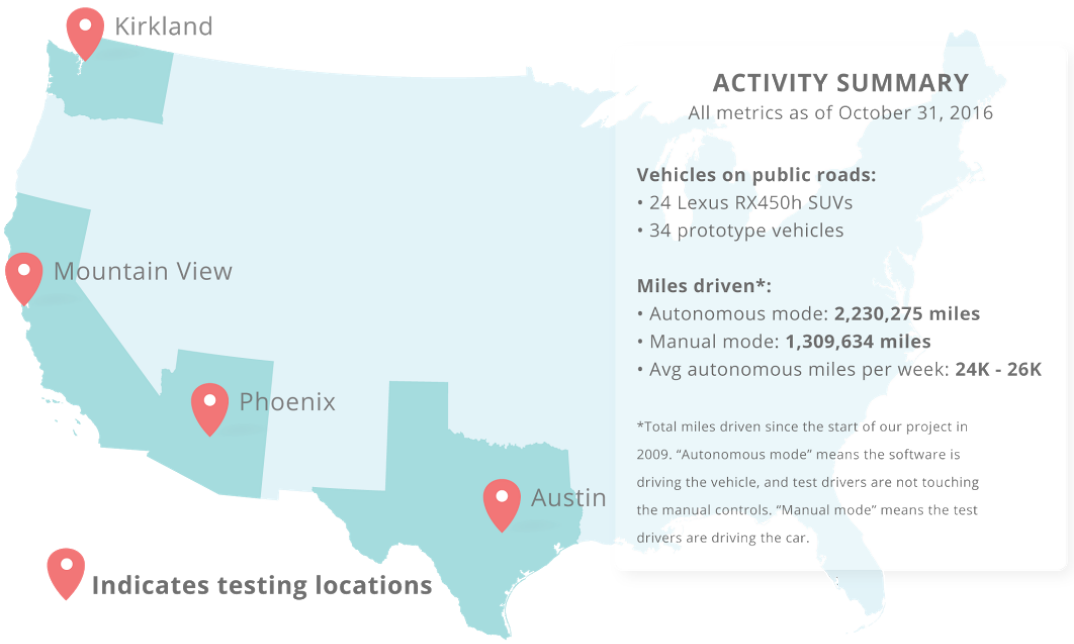
Google Self-Driving Car Project
Monthly Report

October 2016

ON THE ROAD



MASTERING THE THREE-POINT TURN

For many drivers, the three-point turn is one of the last hurdles standing between a learner's permit and the open road. And for good reason. This is one of the trickiest maneuvers to master, as drivers attempt to move a two-ton machine a full 180 degrees. Often, drivers are forced to tentatively inch forward and backward, in tight spaces, without a full view of the road. Our goal is to a develop a fully self-driving car that can handle every part of driving, and that means teaching our car to handle advanced maneuvers like these multi-point turns.

Human drivers do their best to estimate the ideal angle and distance to move in order to solve this geometric puzzle. But all too often, these three-point turns become ten-point turns as drivers awkwardly shuffle around the road. Our self-driving cars, on the other hand, can see a full 360 degrees, measure distance down to a few centimeters, and precisely calculate the quickest path for the car. Our cars don't just follow a few standard turns either. We've taught them to adapt to all kinds of variables — including dead end streets stacked with parked cars, trash bins littered on the curbs, and narrow bottlenecks.

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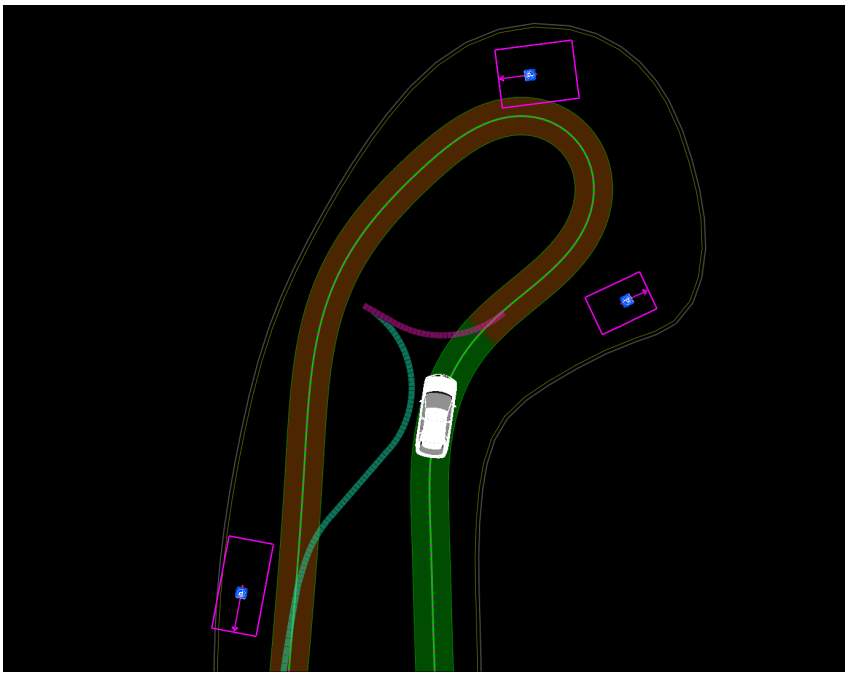

Our car adapts to objects in the road, liked parked cars (purple), when calculating the most efficient and natural multi-point turn

There are an infinite number of possible ways to turn a car around. Both human drivers and self-driving cars have to calculate tradeoffs — how wide do we move? how close do we get to the curb? how many times do we change direction? Our challenge is to teach our self-driving cars to choose the option that's not only the *quickest*, but one that feels *natural* to passengers. For example, our cars could spend most of the three-point turn driving in reverse (after all, our sensors don't have to twist into a yoga pose to get a full 360 degree view of the road behind). But that's not how people drive — they'd much rather drive forward where they have better visibility of the road and can more easily maneuver the car. So we've taught our cars to mimic these human patterns, favoring wider forward arcs, rather than a series of short movements back and forth.

In the quest to perfect the three-point turn, our cars practice about 1,000 multi-point turns every week on real city streets. The ability to navigate elegantly around tight spots is essential to building a driver that can get you from door-to-door, whether it's taking you from your home in a suburban cul-de-sac or dropping you off at a downtown bar hidden down a dead-end street.

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TRAFFIC COLLISIONS INVOLVING AUTONOMOUS FLEET

Given the time we're spending on busy streets, we'll inevitably be involved in collisions; sometimes it's impossible to overcome the realities of speed and distance. Thousands of minor crashes happen every day on typical American streets, 94% of them involving human error, and as many as 55% of them go unreported. (And we think this number is low; for more, see here.)

For collisions occurring in CA, the following summaries are what we submitted in the "Accident Details" section of form OL316 Report of Traffic Accident Involving an Autonomous Vehicle.

October 26, 2016: A Google prototype autonomous vehicle ("Google AV") traveling southbound in autonomous mode on Shoreline Boulevard in Mountain View was involved in an accident. The Google AV entered a slip lane in order to turn right onto El Camino Real and came to a stop to yield to westbound traffic on El Camino Real. As the Google AV began to move forward onto El Camino Real, another vehicle immediately behind the Google AV collided with the rear of the Google AV. At the time of the collision, the Google AV was traveling at approximately 3 mph, and the other vehicle was traveling at approximately 6 mph. The Google AV sustained minor damage to its rear hatch. The other vehicle sustained minor damage to its front bumper. There were no injuries reported at the scene.