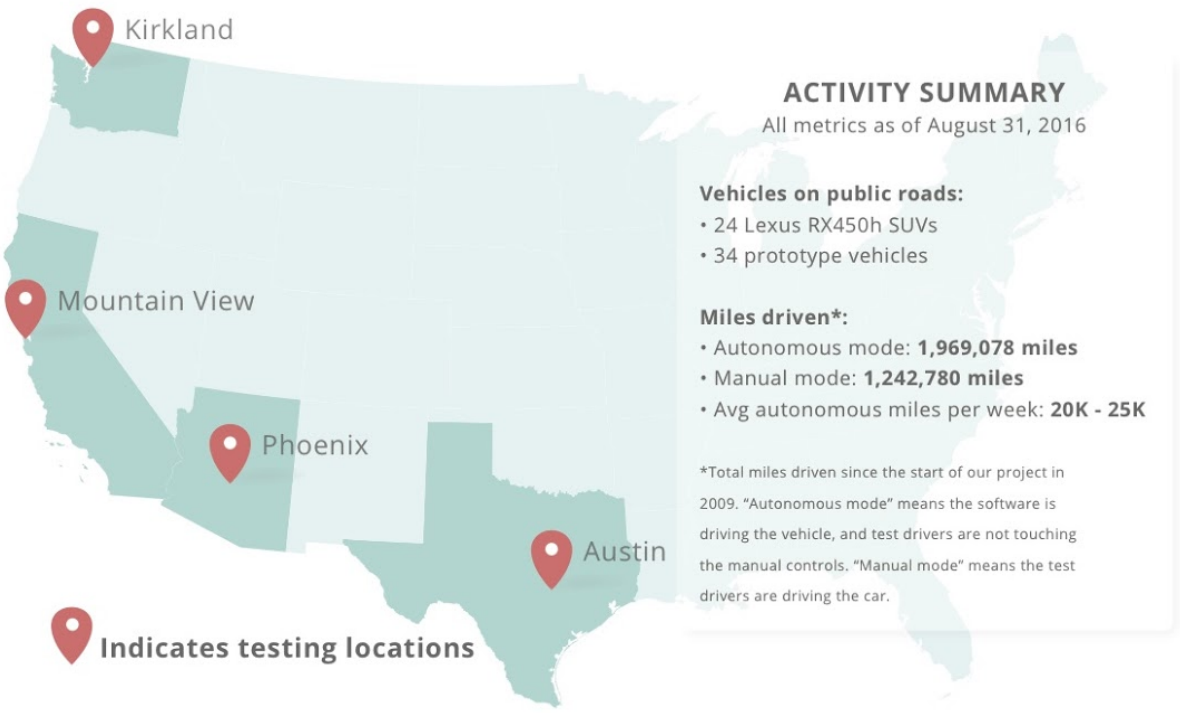
Google Self-Driving Car Project
Monthly Report

August 2016

ON THE ROAD



A RECORD MONTH IN MILES

Real-world testing is critical to developing a truly self-driving car that can handle everyday driving without any human intervention. Just as humans can't master driving by reading a handbook, a fully self-driving car can't be built solely in a lab or on a test track. The real world can pose a whole variety of unique driving challenges, many that might only come once in a lifetime. Rather than program our cars to handle a finite list of situations, we give our cars a core set of driving capabilities so they can safely navigate even the most unexpected scenarios. Through testing on public roads, our cars can hone these driving skills even further.

Lately our cars have been getting a lot more practice. In August alone, our fleet of 58 vehicles traveled a record monthly total of 170,000 miles; of those, 126,000 miles were driven autonomously (i.e. the car was fully in control). Given that the average U.S. adult drives around 12,000 miles a year, our self-driving cars have navigated the equivalent of 10 years of human driving in just 31 days. Over the last year, we've doubled the number of miles we drive, covering anywhere between 20,000 to 25,000 each week.

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We began testing on highways seven years ago, but today most of our miles are on surface streets. While it may be easier to rack up many more miles on highways through driver assist features like cruise control, creating a truly autonomous car requires advanced driving skills in order to master the complexity of neighborhoods. (Highways, with traffic moving in the same direction along divided lanes, present a lower level of complexity when compared to the intersections, construction zones, traffic lights, pedestrians and cyclists found on surface streets.)

By expanding our testing program to four regions across the U.S., we've unlocked fresh opportunities to learn and practice driving in different environments. Whether we're navigating rain in Kirkland, dust in Phoenix or deer in Austin, this real-world experience is getting us ready to introduce our fully self-driving cars to the public.

GETTING TO KNOW OUR NEIGHBORS IN THE VALLEY OF THE SUN

On August 13, we hosted our first open house in Chandler, AZ, where we got to know our neighbors and gave them a chance to see a self-driving car up close. A highlight of the weekend was hearing what people would do with a self-driving vehicle, whether it was "play games with grandkids," "study for class" or "attain my daily moment of zen." We also heard a number of interesting questions, and in this month's report we're answering some of those questions.

