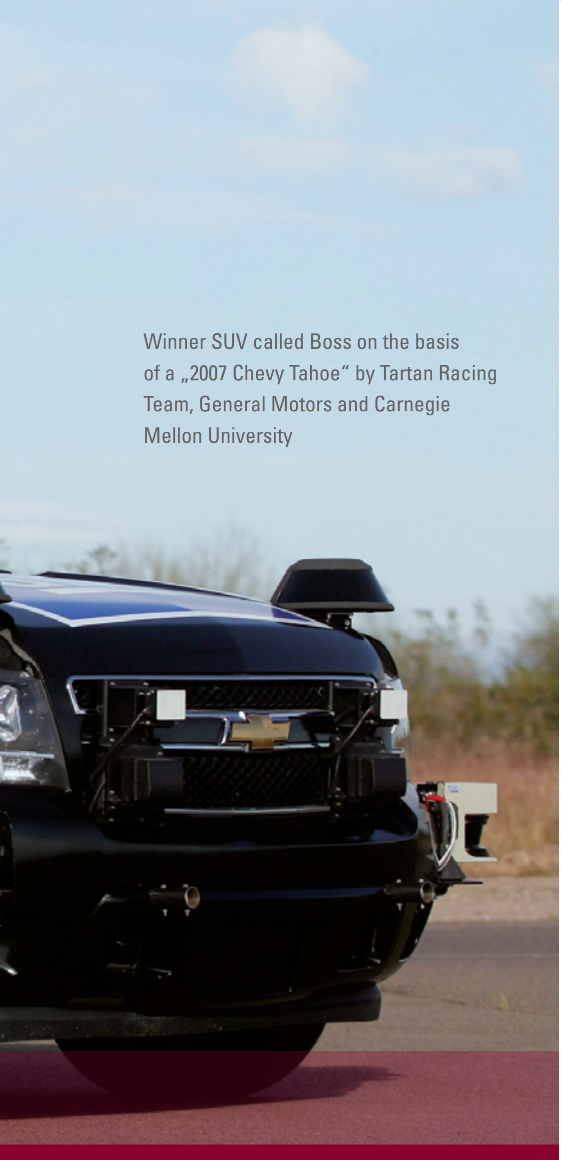
Darpa Urban Challenge 2007
Safe and Autonomous Driving

A driverless car race through urban traffic was the task facing the teams in the Darpa Urban Challenge 2007. Without any human assistance, a 2007 Chevy Tahoe called "Boss" navigated its way to the finishing line and won this year's rally. What sounds like the storyline from a science fiction film is in fact the future of driver assistance systems for safe and autonomous driving.



Winner SUV called Boss on the basis of a „2007 Chevy Tahoe“ by Tartan Racing Team, General Motors and Carnegie Mellon University

1 Challenge Urban Traffic

This was already the third time that the Defense Advanced Research Projects Agency (Darpa), the research centre of the US Department of Defense, had organised the Darpa Challenge as a race on November 3, 2007. Unlike previous competitions, which took place in the deserts of Nevada, this challenge in 2007 focused on accident-free driving without violating traffic regulations.

The cars had to move completely autonomously, performing actions such as parking in specified parking spaces, circumnavigating obstacles on two-lane roads, merging into flowing traffic and crossing intersections. The course covered almost 100 km through the authentic urban environment of the vast George Air Force Base in Victorville, CA (USA), around 160 km to the north of Los Angeles.

2 Technical Development

Packed full of computing power, Boss, the 2007 Chevrolet Tahoe from the Tartan Racing Team, set out on the challenging rally. The car was named after Charles F. “Boss” Kettering, Vice President of GM Research Corp. and co-founder of Delco. For two years, scientists and engineers from the team from Carnegie Mellon University in Pittsburgh, Pennsylvania (USA), had worked to bring the SUV up to the high technical level that secured its victory in the Urban Challenge.

2.1 Technical Revolution for Robot Cars

Using state-of-the-art laser technology, the Trocs software, which was specially developed for Boss, is able to sense stationary and moving objects and evaluate information on the width of the road, the length of parking spaces and stop lines. The autonomous car was equipped with a laser scanner supplied by the Hamburg-based company Ibeo Automobile Sensor that uses the “time of flight” measuring principle. The sensor emits a laser pulse with a range of between 30 cm and 200 m. If it encounters an object, the laser beam is reflected. A photodiode receives the reflection and processes it into a signal. By measuring the time difference between the transmitted pulse and the received reflection, the system calculates the distance to the reflecting object on the basis of the speed of light.

