Robot wars

Fourteen teams of engineers will go head to head in a bid to meet some of the military's toughest challenges. Max Glaskin reports

The MoonBuggy, above, developed by Cumbria's Smith Engineering, will join forces with a UAV to spot snipers and detect IEDs

THIS SUMMER 14 teams of engineers drawn from UK industry and academia will load their vans, travel to a quiet corner of the Wiltshire countryside, and engage in a series of robotic exercises that will shatter the peace of the surrounding livestock.

The MoD Grand Challenge — which will take place in August at Copehill Down, a mock village built during the Cold War — is the latest effort to stimulate the development and use of the kind of autonomous robotic systems expected to revolutionise the battlefield of the future.

The competition is more subtle than its US forebear, the DARPA Grand Challenge, which, after three rounds over six years, is now bearing fruit in the form of reliable robotic vehicle technologies. In contrast, the UK competition runs for just 13 months and the robots must multi-task to acquire sufficient data so that their control station can identify four different threats — some of which are nigh-on impossible for even experienced soldiers under certain conditions. The teams involved in the competition, have to create semi-autonomous robots that can find a sniper, an improvised explosive device (IED), a 4 x 4 vehicle with a gun on it and a group dressed in semi-military uniform carrying arms, and get the information back to a two-man forward control station.

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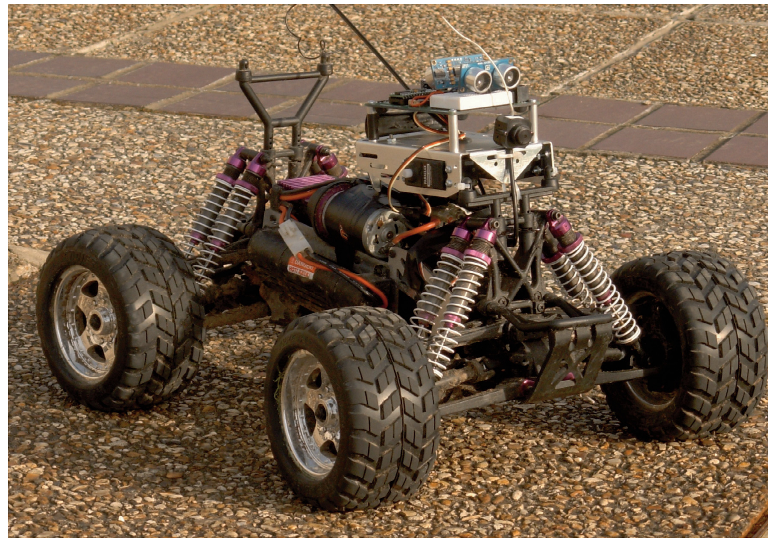
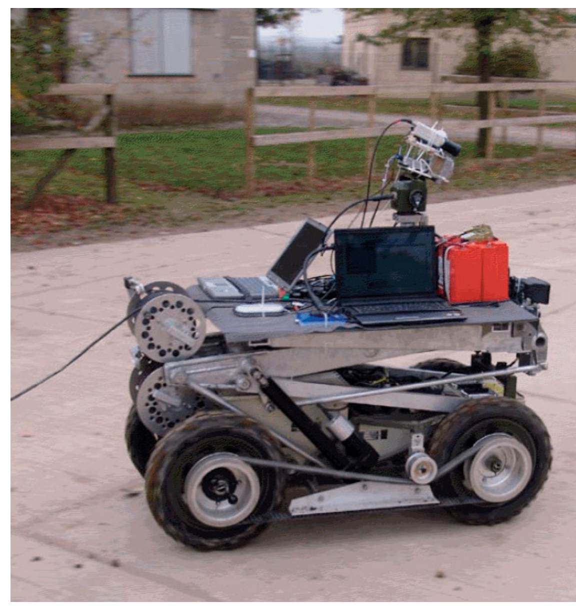
To win the challenge trophy and the opportunity for lucrative MoD contracts, the teams must integrate





their autonomous mobile platform with a suite of sensors and data retrieval and analysis techniques.

For the MoD the competition is a different approach. 'It's a new business model for us and it won't be the last of the new initiatives we will follow to engage with industry, SMEs, academics and schools to promote the requirements and needs of the MoD,' said Andy Wallace, leader of the Grand Challenge programme.

