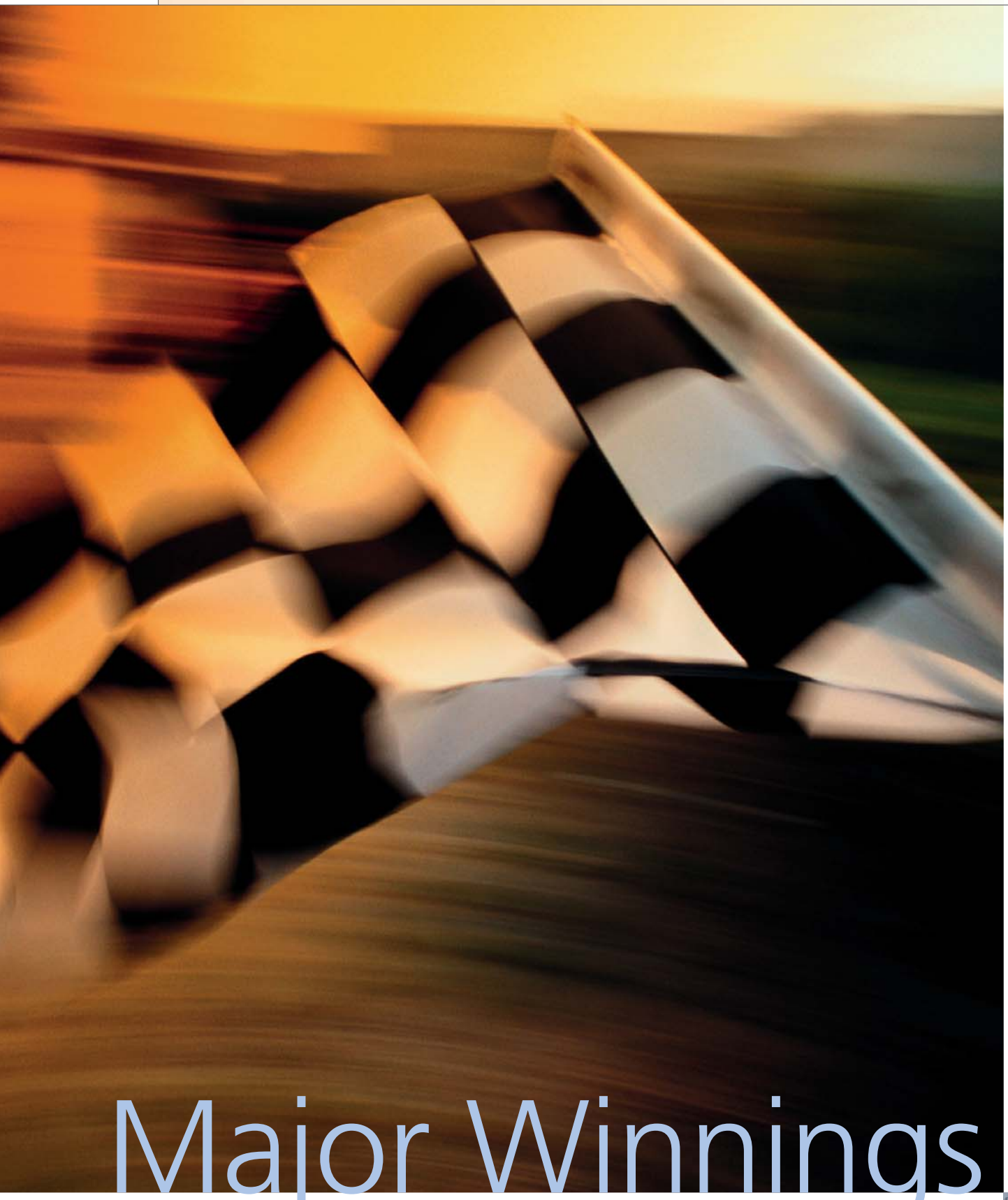


Major Winnings

at the DARPA Urban Challenge

Eleven robot car teams out of the original hundred made it through to the finals of the DARPA Urban Challenge 2007. The winning team and three other finalists developed the control systems for their vehicles with dSPACE tools.

The race on November 3, 2007 was the third competition held by the USA's Defense Advanced Research Projects Agency (DARPA) as part of its program supporting the development of autonomous vehicles. Unlike the previous two competitions, which had the robot vehicles driving through the desert, this time the finals took place in an urban environment. The teams had less than 6 hours to negotiate a 100 km route along the suburban roads of the former George Air Force Base in Victorville, California, about 160 km north of Los Angeles. The vehicles were required to negotiate live traffic while obeying traffic laws and avoiding obstacles, and to compute a new route to their destination if roads were blocked. To mimic road conditions as realistically as possible and to simulate normal urban traffic, the driverless vehicles had to face 50 additional cars driven by stunt drivers.

