The mechanical army

Is it a beach buggy or a lunar module? No, it's a secret weapon designed by techies and aimed at winning the Pentagon's million-dollar battle of the robots

REPORT BY POPE BROCK
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The tortoises had nothing to worry about in the end. Out there in the desert somewhere, along with the 80 U.S. Marines deployed to guard the route, and the hundreds of sheriffs' deputies, state police, crossing guards, Bureau of Land Management agents and Fish and Wildlife personnel – not to mention the control cars trailing the robots, and the army helicopters chattering overhead – 20 biologists were creeping through the sage bushes putting temporary pens around every desert tortoise they could find, the tortoise being an officially protected species.

Worthy work, but in this case a waste of time: out of the 15 robots who took on the Darpa (Defense Advanced Research Project Agency) Grand Challenge, a 142-mile race from Barstow, California, to Primm, Nevada, the farthest any of them got was 7.4 miles, or 5% of the way. On the other hand, you could say they did pretty well, considering that when the Grand Challenge for autonomous ground vehicles (AGVs) was first announced in January 2003, AGVs barely existed.

For years Darpa, which is an arm of the Pentagon, had been trying to encourage defence firms to build them — a congressional mandate had insisted that at least one-third of the US Army's battlefield vehicles should be robot-driven by 2015. The quest was given momentum by the Iraq war, particularly by the episode of Jessica Lynch, the army private who was dramatically rescued from enemy hands. Eight other members of her supply unit died, which would not have happened if AGVs could have replaced them. "It's extraordinarily important. This technology will save American lives," says the Darpa director, Tony Tether.

Thus the Darpa Grand Challenge was born: a $1m prize would go to the inventor of the first robot able to traverse a long and deliberately Iraq-like route in under 10 hours. As Colonel Jose Negron, the programme director, said at that first press conference in 2003, the goal was to, "accelerate technology, to reach out to folks who don't ordinarily work for the Department of Defense. The high-school student who's writing software while his mother's banging on the door saying, ÔCome eat,' that's who we're looking for". And, of course, anybody else with a bright idea.

The result was an onslaught of proposals from engineering companies, universities, hobbyists and junkyard warriors of every description, even a California high-school team. In all, 106

technical papers were submitted, which were slimmed down to about 25 finalists for what promised to be, if nothing else, a very good party.

It's a surprisingly frisky concept coming from the Pentagon, but the unit known as Darpa is like no other US government agency. Created in 1958 in a technological panic — the Soviets had just put their first satellite, Sputnik, into space — Darpa today has 140 programme managers, an annual budget of nearly $3 billion, and a mission captured in its motto: "Transforming Fantasy".

Its projects (about 200, many of them secret) are spread among labs at universities and corporations all over the country; the research horizons range from five years to 50 and beyond. Planes that change shape in flight; soldiers in super-suits leaping over 20ft-high walls; hulls and fuselages that, if damaged, could heal themselves like bones. All these and more are being pursued to help America prevail on "battlefields of the future". None of them can be dismissed out of hand, since Darpa has some grand successes to its credit, first and foremost the internet, which it gave birth to in the 1960s. It has also been responsible for the global-positioning system (GPS) and the computer mouse. Not surprisingly, there have been fiascos as well: for example, the mechanical elephants that Darpa once hoped to send crashing into the jungle after the Vietcong.

In the past year, the agency has had some of its worst publicity thanks to two especially benighted ventures: the privacy-replacing Total Information Awareness network (a project now quashed, so they say), and FutureMap, the short-lived global betting parlour that offered the chance to make money by predicting acts of terrorism. But for a dream factory like Darpa, this stuff comes with the territory. Given all the dead robots left strewn along the trail, the Grand Challenge may seem like another fiasco, or at least a failure. Not so. By investing £7.5m — snack money by government standards — Darpa put dozens of the country's best minds to work on the puzzle of how to make a vehicle drive itself, and put them to work for months, day and night, for free. The race was proof that the seeds are there. It can be done. But not yet.

Two days before the challenge, we're gathered, robots and all, at the California Speedway in Fontana in a hot, stiff wind. It's the last afternoon of the QIDs — the qualification, inspection and demonstration trials; elimination rounds to see which of the 20 or so robots who have made it this far will compete in the big event. The way things are going, it may be zero. Still, the robots are great to look at, a collection of re-wrought Hummers (large SUVs), dune buggies, all-terrain vehicles — there's even a self-driving motorcycle — festooned with sensors, gyroscopes, lasers and multicoloured wiring.

On a highway test run the other day, the Golem — built by a Santa Monica team out of an old pick-up truck — was swarmed by police who thought it was a terrorist device. The budgets are as varied as the robots. Richard Mason, head of the Golem team, has funded his effort with the $35,000 he won on a TV quiz show ("My best category was English poets," he says). But whether the contestants have invested over $3.5m (the Carnegie Mellon squad) or $9,000 (three guys from New York), they share the same dream: to create a machine that can track its own position, perceive an obstacle — with the help of cameras and lasers — revise its route, and do it all really fast.

