MILLIMAN WHITE PAPER

How autonomous driving features rank against human drivers

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Vehicles with autonomous driving features are transforming how we drive

With the rapidly increasing number of autonomous-enabled vehicles on public roads, it is important to consider that autonomous driving is not as scary as what humans think, when you look at the statistics and real data. Autonomous cars use a sophisticated suite of sensors and software to interpret massive streams of data from outside and inside the car.

Autonomous cars improve safety because they:

- Don't drive drunk or text while driving
- Communicate with other cars, better navigating traffic
- Carry more passengers, reducing numbers of vehicles
- Provide safe transportation for the blind, elderly, and children

Drunk driving has been replaced by distracted driving as the leading cause of crashes on our roads today. Autonomous cars solve these issues as well as expand transportation options to a broader range of the population in a more efficient and safer manner. They also relieve congestion, as a fully autonomous vehicle no longer needs a driver, thus carrying more passengers, and they communicate with other vehicles to better navigate traffic.

Waymo is one of the leaders of the autonomous driving revolution, having launched a fleet of level 4 cars providing on-demand transportation in Arizona.[1] Level 4 means the cars drive by themselves but still have a steering wheel. Waymo's cars use radar, cameras, and LiDAR,[2] coupled with software and algorithms that make decisions and drive the car. They recently partnered with Magna to mass produce level 4 cars, and eventually level 5 cars, which are fully self-driving cars with a mission to provide a safe transportation solution through fleets of self-driving vehicles.

Tesla leads sales of autonomous-enabled cars sold to the public.[3]

FIGURE 1: TESLA ROLLING 12 MONTH SALES

Tesla uses radar, external cameras, ultrasonic sensors, and software to provide:

- Autopark
- Automatic emergency braking
- Front and side collision and blind spot warning
- Traffic-aware cruise control acceleration and deceleration
- Autopilot steering and navigation within marked lanes
- Lane change and highway entering and exiting
- Traffic light and stop sign response
- Vehicle summoning in or out of garage or parking

Since I purchased my Tesla X in the fall of 2018, software upgrades have installed while my car charges overnight. I wake up in the morning, and my car shows me how to use what was upgraded. The ability to remotely upgrade autonomous features, coupled with exponential car sales, allows Tesla to collect massive amounts of data to further enhance its autonomous features. Tesla owner autonomous features are approaching level 3, which means they provide limited self-driving.

The vast amounts of data that Tesla collects on public roads to use to enhance autonomous features is pushing Tesla to the forefront of autonomous driving capabilities, fast approaching Waymo, the recognized leader.

When assessing whether machines are better at some tasks than humans we are cautious, especially when making this determination requires relinquishing control of something as fundamental to our lives as driving. We naturally bring our prior experiences, preconceived notions, and biases to the table. As an actuary and former insurance company underwriter who relies on statistics and data to validate assumptions and design insurance products, I decided it was time to provide a statistical framework to study whether, and by how much, an autonomous car drives better than a human. In January 2019, I used my Tesla X and Zendrive's driving behavior model to perform this study.

The driving behavior model

Zendrive was formed in 2013 by a group of Google and Facebook alumni to improve road safety. Through popular mobile apps, Zendrive uses smartphone sensors like the GPS, gyroscope, and accelerometer, with artificial intelligence, to detect vehicle trips and safety-related driving events. Zendrive has collected over 100 billion miles of driving behavior on U.S. roads.

Over the past several years, Milliman has worked with Zendrive to study the impact of driving behaviors on collision frequency. Zendrive created a risk score to predict the number of crashes per mile using each driver's behavior during the first 14 days of driving. We then looked at all collision events following the first 14 days of driving, to segment drivers according to the likelihood that their driving behavior would result in a collision. Relative to the average human driver, the best decile of human drivers and worst decile of human drivers have collision frequencies of 0.26 and 3.64, respectively, relative to the average human driver. This means that the worst decile of drivers is 13 times more likely to have a collision than those in the best decile, as illustrated in the graph in Figure 2. Zendrive has already put these insights to work by providing feedback to drivers to promote safer behavior that ultimately will save lives.

Because Zendrive's model was built on massive amounts of human driver trips on public roads, I used Zendrive's driving behavior model to quantify how much better an autonomous-enabled car performs compared to the human driving population.