'We want to tap into innovations that maybe we haven't in the past so we observed DARPA's competition and have adapted it to what we and our people on operations need. We were conscious that we want to provide a depth to the challenge and we're under no illusion that it's difficult,' said Wallace.

'We might be asking too much of the teams, but we aren't expecting them to start with a clean sheet. We are looking for technologies that are partially mature and would be integrated on a platform to make a solution. We're keeping up to speed with the teams and the sorts of technologies they're working on to see if they are capable of finding the threats. But we won't know until the final how good they are,' he added.

Blue Bear System's UAV, above, will be used by the Stellar team, while Mindsheet's system of autonomous ground vehicles, top right and above right, can each travel at up to 30mph

Of the 14 teams, six have won MoD funding, six more are funding themselves and two are focusing on specific elements of the challenge rather than all of the tasks. The teams coalesced after the MoD held open days last year for all interested parties and they have since visited Copehill Down to get the measure of the environment their robots face.

With the rivalry among the teams palpable and the desire for a competitive edge keeping many of the technical details under wraps, eight of the teams spoke exclusively to *The Engineer* about their entries.

With experience at using visual and thermal imaging sensors onboard unmanned aircraft used to monitor oil and gas installations London-based Barnard Microsystems is opting for an aerial solution to the challenges laid down.

'We're going to use at least two small quadrotors as our sensor platforms — helicopters with a rotor at each corner. They don't have good forward speed and the small blades must rotate fast but they are stable,' said team leader Joe Barnard. Visual imaging will be used in daylight, combined with motion de-blurring technology to optimise the clarity of the images. It will use 12 megapixel cameras to generate image files of up to four megabytes after JPEG compression, and the team recognises this volume of data would strain many methods for transmitting back to the control station. So the data will be stored on board and downloaded only when the craft return.

'We've looked at thermal imaging to spot snipers, but some are so well wrapped up in clothing, with only their eyes uncovered, that the technology picks up very little,' said Barnard. 'It's different at night, of course, where it can be hugely valuable, so we might switch payloads for night operations.' His team would like to use a near infra-red imaging system with an eye-safe laser searchlight. But it costs about £10,000.

Meanwhile, the Silicon Valley Group — a consortium including Kingston and Reading universities and Cumbria's Smith Engineering — is looking at combining an aerial solution with a ground-based vehicle.

Options for a low-cost, unmanned air vehicle (UAV) have included a hot air balloon and a powered glider but it's now thought that a tethered kite would give the required elevation and a measure of positioning control. Smith Engineering is supplying a MoonBuggy ground vehicle and GPS will be used for autonomous vehicle positioning.

'Our prime interest is in acquiring and processing digital stills of the area to be observed for threats,' said team leader Norman Gregory. 'We have unique image recognition software, a semi-autonomous ground control station and the ability to identify wires suspended between structures. And suddenly we've got the loan of a thermal imaging sensor.'

The Stellar team, which includes Bedfordshire-based Blue Bear System Research, Cranfield University, SELEX Sensors and Airborne Systems, Marshall SV Systems Design Group and TRW Conekt, has also opted for a combination of an unmanned ground vehicle (UGV) and autonomous aircraft.

'A ground vehicle on its own is vulnerable and low-level UAVs are at the mercy of the wind,' said project leader Julia Richardson. 'We'll also have a high-level UAV capable of carrying a heavier payload. The UGV will have thermal and optical sensors and I've been very keen on getting radar on board because the main problem of the challenge is spotting armed people. Radar is fantastic at spotting significant pieces of metal, which is a pretty basic discriminator for weapons.'

Middlesex University's I-Spy team has a different idea on how to approach the challenge and is developing two very different air vehicles: a nano air vehicle and a micro air vehicle that will work together to identify and locate the threats.

'We've attacked the problem with an open book,' said project leader Stephen Prior. The nano vehicle weighs up to five ounces (150g). 'It's small, compact and rugged,' he said. 'It's simple but more sophisticated than a mirror on the end of a stick.' The micro vehicle has a maximum take-off weight of 2.5kg and uses multiple rotors so that it can hover. 'It's not a quadrotor and we won't say exactly what it is because we don't want to tip off anyone yet."

