Rolf Gebhardt and **Norman Gregory** examine the problem obstructing vehicles present to IEDD officers attempting to defuse a VBIED, and outline a new vehicle-moving system which could save valuable time and even lives

BLOCKED IN

Each new terrorist attack committed around the world, and each renewed statement by international terror groups about their intentions to continue disruptive activities, offers a stark reminder for established nations that they cannot let their guard down. During 2013 there were 152 terrorist attacks within the European Union, according to Europol, of which 31 were bomb attacks, compared to 91 bomb attacks in 2012. Proactive policing and intelligence-gathering by Europol and member states has resulted in successful prevention of recent terrorist attacks and has played its part in reducing the number of attacks from 316 in 2009 to the lower levels we see today.

Notwithstanding that many nations have robust and well-resourced anti-terrorist units, it is apparent that no matter how well supported such organisations are, security screening and intelligence gathering cannot eliminate all threats. A few of the bombers will always get through. In this article, we will address some issues that improvised explosive device disposal (IEDD) teams may face when responding to incidents involving a known car bomb.

Terrorist groups have diverse motivations for carrying out acts of terrorism. They seek both to maximise publicity for their cause as well as to destabilise society. One means of achieving their goals is the use of vehicle-borne improvised explosive devices (VBIEDs). The explosives are hidden in a vehicle and moved into a public area, such as an airport or underground parking areas in a city, where they will cause maximum disruption. The terrorists' next step is often to notify the relevant authorities that they have placed a VBIED in that location; alternatively, if no warning is given, the vehicle or its contents may attract suspicion. The current response strategy is for first responders or IEDD teams to be alerted and take responsibility for managing the response to this critical threat. Having been deployed to an incident, an operational process will be implemented in accordance with determined priorities. Clearly, each IEDD team will work to national priorities, which include the safety of personnel and property, although this article will examine just one aspect of the process.

The discovery of an IED device triggers the imposition of a set mandatory evacuation distance for a suspected IED. If the main concern is to neutralise the threat quickly, typically an IEDD robot vehicle would be deployed to disrupt the explosive device. If the IED has been discovered in a vehicle, and adjacent vehicles or areas with height restrictions, walls or structural pillars have restricted access for the IEDD robot, the ability of the IEDD team to disrupt or neutralise the device will be severely hindered.

Current techniques for removing these inconvenient "blocking" vehicles in confined spaces – such as through a hook-and-line method in which an operator hooks a cable to the vehicle, finds a suitable pulling position and attempts to accurately and safely drag the blocking vehicle away – can take well in excess of one hour. There are also risks due to the lack of precision when dragging a vehicle which may have the parking brake applied or driving wheels askew. If time is a critical factor in the operation, then the rush to solve the problem will induce a higher level of risk. So how can modern technology make the IEDD team's task easier? With new technology becoming more readily available, it should be possible to design and produce a tool which will enable the task to be completed in a faster and safer manner.

Let's first look at the challenge of extracting a "blocking vehicle". The suspect vehicle is parked next to a wall, with a "blocking" car alongside and another in front. We know the IED is inside the vehicle, but the IEDD robot cannot get close enough to place an appropriate

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When push comes to shove: the AVERT project's deployment unit is manoeuvred into position before the bogies are released

disrupting explosive to make the device safe. In the past, IEDD teams have made the decision to remove the blocking vehicle, but carrying out the task manually is time-consuming and adds more risk: it could knock the vehicle carrying the IED and trigger the device, especially if the central locking and jammed steering makes it difficult to pull straight.

Instead, how about jacking the vehicle up and pulling it away? This is possible, but manually positioning suitable rolling jacks adds unnecessary risk, complexity and time. But what if we could remotely position the jacks and rely on them to extract the vehicle in a safe direction without running into obstacles? We then have a solution, provided it can be done in an acceptable time period. Issues which now must be addressed are obstacles which must be navigated and height clearance under a vehicle – perhaps as little as 125mm. And, of course, the jacks need enough power to get into position, lift several tons, and complete extraction.

So we needs an autonomous jack, one for each wheel, which is very low profile to get under the typical family saloon car, has good lifting capacity, its own satnav and which can autonomously get in position, lift and withdraw. Manoeuvrability is key; ideally each unit should be able to rotate within its own axis (a turning circle of zero).

OK, we make a swarm of four "bogies" which self-position using a navigation package, lift the target vehicle's wheels and extract along a pre-determined safe route. We solve the manoeuvrability problem by designing omni-directional wheels which turn on their own axis and can lift their share of the load. The bogie will navigate to a wheel in pairs and, when in position, lift by compression using a horizontal screw jack, all powered by the onboard battery pack. The intelligent bogies communicate with each other wirelessly, so the co-ordinated swarm can operate autonomously while passing data and status to the Command Console managed by the IEDD operator.

With the mechanical engineering problems solved, what of the small matter of navigation? To establish routes, we need to build an accurate, precise and reliable map, quickly and in an unknown environment. Within the constraints of available computing power and, critically, time to complete the mission, the use of any existing multiple mapping programmes is not possible. The problem can be solved, however, if we can create one consistent world map for the area of interest (AOI) by scanning from two different positions; in this way real anchor points can be created. Laser scanning in 3-D can provide the required data in a realistic timescale of minutes and, by using smart algorithms that are constantly updated as the robots move, it is possible to locate the AOI and obstacles in 3D, due to the fact that each map is recorded in "grid cells". Path planning can be achieved by avoiding cells which have been designated a "no-go" area because of a surveyed obstruction. There are obvious trade-offs in the process but, because data is gathered in real-time, the adaptive algorithms can provide course corrections around "no-go" cells in the necessary timescale to allow the robot swarm to appear to travel in a steady unimpeded manner.

