

Navigation^{NEWS}

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The Rise of the Autocars

Navigation

NEWS

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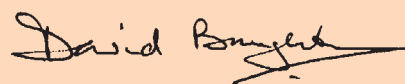
Comment

We go to press with fond memories of a spectacular AGM still bouncing round our heads. And what an AGM it was - a celebration of 60 years, a first real look at the Royal Charter and a new look for the future, all rolled into one.

Looking to the future, the re-branding of the Institute - seen in this issue, and emerging on the website - has generally received an enthusiastic reception although, it must be said, not by all. But as Peter Chapman-Andrews explained at the AGM, those who harp after the - admittedly attractive - image that has served us well for 60 years must face the reality that our numbers are dropping (by 12% in a decade) and our average age is climbing (56.6 years, climbing 5 months per year). What has served us well in the past will not do so for a future in which we must face reality and adapt.

There would be no future were it not for those past 60 years, and it was a privilege to be able to greet half a dozen of our founders - all well into their 80s - at the AGM. Within their ranks was the founding Director, Michael Richey, who hit his 90th birthday just one week later. We owe a debt of gratitude to these gentlemen and pass birthday wishes to Mike.

Let's hope that, in another 60 years, members will look back to a turning point where the Institute successfully altered heading to cope with a dramatically changed navigation environment.



David Broughton, Director

FRONT COVER

The cover of this issue shows the Elise-Fox, the robotic car developed by 'Team CART' for the 2007 DARPA Urban Challenge.

The US Defense Advanced Research Projects Agency (DARPA) has a strong reputation for advancing navigation science in the pursuit of military technology through its 'Grand Challenges.' This year, the challenge is going urban. Tony Fyler talks to DARPA and to some of the competing teams about the rise and rise of autonomous land vehicle technology.

'No-one on their death-bed has ever looked back and said "Y'know, I wish I'd spent more time with my family, and less time building supercool high-tech robots to hurtle through the city in a winner-takes-all race for million-dollar stakes."'

So says Dr Richard Mason, leader of Team Golem, one of the teams competing in the 2007 DARPA Urban Challenge. He has a point. DARPA's 'Grand Challenges' are custom-designed to get the creative and problem-solving juices of everyone from experienced academics to dedicated tinkerers flowing. And this year's Urban Challenge for autonomous land vehicles, or autocars, represents what Professor Norm Whitaker, Programme Manager at DARPA, describes as a 'quantum leap in difficulty' from even last year's requirements.

The Requirements – and the Prize

The Rules of the Urban Challenge set out exactly the kinds of obstacles the vehicles are likely to encounter:

The Urban Challenge course tests the vehicle's ability to operate safely and effectively with other vehicles in and around an urban environment. The course will be nominally 60 miles in total distance, with a time objective of six hours. The road surface will range in quality from new pavement to potholes and broken pavement. Sections of dirt road may also be encountered. The vehicle may negotiate sharp curbs, downed branches, traffic barrels, drains, hydrants, rocks, brush, construction equipment, concrete safety rails, power line poles, and other stationary items likely to be found in an urban environment. Vehicles will obey traffic laws as they negotiate traffic circles, intersections, and merge with moving traffic. Traffic on the route may be provided by manned vehicles, tele-operated vehicles, and other autonomous vehicles. Static vehicles may also be parked or stopped along the route. Roads may be blocked by DARPA during the course of the event. Trees and buildings along the route may interfere with GPS. Along some road segments there may be significant distances between waypoints, requiring vehicles to use their sensors to stay in the travel lane.

To complete the Urban Challenge, a vehicle must negotiate all hazards, re-plan for alternate routes, and avoid static and dynamic obstacles while completing a complex, multi-part mission at speeds of up to 30 mph, resulting in an average speed of at least 10 mph.

A particular cause for concern this year is that, in an amendment to previous challenges,

teams will have only five minutes to process their mission descriptions before sending their autocars out onto the course.

To the layman, it might sound like the stuff of science fiction – robots that can make their way, uncorrected by humans, through an urban jungle. But Professor Whitaker says the community of researchers in the autocar field has responded to the toughness of the challenge with an extra burst of enthusiasm.

'The extra difficulty has been met with a step up in levels of participation and investment, which is a great vote of confidence by the teams.'

There's also the matter of the money. First place winners – those who complete the course in the fastest time – stand to win \$2m. Second place brings the team a paltry million dollars, and third place winners drive off with a half-million. Which still buys an awful lot of spanners and circuit-boards.

It is arguable of course that there are easier ways of raising \$2m. 'Absolutely,' agrees Richard Mason, 'but none that are quite as cool.'

The Urban Challenge has come about as an outgrowth of previous DARPA events that have tested autonomous navigation abilities in desert environments. With the shift in US priorities to warfare and security operations in city environments, the idea of equipping vehicles with the technology to find their way through those environments without risking human beings has become not only ethically

Rise of the Autocars



economically attractive. But while Professor Whitaker admits that 'protecting the warfighter' is the meat and potatoes of DARPA's challenge projects, much previous development of military autonomous vehicle technology – including assisted parking and driver safety systems - has found its way into the civilian world. 'In both the military and civilian worlds,' says Professor Whitaker, 'we're dealing with life-saving technology.'

Approach Roads

Starting from the same premise and rules and with the same incentive, there are almost as many approaches to the Urban Challenge as there are entrants. Asked to delineate their thinking on the challenges, Team CART from West Virginia, builders of the Elise-Fox, say that for them, it comes down to developing multiple benefits from the same investment. 'What we're building is an example of a plausible, attractive, interesting electric car, integrating our remote control systems and studying a cadre of algorithms and software that we plan to spin off. For us, it really comes down to working more carefully with fewer resources and without backup equipment.'