A second reflection measurement determines the velocity and the direction of motion. The software, which was individually programmed by the team from Carnegie Mellon University, uses the data from the laser scanner sensor to form a graphical animation, **Figure 1**, of the environment. More than 500,000 lines of code and ten high-performance PCs with 2.16 GHz Intel Core2 Duo processors are necessary to allow Boss to produce an image of its surroundings.

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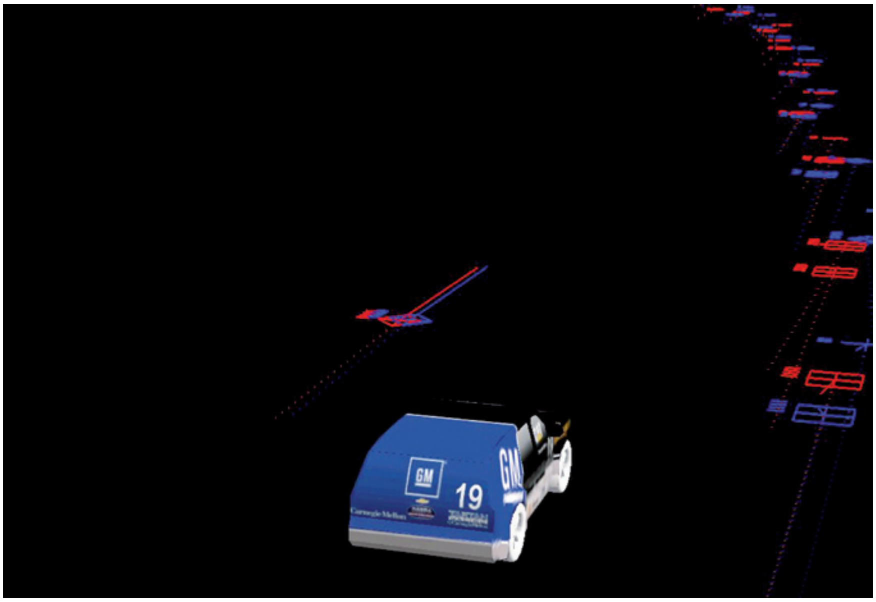

Figure 1: Software Trocs reproduces a graphical animation of the environment of Boss

2.2 Technology Carrier

In addition to the laser scanners, Boss is also equipped with GPS, cameras, radar systems from Sick and Tyco Electronics as well as with five of the latest-generation radar sensors from Continental Automotive Systems (CAS). A close-to-series ARS300 sensor is fitted to each side of the vehicle on so-called panheads, **Figure 2**. With an output of 76 GHz and an opening angle of 4.3°, the radar scans the close area with a range of up to 60 m and a 56° field of vision. In the long-distance range up to 200 m, the field of vision is 18°. With these values, the new sensor has a greater range than all other scanners currently available. A further feature of the successor to the series-production model ARS200 is the ability to determine the relative velocity of moving objects with an accuracy of 0.5 km/h. This means that Boss can not only decide within a fraction of a second whether it is approaching a moving object or a stationary one, it can also autonomously turn into junctions even with traffic. The ability to precisely measure the speed of passing vehicles allows Boss to find a big enough gap in order to join the flowing traffic. In addition to the sensors fitted to the front of the vehicle, there is a further ARS300 at the rear. This allows the race-winning SUV to precisely measure the speed of other vehicles after an overtaking manoeuvre and to move safely back into the lane. A decisive role is played by the sensor for ContiGuard, a driver assistance system developed by CAS, which networks the environmental sensors with active and passive safety systems in the vehicle.

Boss's tyres with ContiSeal technology – which also comes from the German automotive supplier located in Hanover – also helped the car to win the competition. Even though a screw had damaged the tread of the left rear tyre, the car was still able to finish the race, as a further protective layer had automatically sealed the hole.

Figure 2: Radar sensor ARS300 from Continental Automotive Systems

3 Outlook

"Technologies such as the intersection assistant or lane detector will be available for ordinary passenger cars in the near future," said Dr. Karl-Thomas Neumann, member of the Executive Board of Continental Automotive Systems, on the one hand. "This competition enables Continental Automotive Systems to drive forward the implementation of new technologies that will be used in driver assistance systems for production cars in the near future, representing a further step forward in improving road safety."

The US Department of Defense, on the other hand, has different goals in mind: From their point of view, the research is aimed at ensuring that, by 2015, one third or operational ground-combat vehicles are to be unmanned. The financial support given to the teams by the Defense Department will allow the Pentagon to benefit from the new technology. The scientists, however, see their work as progress in the interests of autonomous and safe driving. The technologies tested in the Urban Challenge make a valuable contribution to the further development of driver assistance systems. ■