The two Rover robots now on Mars share some of this same technology (though humans are ultimately in charge). They operate, however, at a top speed of one-tenth of a mile an hour. Estimates are that for a robot to win the Grand Challenge in under 10 hours, it will have to average better than 20mph. And one more thing: even if the software divisions within each robot work fine on their own, they often come to grief when trying to talk to each other. Systems fusion is what the Darpa director, Tony Tether, calls the "secret sauce" — so far there's no such thing as flawless control software. Nearly everyone's exhausted from weeks of all-nighters, and nobody feels ready. "We need one more week and we have six hours," says John Porter, 53, head of the SciAutonics1 team and a British expat from Ascot, Berkshire. "Everything has come together too late." Most want a month, if not a year.

Out here on the oval track, the obstacles could not be less imposing — two corrugated tin gates, several old cars — but few manage to negotiate them all. The others are bucking, stalling and carrying on like teenagers with too much homework while an unseen announcer describes the action over a PA system ("CajunBot has engaged the wall"). Every few minutes another failure is dragged or driven off the track, back to garage bays nearby which have turned into long rows of emergency rooms — though Team Axion's work-pit is cheered by the presence of the so-called Axion twins, a pair of leggy blondes in off-the-shoulder powder-blue tank tops, who are selling and signing calendars and (according to Axion) "answering questions about Autonomous Ground Vehicles". Then up to the starting line comes... which one is that? It looks like a tank with a steam shovel for a nose, and a big alligator transfer stuck way out front: the Autonomous Solutions Navigator from the University of Florida. Three, two, one... It zooms off but stops almost immediately, seeming to sniff something on the wind. Slowly it swings 45 degrees right ("No! No!" cries a voice from somewhere), then points its snout toward the fence where I'm standing about 100 yards away. It starts up again, gathering speed. Flattening a couple of traffic cones, it heads towards me like a rhino, banks into the concrete with a great scraping sound, rolls over a gate, then stops, apparently spent. But no. Doing a full and precise 180, it points itself directly at the concrete wall again, and the cluster of spectators behind it, takes off and smashes into it at full speed, tangling the steam shovel with the gator face in the wire fencing above. Only seven of the 20 robots make it around the course. But it's a measure of how fast Darpa is loosening the rules that when the 15 finalists are chosen — those going on to Barstow — the Navigator makes the cut.

Friday, March 12: the Grand Challenge circus train arrives at the Slash X Cafe biker bar outside Barstow. Ordinarily, the Slash X, a rectangular box with a steer's skull over the door, sits by itself in the empty desert, but not today. Big white registration and barbecue tents have been set up out back, and behind them stretches a metropolis of trailers, cars, robots and lots and lots of people. Beyond that, there's nothing but sage bushes and critters, which is why the Slash X has been chosen as the starting line for the big race: its back door opens out onto 58,000 acres of government preserve, an off-road biker's paradise. For months after it chose this spot, the Pentagon kept it a secret for security reasons. "We had to keep it under wraps till a week ago," says Tina Bilby, the cafe owner's daughter, "or they'd have buried me out back."

But there's one big secret left. None of the teams knows exactly what the route is going to be. At 4.30am, two hours before the start, each will receive the RDDF, or route definition data file, a CD-Rom containing several thousand global-positioning co-ordinates, called waypoints, which

will tell them what track to follow, where it narrows, where it widens. Just how many GPS points will be required is unclear, since the length of the course has been shrinking like a cheap suit. Months ago Darpa was talking about 250 miles or so, but that's been whittled down to under 150 — "Approximately the distance from Baghdad to Takrit," as Tether says. For some at least, this sounds remotely feasible, assuming their robots can start. Ladibug, built by a small Missouri firm, is still having big problems, despite recently having been blessed by a couple of orange-robed Buddhist monks in Los Angeles.

March 13, dawn: up into the grandstand near the starting line, where 200 people sit swathed in coats and drinking hot coffee, three young men climb, take off their shirts and start painting each other orange. First a big letter on each chest — CIT for California Institute of Technology — and then on their backs BOB, for Bob, the name of the Cal Tech robot. The buzz on Bob has been pretty good, despite its cracking into a start chute in practice yesterday and losing a couple of parts.