What's been different for your self-driving cars in the Phoenix area?
We knew the area's desert conditions, including extreme temperatures and dust in the air, would provide new experiences for our software and sensors. Since we've started driving, we've also encountered a few more unique things on the road. For example, we've learned to navigate around watering trucks (trucks that water plants in road medians and travel about 3 mph on 45 mph roads). Our cars have also gotten more practice with a new traffic light configurations: a four-stack signal that includes a red, yellow, flashing yellow (yield to oncoming traffic) and green light.

What will your cars do when there's a haboob?
Haboobs — those giant dust storms that sweep desert areas — are certainly something we don't see in our hometown of Mountain View, CA. When we encounter one in Arizona, the safest thing for our car to do is pull over and wait for the storm to pass (just as human drivers would). Even when we're stopped on the side of the road, our car can still learn from the experience as our sensors detect the extreme amounts of dust in the air.

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Can your cars drive in the dark?
Yes. Our self-driving cars navigate using a combination of cameras, lasers and radars. Lasers show us the shape of objects in the world, while radars can detect vehicles far ahead and determine their speed. Neither of these technologies need light to detect objects, thus helping our cars safely navigate at night.

Can your cars navigate school zones?
In school zones, our cars are on high alert. They're designed to pay extra attention to pedestrians and cyclists, driving conservatively around these road users. We've also taught our cars to detect school zone signs (in Phoenix we've seen the use of temporary "slow zone" signs) and stop signs that appear on school buses. With all these considerations, our self-driving cars are designed to safely and carefully navigate school zones.

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.

Collisions while in manual mode

August 8, 2016: A Google prototype vehicle operating in manual mode traveling eastbound on California Rd. in Mountain View, CA was involved in a minor accident. The Google vehicle was stopped at the intersection of Rengstorff Ave. waiting for pedestrians on Rengstorff Ave. to complete their crossing before it could make a turn, when another vehicle approaching from behind collided with the rear bumper of the Google vehicle. The other vehicle was traveling at approximately 4 mph at the time of the collision. The Google vehicle sustained minor damage to its rear hatch and bumper. There was no visible damage to the other vehicle. No injuries were reported by the parties at the scene.

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August 9, 2016: A Google Lexus-model vehicle operating in manual mode traveling westbound on Chandler Blvd. in Chandler, AZ, was involved in a collision with a vehicle that ran a red-light. The Google vehicle was stopped in the intersection of Beck Dr. yielding to oncoming traffic while preparing to make a left turn. After the traffic light turned red, the Google vehicle's test driver proceeded to complete a left turn onto Beck Dr. As the driver was making the turn, a vehicle travelling eastbound on Chandler Blvd. drove through a red light and into the intersection at approximately 45 mph, making contact with our vehicle. At the time of collision, our vehicle was traveling at 2 mph. Both vehicles experienced moderate damage. No injuries were reported by the parties at the scene.

August 16, 2016: A Google Lexus-model vehicle traveling eastbound in manual mode on Ray Rd. near the intersection of Mckemy Ave. in Chandler, AZ, was rear-ended. The Google vehicle was traveling in the far right lane on a straight path at approximately 42 mph when a vehicle approaching from behind in the same lane collided with the rear of the Google vehicle. The other vehicle was travelling at approximately 67 mph. The posted speed limit was 45 mph. The Google vehicle sustained moderate damage to its rear bumper and trunk. The other vehicle sustained significant damage to its front end. No injuries were reported by the parties at the scene.

Collisions in autonomous mode

August 16, 2016: A Google prototype vehicle travelling southeastbound on Phyllis Ave. in Mountain View in autonomous mode was involved in an accident. In preparation for making a right turn onto Grant Rd., the Google vehicle entered the right-turn slip lane and advanced forward at 6 mph to gain a better view of traffic traveling southbound on Grant Rd. As the Google vehicle moved forward, it detected a vehicle approaching southbound on Grant Rd. and came to a stop to yield to that vehicle. Approximately one second later, a vehicle approaching from behind the Google vehicle at approximately 5 mph collided with the rear bumper of the Google vehicle. The Google vehicle experienced moderate damage to its rear bumper and hatch. The other vehicle experienced mild damage to its front bumper. No injuries were reported by the parties at the scene.

August 22, 2016: A Google Lexus-model autonomous vehicle traveling northbound in autonomous mode on Desert Breeze Rd. in Chandler, AZ was rear-ended. The Google vehicle was stopped at a red light at the intersection of Ray Rd. and yielding to cross traffic before it could make a right turn. A vehicle approaching from behind the Google vehicle at approximately 7 mph collided with the rear bumper of the Google vehicle. The Google vehicle experienced moderate damage to its rear bumper. The other vehicle experienced mild damage to its front bumper. No injuries were reported by the parties at the scene.

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WHAT WE'VE BEEN READING

NHTSA: Traffic fatalities up sharply in 2015
Arizona Republic: Google shows off self-driving cars in Chandler
Bloomberg: Google's driverless-car czar on taking the human out of the equation
Autoblog: Millions of Americans are driving drowsy
Washington Post: Self-driving cars reach a fork in the road, and automakers take different routes