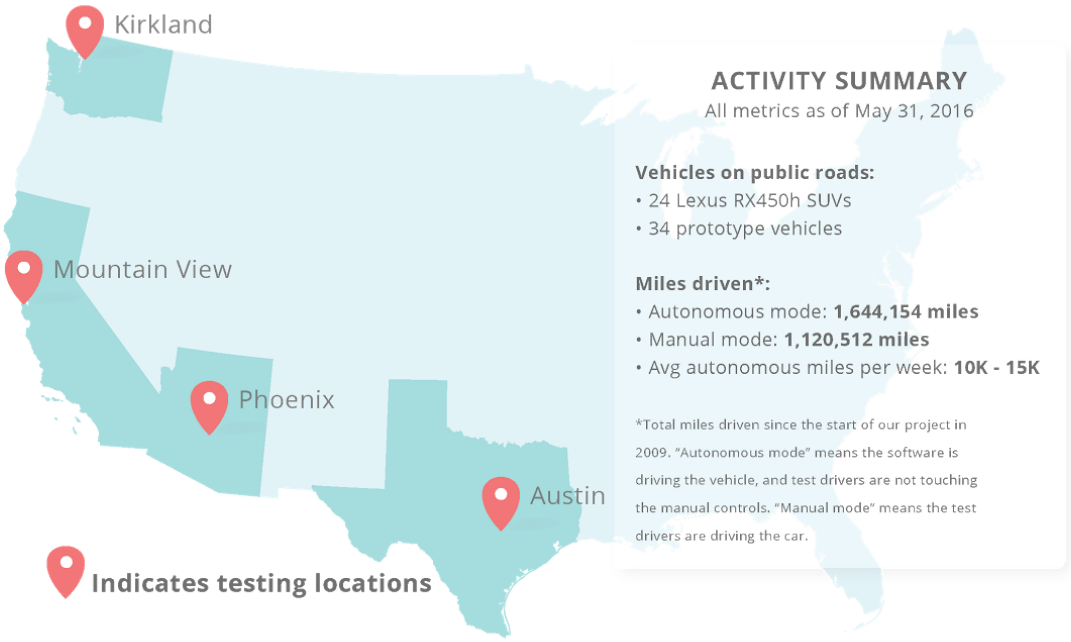
Google Self-Driving Car Project
Monthly Report

May 2016

ON THE ROAD



SOUNDS OF THE SELF-DRIVING CAR

Every day, we hear a chorus of sounds on the road: cars accelerating, music playing, cyclists whirring past. This month, we explore how we're developing the voice of a self-driving car.

Down with the tyrannical horn: Teaching a self-driving car to honk

In his 1983 essay, *The Tyranny of the Horn*, Eugene Garfield describes the car horn as an "instrument of torture" — something anyone who's ever sat in a traffic jam can tell you. When the car horn was first developed, "a predictable thing happened. Any usefulness that the horn had was quickly negated by the fact that people in cities were constantly tooting at one another."

The human act of honking may be (performance) art, but our self-driving cars aim to be polite, considerate, and only honk when it makes driving safer for everyone.

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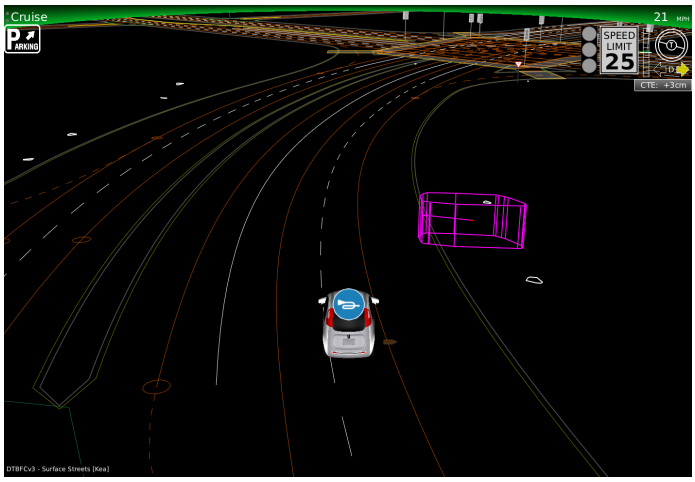

In our self-driving software, a horn appears above our vehicle to indicate when we've decided to honk, e.g. when a car is backing out of a driveway and we want to make sure the driver knows we're coming

Our self-driving cars are designed to see 360 degrees and not be distracted, unlike human drivers, who are not always fully aware of their surroundings. Our self-driving software is designed to recognize when honking may help alert other drivers to our presence — for example, when a driver begins swerving into our lane or backing out of a blind driveway. During testing, we taught our vehicles to distinguish between potentially tricky situations and false positives, i.e. the difference between a car facing the wrong way during a three-point turn, and one that's about to drive down the wrong side of the road. At first, we only played the horn inside the vehicle so we wouldn't confuse others on the road with a wayward beep. Each time our cars sound the horn, our test drivers take note whether the beep was appropriate, and this feedback helps our engineering team refine our software further.

As our honking algorithms improved, we've begun broadcasting our car horn to the world. We've even taught our vehicles to use different types of honks depending on the situation. If another vehicle is slowly reversing towards us, we might sound two short, quieter pips as a friendly heads up to let the driver know we're behind. However, if there's a situation that requires more urgency, we'll use one loud sustained honk.

Our goal is to teach our cars to honk like a patient, seasoned driver. As we become more experienced honkers, we hope our cars will also be able to predict how other drivers respond to a beep in different situations.

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The hum of our prototype vehicle

For many people who live in our test cities, the design of our prototype vehicles makes them easy to distinguish from other vehicles on the road. But those with a keen ear may also recognize the distinct sounds of our self-driving prototype.

Because our prototype is an electric vehicle, our engine does not purr or rev like combustion engines. But quiet isn't always a good thing. Pedestrians and cyclists often rely on sound to alert them to a nearby car, particularly if they're about to cross the street or change lanes. For people with visual impairments, the sound of an approaching vehicle can be critical information.

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We've designed the hum of our vehicle to be familiar so that pedestrians and cyclists around know what to expect. Our prototype mimics the sound characteristics of traditional cars, such as increasing the pitch when it accelerates, and decreasing the pitch when it decelerates.

But we also wanted to insert a little personality and create a unique voice for our self-driving car, so we looked to different places for inspiration — from other vehicles and modes of transport to consumer electronics products to ambient art sculptures (we even previously experimented with the sound of an orca!). From these explorations, we've aimed to have a voice that matches our face: neighbors often tell us our prototype vehicles look friendly and a little futuristic, and we hope we sound like it, too.

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.)

(CA regulations require us to submit CA DMV form OL316 Report of Traffic Accident Involving an Autonomous Vehicle for all collisions involving our cars. The following summaries are what we submitted in the "Accident Details" section of that form.)

May 4, 2016: A Google self-driving prototype vehicle in manual mode and proceeding west on Latham St. in Mountain View struck a median while travelling at 9 mph near the intersection of Chiquita Ave. There were no other vehicles involved and no traffic in the vicinity. There were no injuries. The Google AV sustained minor damage.

WHAT WE'VE BEEN READING

- **Financial Times:** Driverless cars: When robots rule the world [Video] (May 2016)
- **New York Times:** It's no accident: Advocates want to speak of car 'crashes' instead (May 2016)
- **Automotive News:** Silicon Valley and Detroit: The best of frenemies (May 2016)
- **Outside Magazine:** Want to Keep Roadies Safe? Get Google on It. (May 2016)