The first robot rolls into view: No 22, Sandstorm, a modified red 1986 Hummer from Pittsburgh's Carnegie Mellon University. Known as "Big Red", Sandstorm was built by the Red Team, led by the legendary if egomaniacal William "Red" Whittaker. An apostle of the potential of robots to change the world, he has been a groundbreaker in the business since the 1980s. His robots have searched for meteorites in Antarctica, assessed damage at Chernobyl and pioneered the 3-D mapping of mine shafts. He's got a big team: 30 graduate and undergraduate students. Just days before the QIDs, Big Red cracked up going too fast on a turn and sustained serious damage, making last-minute work especially frantic. "You can rebuild a lot of electromechanical elements," Whittaker says, "but you can't recover that tuning and skills of 1,000 miles of practice. That's just how life goes. There's no great race team that hasn't felt the sting of mishap on the eve of action."

Just then, four marines in full dress uniform appear across the way, riding identical palominos. Two of them hold flags like sceptres. They come to a solemn stop. Several generals on the announcer's platform remove their hats. An unseen woman sings The Star Spangled Banner and Tether's speech is drowned by a helicopter. The robots will be released one by one, at five-minute intervals. The first countdown begins. "We're 30 seconds from history!" cries the announcer. A man in a black-and-white referee suit whips a green flag. Sandstorm's strobe light comes on. "Ladies and gentlemen, Sandstorm!" The vehicle slides smoothly out of the chute, crosses the starting area, and makes a left. There it is in embryo: the small amazement of a machine turning left where the left is. In the grandstand, dozens crane to see as Sandstorm moves down a half-mile or so of dirt road, turns left again, and cruises across our line of sight like an ocean liner, then vanishes into the hills.

"Ladies and gentlemen, in chute five, Bob!" The guys painted with orange letters go predictably nuts. Bob, originally a 1996 Chevy Tahoe, starts off without incident, makes the left, then heads down the road, makes another turn — and stops. Hundreds of hushed spectators watch to see what Bob will do next. Apparently nothing, at least for now. So DAD, a computerised ex-pick-up truck from a firm called Digital Auto Drive, gets the green flag. We watch DAD. DAD passes Bob.

An encouraging start, giving little hint of the carnage to follow. In the next few minutes, No 25 from Virginia Tech stops dead, smoking, 20 yards from the start line and has to be shoved off. Axion's modified Jeep Grand Cherokee wanders off in front of the grandstand like a bloodhound trying to recover the scent before quitting the race. CajunBot runs into a rock. "Can you imagine the people in the Middle East seeing a bunch of these autonomous vehicles coming at them?

They'd have thought the world was coming to an end and surrendered without a fight!" the announcer cries, as No 13 from Falls Church, Virginia, trundles past the grandstand and turns over on its side. Navigator, the robot that attacked the fence at the QID, gets a bit farther before lurching off the trail and wrapping itself in barbed wire.

Bob's moving! But he has only turned sideways. Sandstorm is still out there, plugging along over the roads still after that million bucks. It's the best we can hope for as the rest of the field, including the motorcycle, come to more or less immediate grief. As this isn't a Disney movie, the Doom Buggy, built by high-schoolers, runs into the first wall it sees. Then suddenly there's a whisper in the grandstand that Big Red is in trouble. Conflicting rumours, none good: eventually we get the truth, that trying to negotiate a sharp-angled turn, Big Red's left wheels went over a cliff, and another tyre caught fire trying to spin the vehicle free.

Just after 11am, Tony Tether announces: "The Grand Challenge ended about 10 minutes ago when the last robot went out." Top finishers are 7.4 miles (Sandstorm), 6.7 (SciAutonicsII) and 6.0 (DAD). Golem is fourth at 5.2.

High above Buffalo Bill's casino in Primm, Nevada, 25 miles outside Las Vegas, there is a rollercoaster, a huge yellow worm with boxes of screaming people that twists and banks and shoots right down through the ceiling, just over the heads of thousands of other people too immersed in slot machines, roulette and blackjack to notice. Claustrophobic and vast at the same time, Buffalo Bill's is blasted by live rock music and lit almost entirely by eye-pummelling neon. It stands in polar opposition to the kind of thinking required to build a robot, the purpose of Buffalo Bill's being to dislodge all reason.

Someplace right outside is, or would have been, the finish line. It's late afternoon, and in the casino's back parking lot, members of the public browse like museum-goers among the robots that have been trucked or driven the rest of the route. The University of Louisiana team is cooking up a Cajun stew. Col Negron, the Grand Challenge director, is among the throng. "Not all the vehicles went as far as we'd have liked," he says, "but just to see them going out of the gate, doing seven miles, that's outstanding. I don't think people comprehend how difficult that seven miles was."

He promises another challenge, probably within 18 months, the date to be announced this summer. Nearly all the competitors say they'll be back; most also believe that next time, the prize will be within reach. After that, who knows?

It's not as though all robots have to join the army. "Within 20 years I think a growing majority of automobiles will be auto-controlled," says Bruce Hall, co-head of the DAD team. "You get in

your car, press a button and don't touch anything again till you get to your exit." Leaving you free to concentrate on swearing at the traffic.