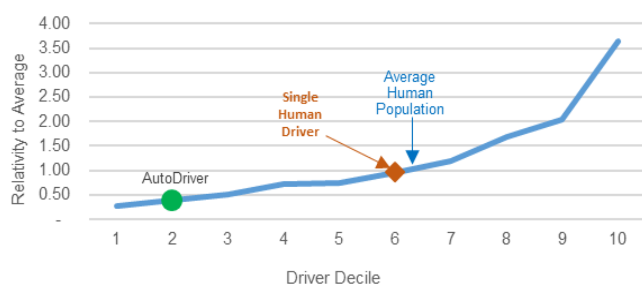
I installed Zendrive's driving behavior model onto my iPhone, and set up a user ID that I called Auto Driver. For two weeks, I engaged my Tesla X Autopilot as much it would allow me to, driving me to and from work each day. The driving behavior for each trip was collected and scored. After two weeks, the data and score for each trip was aggregated into a score for Auto Driver. Once I had Auto Driver's score, I created a new user ID called Single Human Driver. I did not engage Autopilot at any point in time for the next two weeks. Because I knew I was being scored, I probably drove a little more safely than I normally would—leaving a little extra room between my car and the car in front of me to avoid a hard braking event, and trying not to pick up my phone during the trip—as I knew these events would impact my trip score. My knowledge of the scoring model created a bias toward a better score than I might truly deserve.

To control for this bias, and to incorporate a larger sample size, I also compared Auto Driver's score to the full population of human drivers in Zendrive's developed human driver model.

Autonomous feature driving results

Figure 2 charts the relativity of 10 deciles of the scored human driving population collision frequency per mile to the average of the scored human population. The Single Human Driver score falls into the 6th decile of human drivers, which has a frequency of 0.96 relative to the average human. The Auto Driver score falls into the 2nd decile of human drivers, which has a frequency of 0.39 relative to the average human, as depicted in Figure 2.

FIGURE 2: COLLISION RATE RELATIVITIES



The table in Figure 3 calculates Auto Driver's improved collision rate relative to the Single Human Driver and large population of human drivers.

FIGURE 3: COMPARISON OF COLLISION FREQUENCY

DRIVER	COLLISION FREQUENCY PER MILLION MILES RELATIVE TO POPULATION	AUTO DRIVER PERCENT IMPROVEMENT
Auto Driver	0.39	
Single Human Driver	0.96	59.6%
Average Human Population	1.00	61.2%
Worst Decile of Human Drivers	3.64	89.3%

The important takeaway is not that I drive close to the average human driver, but that the autonomous features on my Tesla X have a driver risk score consistent with a collision rate 59.6% better than I do under similar conditions (the same car, on the same roads, at the same time of day, in the same season, with the same occupants), and 61.2% better than the average population of human drivers.

The study did not take into account Tesla software improvements released subsequent to February 11, 2019, when I completed the data collection period. Therefore, it is a measurement tool to start quantifying the improvement of autonomous features, but only the tip of the iceberg in terms of potential ways to assess the various packages of autonomous driving features and quantify improvement in driving safety. I believe the statistical evidence demonstrates that passing control from the driver to the vehicle improves road safety.[4] I am hopeful that this finding will change both how people view autonomous-enabled vehicles and how insurance companies design products to insure them and their passengers.

In addition to dramatically improving collision frequency and road safety, autonomous-enabled vehicles offer many other transformative transportation solutions, including the ability to transport passengers not able to drive themselves and to better navigate and improve traffic congestion, resulting in an overall improved transportation experience for everyone.

With the benefits of autonomous-enabled vehicles comes the requirement to understand the impact on insurance rates and coverages. This means developing insurance products that not only consider the reduction in expected collision frequency, but that also provide coverage in an evolutionary manner as autonomous features develop. Autonomous features create product liability while the vehicle hardware and software drive the car. They also create cyber exposure, and require additional property coverage for the chargers and other paraphernalia used to operate the car that traditional automobile insurance doesn't provide. Incorporating these coverage needs directly into the insurance product covering the transportation solution creates a seamless insurance experience, and avoids overlapping coverage and higher insurance premiums that result from having separate policies covering each exposure.

Tesla has recently created its own personal automobile insurance product in California that provides insurance to Tesla owners in a way that provides charger and cyber coverage and evolves as its autonomous levels increase. As more car manufacturers launch autonomous-enabled vehicles, and fleets of vehicles provide micro-duration on-demand transportation services, Milliman is helping the insurance market evolve and provide transportation insurance for the future.

ENDNOTES

[1] Waymo has driven 10 million miles autonomously on public roads in 25 states and 7 billion simulated miles.

[2] LiDAR is a surveying technology that uses light and radar.

[3] CarSalesBase. Tesla. Retrieved April 25, 2019, from http://carsalesbase.com/us-car-sales-data/tesla/.

[4] In this instance, using my Tesla X. It is possible for different results using different autonomous features, vehicles, drivers, and conditions.

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