, 2012.
[iii] Robert L. Darbelnet, AAA President, "Crashes vs. Congestion – What's the Cost to Society?" Washington, D.C. – March 5, 2008
[iv] Elly Martin, a spokeswoman for the National Highway Traffic Safety Administration, CNN Money.com, March 5th 2008.
[v] 2013 AlcoholAlert.com
[vi] 2013 AlcoholAlert.com
[vii] www.just-auto.com, Interview with GM's autonomous car specialist, by QUBE, 9 May 2012
[viii] "Self-driving cars now legal in California" By Heather Kelly, CNN, October 30, 2012
[ix] Harvey J. Miller and Shih-Lung Shaw (2001). "*Geographic Information Systems for Transportation*". Oxford University Press. ISBN 0-19-512394-8.
[x] "Self-driving cars now legal in California" By Heather Kelly, CNN, October 30, 2012
[xi] www.just-auto.com, Interview with GM's autonomous car specialist, by QUBE, 9 May 2012
[xii] World Health Organization. "Global Status Report on Road Safety, 2009 and 2013".