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BACKGROUND

Torc self-driving car technology

Introduction

Torc Robotics is a self-driving software solutions company that has developed a complete self-driving system for consumer automobiles. Torc's technology is based on commercially proven systems the company has developed over the past decade for safety-critical situations such as mining and defense.

Founded in 2005, Torc has integrated its self-driving technology on ground vehicles ranging from SUVs to 300-ton mining trucks. Torc has converted more than 100 vehicle platforms to autonomous and remote operation in real-world applications. Torc's autonomous system has been proven in complex driving situations on roads in more than 20 states and work zones around the world.

The Torc team is passionate about robotics and is dedicated to making the world safer and more accessible through its autonomous systems, according to Michael Fleming, CEO and co-founder.

Torc first established itself as a leader in autonomous vehicles in 2007, when its vehicle placed third in the Defense Advanced Research Projects Agency (DARPA) Urban Challenge, a 60-mile course that required vehicles to travel autonomously through on- and off-road environments and navigate parking lots, road blocks, and merging while obeying traffic laws.

Since then, Torc has continuously improved its technology through early adopter markets including mining, construction, and defense. "Over the last decade, we have been continuously improving our end-to-end self-driving software and create the proper balance between performance, cost, reliability, and safety," says Torc CEO Michael Fleming. "We have been waiting for the mobility market to take off and the time is now."

In July 2017, Torc [unveiled its self-driving car project named Asimov](#). The technology was implemented on two Lexus RX vehicles, which have been operating on public roads in a variety of weather conditions, since February 2017.

In April 2017, one of Torc's self-driving vehicles [demonstrated a long-distance drive](#), logging more than 1,000 autonomous miles during a round trip from company headquarters in Blacksburg, Virginia, to the Ford Piquette Avenue Plant in Detroit—birthplace of the Model T. The car drove autonomously on highways, freeways, winding mountain roads, and city streets.

Torc's self-driving car [traveled coast-to-coast](#) to become the first car certified in Washington State's self-driving permit program. The car completed 6,500+ autonomous miles—successfully maneuvering heavy urban traffic, aggressive tailgating, heavy rains, and highway detours.

The company took CES 2018 by storm. Although rain caused other companies to cancel rides in their autonomous vehicles, Torc stayed on the road. "Weather clearly wasn't a deterrent for Torc; coming out of dinner that night, I saw one of its vehicles pass me by on the street like it was no big deal," Ryan Felton wrote in his article "[How This Tiny Virginia Company Is Running Circles Around The Self-Driving Car Industry](#)," for Jalopnik. Other headlines from CES included CNET's "[Torc car drives itself as well as any human at CES 2018](#)" and Sensor Magazine's "[Torc Car Thumbs Nose At Wrong-Way Drivers](#)."

In October 2018, Torc announced it was [expanding its commercialization capabilities](#) by integrating its

autonomous vehicle technology on a 2017 Chrysler Pacifica Hybrid.

Torc continues to refine its technology with continual testing and creates partnerships with carmakers and systems developers around the world.

In November 2018, Torc and AAA Northern California Nevada & Utah (NCNU) pitted Torc's self-driving software against some of the most unpredictable traffic hazards in an effort to develop safety criteria for self-driving vehicles at Ohio's Transportation Research Center (TRC). Torc and AAA Northern California Nevada & Utah also challenged Torc's vehicles in Las Vegas traffic in January 2018.

Torc is certified for autonomous testing in Nevada, California and Washington.

Torc products and services

Torc offers the following technology and services to carmakers and systems developers:

Autonomous software

Torc offers an end-to-end self-driving software stack that can be integrated on multiple platforms for a variety of applications.

Engineering partnership

While Torc offers commercial off-the-shelf solutions for customers to use independently, the firm also offers a seasoned team to help automakers implement autonomous technology on their unique platforms.

"There is so much confusion about how to implement robotics on cars and how autonomous software can interface with different mass-produced car models. Our team helps carmakers and systems developers navigate the different options and jumpstart their programs for a fast-approaching transportation revolution."

—Michael Fleming

Hardware/software products

Torc offers complete systems for localization, safety, and drive-by-wire control.

Technology

Torc's system operates like a human driver and is able to manage more than 60 complex scenarios ranging from driving in rain and snow, to recognizing pedestrians both in and out of crosswalks and understanding precedence at a four-way stops with cross traffic.

[Read Torc's full list of capabilities here.](#)

Experience

Torc has more than 10 years of experience building and testing self-driving vehicles in real-world conditions. Its technology has allowed businesses in a wide range of industries to work safer, smarter and more efficiently.

Many of Torc's clients require off-road autonomous capabilities that are more complicated than on-road systems. Their vehicles must maneuver past small obstacles that are difficult to see, areas without marked pathways, and uneven terrain.