Team Stanford on the other hand is putting a strong emphasis on artificial intelligence software. 'With a lot of our equipment being off-the-shelf, we don't feel we need to custom-build a lot of hardware,' they explain. 'That frees us up to focus on what we do best – exploring probabilistic reasoning, machine learning and other AI techniques to help our robot make decisions under complicated circumstances.'

As former Grand Challenge winners, Team Stanford know their AIs from their elbows. But they say the extra difficulty this year is making them look again at their systems.

'The challenge this year is to go from robots that sense their environment to robots that *understand* their environment. In the last Grand Challenge [in a desert



The coolest way to earn \$2m?
Team Golem's Challenger

environment], it didn't matter whether that lump on the right was a rock or a bush, because either way, you'd drive around it. This year, the robots must reason about moving objects, including other robots, and their intentions. That's where probabilistic reasoning, in which a robot uses not formal logic but assessments of what it *likely*, can play an important role.'

In contrast, Richard Mason says Team Golem is focusing on 'the less glamorous elements, like getting the car to stop in a smooth, accurate manner. Ordinarily,' he adds, 'you just hit the brakes – how hard can that be? But when you get into it, you realise that we have very poor intuition about what does and doesn't require "intelligence", because we don't appreciate what our brains do very well.'

Tackling the GPS outage question head-on, Team 23 is putting its faith in what it calls 'a unique optical system, that will let our vehicle navigate entirely without the aid of GPS,' while Team Insight, in another Lotus, is focusing on space efficiency and scalable solutions (including rapid processing), to appeal to both military and civil markets.

A Bunch Of Dropouts though probably has the most honest answer. 'We're on a very steep learning curve, and we've been addressing the challenges we've faced so far with the rigorous adherence to an unpaid 112 hour work week.'

Even If We Don't Win... We Win

Naturally, with so varied a field, the motivations that drive each team are equally diverse. While Team Golem may simply want to have no death-bed regrets, Team Stanford takes a highly philosophical view of its entry. 'Even if we don't win, we win,' says the team's David Orenstein like a modern-day Confucius. 'We and all the teams will have made important contributions to the field of robotics, and everyone benefits from that.' Team CART, taking up the middle ground between Golem and Stanford, merely asks 'Where else would you rather be, and what would you rather work on? We've been fielding intelligent technology for a decade, and this is a natural progression from that. If something's described as a "Grand Challenge," you can count us in!'

The Dropouts (so named because the three leading members of the team are genuinely high school dropouts) see the Challenge as a proving-ground. 'It's a very rare opportunity for those of us who are not members of the usual circles of big industry and big academia to participate in developing and testing exciting new technology,' says Kevin Jackson, team leader. 'I've been fascinated by machine intelligence and cognitive science for a long time and this is a chance to actually do something in the field despite being an outsider and an underdog.'

Everything's A Concern

As *Navigation News* goes to print, many of the teams are in a flurry of activity, preparing for and undertaking their site visits by



Junior – Team Stanford's hyper-intelligent baby



Eyes front! Team Insight's Challenger has plenty of sensors

DARPA officials, with no guarantees of even making it to the start line in November. There are a series of stages, at which various technical elements of the machines are tested to ensure they are developing sufficiently well to stand a chance in the competition. Many of the teams are still concerned about one element of their approach or another. Kevin Jackson views his chances with candour. 'Since none of us had ever *built* a robot before, we've had some pretty steep learning curves to get all the

actuators and sensors working together with a reliable computing platform. These issues are why we didn't make it to the *last* Grand Challenge. Still, what was it Benjamin Franklin said? "If at first you truly suck, try, try again"? Something like that anyway. Right now my main concern is getting the machine's vision system running fast enough to see other vehicles' positions relative to limit lines.'

Candour – or graveyard honesty – is not in short supply at Team CART either. 'Oh,

everything's a concern,' admits team leader Bruce Mutter. 'Several issues come immediately to mind. Required extraction manoeuvres, sensor reliability issues, testing time...the thing is, it's intended to be difficult, but we have to remain confident, or there's no point.'

Testing is also the chief concern at Team Stanford, which in dealing with probabilistic reasoning, has significantly different issues to weed out. 'A lot rides on the testing, certainly,' says David Orenstein, 'but we have an extensive regimen planned over the summer.' David goes further, adding that while difficult, he believes the Urban Challenge is 'entirely realistic' in 2007. 'In fact,' he says, 'we are confident that in a matter of decades, cars will truly be able to drive themselves, making driving safer for everyone and providing other benefits.'

It's a provocative statement, echoing the prediction of Professor Brad Parkinson at the European Navigation Conference in 2006. Professor Whitaker of DARPA acknowledges the technical possibility, while pointing out that there is still, in 2007, much more to driving a car than just technology. 'Autonomous vehicles are already a reality in many niche markets, and insights, approaches and technologies developed under the Urban Challenge programme are immediately applicable to several of them. The act of driving an automobile though depends on substantial infrastructure support, and the introduction of autonomous vehicles would require progress in a number of areas, including driver training, liability insurance, traffic signals and the legal system to name just a few, so widescale deployment of autonomous technologies will take longer. But the death toll every year on US highways alone is over 40,000 lives. Research and development efforts that are able to provide even fractional solutions will positively impact countless human lives, making the dollar investment more than worthwhile.'

'I helped save around 40,000 lives a year in the US alone.'

Now *that* would be good thing to remember on your death-bed.

How many of the teams make it through to the starting line in November, out of a field of more than 50, will depend on how well they address the outstanding issues they each face, and *Navigation News* will keep you updated on their progress. For more information on the Urban Challenge and the teams intending to meet it, visit www.darpa.mil/grandchallenge



SAMI - A great looking Challenger from A Bunch of Dropouts