All the teams taking part in the DARPA Urban Challenge proved that autonomous vehicles can work. The teams developed their driverless vehicles in an amazingly short time, with the main focus on the further development of driver assistance systems.

Successful Teams with dSPACE Involvement

The winning team, Tartan Racing from Carnegie Mellon University, used dSPACE tools, and so did three other teams: TEAM CarOLO, Technische Universität Braunschweig, Germany; Team AnnnieWay, Universität Karlsruhe; Team Oshkosh Truck, Wicsonsin, USA.

Team CarOLO, Technische Universität Braunschweig, Germany

The interdisciplinary Team CarOLO from the Technische Universität Braunschweig consists of five institutes from computer science, electrical engineering, and mechanical engineering, and includes 6 professors, 10 other research associates, and 20 students. Together with students from the relevant university courses, the research associates conceived, designed, implemented, tested and optimized the concept and the software for an autonomous




vehicle called Caroline. The vehicle body is based on a VW Passat and equipped with special sensors such as multiple laser scanners, cameras, radar and LIDAR sensors to detect its environment. A high-performance GPS receiver is also used to ensure that the vehicle's current position is always known precisely. The team used the dSPACE MicroAutoBox as a development tool for the control system (longitudinal and latitudinal dynamics). This allowed various control algorithms to be evaluated quickly by means of rapid prototyping. The team got the project up and running within one year.

The challenge was organized in several stages. The first critical test was the site visit, a kind of quarter-final. The team went to San Antonio, Texas for just four weeks in June 2007 to perform intensive testing at the South West Research Institute. On the day of the site visit, the vehicle had to pass various tests on a circular track.

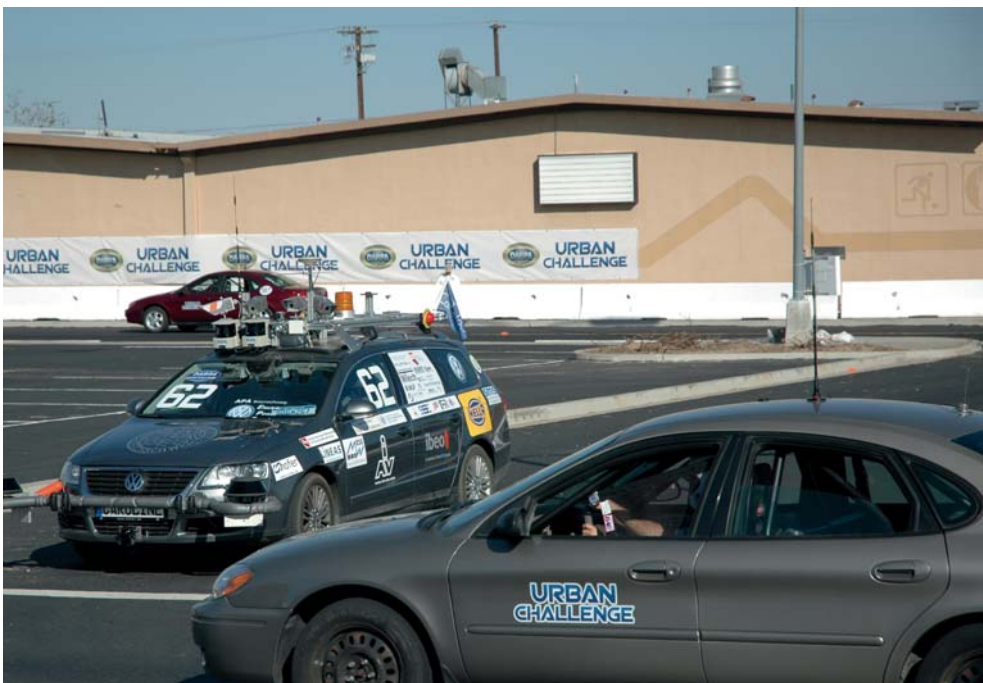
> "Within a year and a half, we succeeded in converting a normal, off-the-peg Passat into an automotive robot."
>
> *Jörn Marten Wille, Team CarOLO, Technische Universität Braunschweig*

Then the team returned to Germany to do further development work on the vehicle. About five weeks before the actual challenge at the end of October, the team flew to San Antonio again to perform final tests. A few days before the start of the National Qualification Event (a kind of semifinal) at the end of October, the team set off for Victorville, California. For days, the teams had to pass tests set up by the DARPA jury members on unknown terrain. Of the 100 teams that originally entered for the event, only 36 were still around in the semifinal. 11 of these were invited to the finals, which took place on November 3, 2007.