Torc engineers have a strong understanding of the tradeoffs in designing and deploying self-driving vehicles—from sensor selection and placement, distributed versus centralized computing, algorithm

selection, and dynamics and safety. This includes system hardware and software design, vehicle integration, along with validation and testing.

The Team

Torc's headquarters in Blacksburg, Virginia, is strategically located to support self-driving vehicle development. The 20,000-square-foot facility contains garages, a 22-acre test site, and is adjacent to a 2.2-mile closed road course with weather generating capabilities. "Blacksburg is an ideal testing location," Fleming said. "We have mountains, highways, fog, snow. We can take advantage of difficult driving situations."

Torc has one of the deepest and longest-tenured benches of engineering talent, having retained the majority of its employees who competed in the 2007 DARPA Urban Challenge. Now more than 100 strong, Torc is recruiting new talent and continues to grow quickly. Fleming calls the company's pace "rocket ship mode."

The firm has one core value: "winning teams," which supports a culture of collaboration, growth, and excellence.

History

Early beginnings

In 2005, a group of Virginia Tech students lead by Dr. Charlie Reinholtz designed and built three autonomous robots to compete in the AUVSI Intelligent Ground Vehicle Competition. The competition required robots to autonomously drive through obstacle courses at speeds up to 5 mph. After three rigorous days of competition with 27 other competitors, the team placed first, second and third in the autonomous and navigation challenges, and first and second in the design competition.

The team built two autonomous vehicles to compete in the DARPA Grand Challenge. After competing against an initial 195 applicants, the team placed eighth and ninth, completing nearly 100 combined miles of autonomous driving in the harsh rocky desert terrain.

These successes generated a wealth of interest across several markets including automotive, mining and defense. After receiving numerous requests for the commercial application of its technologies, the team created a spin-off company called Torc Robotics. Shortly thereafter, DARPA announced the next robotic challenge.

DARPA Urban Challenge

The 2007 DARPA Urban Challenge was a 60-mile race through urban and off-road terrain. Unlike previous challenges, other manned and autonomous vehicles would be present on the course at the same time. This required teams to obey California's driving laws and be able to merge with moving traffic, intersection progression, and execute U-turns.

Torc entered the competition in partnership with Virginia Tech, forming team VictorTango, and was awarded one of the \$1 million DARPA grants. The team finished third out of 89 teams, completing the event in four hours and 36 minutes. This early success and funding positioned the company to further develop its self-driving technology.

Blind driver challenge

In 2010, Torc partnered with a robotics team at Virginia Tech to develop a vehicle for the National Federation of the Blind's (NFB) Blind Driver Challenge. The team received the National Instruments' 2010 Application of the Year for the project.

On January 29, 2011, a blind driver independently drove Torc's vehicle down the main straightaway, onto the road course at the Daytona Speedway. While the systems were specifically designed for the Challenge, they were later used for other autonomous driving solutions.

Logging autonomous miles on public roads

After implementing Torc technology in two Lexus RX vehicles, they successfully logged robotic testing in more than 20 states while operating on both public roads and closed courses with zero accidents. The testing included a coast-to-coast trip across the United States and extensive driving in densely-packed streets such as those located in Las Vegas, Nevada.

Torc's autonomous vehicle technology has [successfully navigated](#) heavy urban traffic, aggressive tailgating, heavy rains, [snow](#), and highway detours.

The Torc team tests the vehicles daily when they are in Blacksburg and takes advantage of changing weather conditions, road construction and other variables to challenge the vehicles.

Virginia's limited regulation of self-driving cars also makes it easier for the company to develop, test and validate its systems. In the past, Fleming has met with government officials to encourage them to not over regulate self-driving cars because doing so could push companies to relocate.

AAA partnership

Torc and AAA Northern California Nevada & Utah (NCNU) announced a partnership in January 2018 to help develop safety criteria for self-driving vehicles. The [partners tested Torc's Asimov vehicle](#) in Las Vegas and California. The partners also pitted Torc's self-driving software against some of the most unpredictable traffic hazards during testing in November in a safe, controlled environment at Ohio's Transportation Research Center (TRC).

Expanding commercialization capabilities

In October 2018, Torc announced it had [integrated its autonomous vehicle technology](#) on a 2017 Chrysler Pacifica Hybrid. The Pacifica implementation includes LiDAR, radar, cameras, and GPS antennas that provide 360-degree perception of the vehicle's surroundings. The components have been updated from the versions used on the Lexus vehicles for commercialization readiness.

In late December, Torc announced it was [partnering with Bordrin Motor Corporation](#) to develop Level 4 self-driving electric vehicles for mobility services in smart cities. The partnership will incorporate Torc's Asimov SAE Level 4 self-driving vehicle capabilities with Bordrin's advanced and long-range electric vehicles.

In January 2019, Torc [announced a partnership with Transdev](#), an operator and global mobility provider, at CES 2019.