Rob Mullins' Locust team is also planning to use two flying platforms. A 60cm dia hovering disc powered by batteries and thermo-electric generator, will transmit audio and video via a secure link to a soldier's PDA. 'We can get information back to troops immediately,' said Mullins.

Copehill Down in Wiltshire, below, will this summer become the scene of the UK's answer to the DARPA Grand Challenge

‘Every piece of technology we have started to use has been trumped by something new as the project has progressed’ Stephen Crampton, Swarm Systems

‘Throw it, fly it, receive the information. If it takes any longer than that it’s too late.’ The disc can fly pre-set patterns so is semi-autonomous and has anti-collision sensors. The cameras have automatic focusing and near infra red capabilities. The aircraft body is made using a secret process and with the engine the total weight without payload is just 10g. ‘It’s a somewhat sophisticated rotor the design of which, for now, we have to keep secret,’ said Mullins.

The second platform is an aircraft with a 10in (25cm) wingspan which can fly 1.2km and return. It weighs just 38g and has flown successfully in crosswinds of up to 17mph (15 knots). ‘Our platforms are safe, with no external impellors and we have put as much intelligence as possible into the payload so the data can be encoded into any format,’ claimed Mullins. ‘They can store up to four gigabytes on board, or transmit the data back to the PDA hand controller. We are not trying to make things complicated for the soldier. We make the task simple.’

The Swarm Systems consortium is opting for yet another approach with the development of a flock of eight quadrotor micro air vehicles (MAVs). Bristling with sensors and armed with five megapixel cameras, these small flying machines, each weighing less than one kilogram, will fly autonomously, guided by GPS, and use Wi-Fi to transmit image files back to the base station for processing.

Leader Stephen Crampton is confident that his consortium, which includes experts from Essex and Surrey universities, is on the right track. ‘We’re able to use the same approach to find all four targets,’ said Crampton.

The speed of change in sensing technologies has also led Crampton to reconsider an earlier decision not to use thermal imaging. ‘When we started, the sensors were too heavy for our vehicles and, at £10,000, too costly. But a few weeks ago we found some new ones that might do the job and cost only £3,000. In fact, every piece of technology we have started to use has been trumped by something new as the project has progressed — it all gets better, faster, lighter, cheaper.’

Crampton, believes the MoD is right to give teams just 13 months. ‘They won’t see the reliability levels that DARPA Grand Challenge entrants achieved with their two-year contest, but they’ll learn a lot because each team will be the best in one or two areas. The team that will win will be the one that has done the most testing.’

R&D firm Mindsheet also believes that a large number of vehicles is the way forward but, with the exception of a tethered aerial observation platform is developing a swarm of small autonomous ground vehicles. Each able to travel at up to 30mph to avoid capture, these vehicles will fan out across Copehill Down, all following pre-designed courses mapped by GPS and with obstacle-avoidance sensors on board to prevent collisions.

Their whip aerials will permit communication with the forward command post or, if the Wi-Fi connection isn’t working, GPRS will be used. ‘It’s not rocket science, getting telemetry to work and to use vehicles as relay stations,’ said leader Raglan Tribe. ‘We’ve developed a threat detection system according to the pose and movement of people and it currently works off-line, using thermal and video imaging to classify moving patterns and identify if they are anomalous.’

Tribe believes the two hardest challenges will be to spot a sniper and an IED. ‘We asked a sniper where he would go and learned from his answers that trying to identify someone of his calibre would be a bridge too far for us. And we have no idea at all how an IED will be packaged.’

Though many of the teams involved draw heavily on the UK’s academic research, some defence big-hitters are also hoping for a successful result. Qinetiq’s Coretex team, for example, hopes to draw on the company’s vast experience in military technology.

Team leader Indi Hothi revealed that its platform will be a UAV with vertical take-off capability, a one-metre wingspan and long transient flight capability. ‘It’s unlike most other UAVs,’ said Hothi. ‘It can be disposable if necessary. It is low cost so if it is lost it’s not prohibitive, and it’s light enough to be carried by a soldier.’ Intellectual property issues and competitive advantage prevented the release of information about the Coretex control station and sensors.

With less than six months to go before the final, the MoD’s Wallace is impressed with all the teams’ approaches. ‘The Grand Challenge was designed so there would be no constraint on people’s development processes, so they could give free rein to their imagination,’ he said. ‘Now we are considering how we can offer opportunities to the teams that have attractive technologies.’