The know-how that the team gathered while developing Caroline will go into a follow-up project that will be carried out by the Institute of Control Engineering in cooperation with the Institute of Aviation and the Institute of Operating Systems and Computer Architectures. Caroline will still be used as a technology carrier for the new autonomous vehicle and for further research on autonomous driving in urban traffic. It is likely to be quite a few years, though, before this scenario is truly mastered. The Urban Challenge was a big step in the right direction, but it was only a very simplified scenario compared to the traffic conditions in a real city.

As project leader, Jörn Marten Wille from Team CarOLO at the Technische Universität Braunschweig was responsible for the development of vehicle control (longitudinal and latitudinal control and trajectory generation).

During the race: the autonomous vehicle Caroline encounters one of 50 cars driven by stunt drivers that DARPA put on the scene to create a realistic traffic scenario.



Moritz Werling from Team AnnieWAY from the Universität Karlsruhe, Germany. Werling was responsible for vehicle control.

AnnieWAY in training with its fellow robot Stanley at Stanford University in Palo Alto, near San Francisco.

Team AnnieWAY, Universität Karlsruhe, Germany

AnnieWAY is a joint team consisting of members of the TR28 special research department "Cognitive Automobiles" coordinated by Universität Karlsruhe and researchers at the Technische Universität München, the Universität der Bundeswehr München, and the Fraunhofer Institute of Information and Data Processing in Karlsruhe. The driverless vehicle is a VW Passat. Its electronic control system was developed with the aid of the dSPACE AutoBox. The control system is given the trajectory that the vehicle has to follow and receives indicator commands from the host computer via UDP (User Datagram Protocol). The controller is implemented on the AutoBox in C and stabilizes the trajectory by comparing the current position with the desired one. The position is provided by a coupled navigation device connected to the AutoBox via CAN (DS4302 CAN Interface Board). Finally, the controller's actuating variables for the steering wheel, accelerator, and brake are sent to the converted Passat via CAN. Digital I/Os (DS4002 Timing and Digital I/O Board) are used to engage the gears, to switch the laser scanner, warning lights and status LEDs on and off, and to read DARPA's emergency stop status.

> "My adrenalin still shoots up when I hear our car's siren in the video. During the challenge I had to get a grip on myself every time I switched the car 'live', then left it and waited for it to drive off on its own. During trials, we always had a driver at the wheel as a safety backup. It was even worse when the vehicle disappeared from sight. You can't imagine how relieved our team was when AnnieWAY came round that corner after completing the route successfully."
>
> *Moritz Werling from Team AnnieWAY from the Universität Karlsruhe, Germany*

This system has the following advantages:

- Meets tough real-time requirements, even with a non-real-time-capable PC.
- Safety functions can be implemented directly on the reliable AutoBox (emergency stop).
- Trajectory planning and trajectory control are not coupled.

While there can be no doubt that the challenge has given an enormous boost to the development of self-driving vehicles, it is actually only a sideshow. TR28's real goals are a lot higher (http://www.kognimobil.org/), even though achieving them is a long way off. In the future, the vehicles will have to cope without receiving prior information on their environment. A detailed map of the road network like that used by the vehicles in the Urban Challenge might no longer be necessary. A vehicle approaching an intersection would recognize it as such with the aid of its sensors. Data interchange between vehicles is also conceivable. ■

Team Oshkosh Truck, Wisconsin, USA

"We were mainly 3 groups working together – Oshkosh Truck, Wisconsin (headquarters of the Oshkosh company); Teledyne, California; and Parma University in Italy with the Artificial Vision and Intelligent Systems Laboratory (VisLab). We organized weekly teleconferences and many trips to the US to develop and test the system. The teamwork was very successful and well coordinated. We had several critical, very exciting situations. For example, we were still testing the system the night before the race. We – just like everyone else, I believe – had a very tight schedule that did not allow us to include everything we designed and realized. For example, we unfortunately did not use the whole potential of vision (we developed 4 systems and only used 2 of them!) due to lack of testing time. Oshkosh is indeed interested in having these technologies in its vehicles. For Oshkosh and VisLab the Urban Challenge was not just a race and nothing more.

We see a wide range of possibilities to implement these technologies on real vehicles as a retrofit. And we already did so: We demonstrated a palletized load system (PLS) vehicle able to reach a destination, unload, and get back autonomously. We did that just after the Grand Challenge, in January 2006."

"The whole event was amazing! A wonderful experience, even if our vehicle didn't make it to the finish line as it did two years ago during the DARPA Grand Challenge. We learned a lot from this and previous experiences: We already have 15 years' experience in the field of autonomous vehicles, but nevertheless this experience let us improve our systems in terms of robustness and maintenance."

Prof. Alberto Broggi, Team Oshkosh Truck, Parma University, Italy

The Oshkosh truck navigating the city streets.

Prof. Alberto Broggi was responsible for Team Oshkosh in the VisLab team. In particular, his group was involved with sensors for the surrounding environment. They used video cameras and a link between vision and laser for this.