Ideally, the lasers needed for the task should be mounted on the Deployment Unit (DU) which carries the bogies. When the robot deployment plan has been determined by the system, the IEDD operator can approve and initiate the process to remove the "blocking vehicle". This system can be augmented by digital cameras placed on the DU and the bogies so the operator can monitor the process. To complete this proposed extraction method, the communications network should be capable of operating with existing IEDD team equipment. Finally, reliability and robustness are essential for such a system, and therefore the design, engineering and build quality need to be first class.

Currently, there is no such automated system available to assist IEDD teams in the removal of a blocking vehicle. But if this process was automated and carried out quickly, then the IEDD Team could focus on their prime task of neutralising the threat. Accordingly, around three years ago, a consortium partly funded by the European Union started work on developing such a capability. The Autonomous Vehicle Emergency Recovery Tool (AVERT) project was conceived to provide such a tool for IEDD Teams. The system comprises three units and subsystems: the Command System with wireless communications; the Deployment Unit with onboard sensors and processing capabilities, which transports the lifting bogies; and a deployable lifting mechanism – the bogies. This project is now reaching maturity.

To date, the project has met its goals of producing a system with modules for rapid survey, dynamic mapping and path planning and mapping in 3D visualisation. Low-profile high-load lifting units with omni-directional wheels and integrated long-life power packs have been built, and the system was engineered in an open architecture manner to allow options for integration with other systems.

The trade-off between using new, effective technology and old, proven traditional methods always presents a dilemma. Cost is an important factor, but what is undeniable is that equipment which gives an operator the option to execute a time-sensitive and life-threatening incident more safely and quickly is worth considering. Cost is another important consideration, but while development and prototype testing has been very positive, it is impossible to say accurately until the production design is finalised. A reasonable estimate for a basic capability could be expected to be in the order of £150k, taking into account the selected sensor and communications package.

Several potential users have been involved in the development programme, and there is a scheduled user demonstration for AVERT in spring 2015, which potential users from countries including Austria, Belgium, France, Germany, Greece, Spain, Switzerland and the UK will attend. AVERT could enter commercial production at the end of 2015, thereby making available a potentially important tool for IEDD teams to enhance their capabilities.

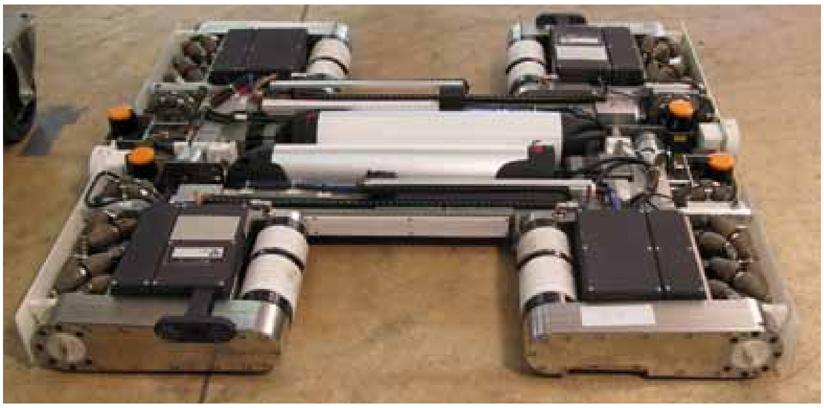
CASE STUDY:

Clearing the way for IEDD

On arrival at the area of operation, the IEDD team will determine the strategy to be employed which may include the removal of a blocking vehicle. If the AVERT tool is part of that process, the Command Console would be activated from a safe location, and the Deployment Unit (DU), which carries the self-powered lifting bogies would be deployed to the area of interest. The removal of the blocking vehicle is controlled by the IEDD operator; the AVERT system can be used autonomous, semi-autonomous, or with manual intervention for this purpose as decided by the operator. The DU's on-board sensor rig has a SICK laser, a Pan-Tilt Unit and a mast-mounted digital camera. The main data processing will be carried out on the DU; sensors will scan the area and produce a global map which is effectively a 3D reconstruction of the area of interest, along with a video stream from an onboard camera relayed back to the Command Console. This processed data then outputs options for the IEDD operator to initiate the deployment of the lifting bogies, which will navigate their local path and position themselves autonomously, quickly and accurately, using their sensors to avoid collisions and navigate over or around obstacles.

The bogies, which operate as two pairs that split into individual units, are operated autonomously when self-positioning under the vehicle, moving into place from any approach direction to locate the vehicle's pick up points. The bogies operate as a swarm of autonomous lifting robots. The omni-directional movement capability is designed for the co-ordinated bogie units to manoeuvre the vehicle in any direction. After being positioned underneath the target vehicle, the bogies' design offers a commanded split of the bogie into two sections, enabling both bogie sections to manoeuvre independently, dock on either side of the target vehicle's wheels and lift them off the ground by progressively compressing two rollers against the tyre. The low profile bogie system has the capability to lift considerable loads and move vehicles with weights in excess of the typical SUV (Range Rover-type) or a light commercial van.

Once the blocking vehicle has been lifted, the IEDD operator inputs the "OK to move signal" through the Command Unit, and the vehicle is autonomously relocated to a pre-determined position. This then allows the IEDD team to tackle its prime task of neutralising the target vehicle carrying the IED. The testing of the prototype AVERT tool has demonstrated the capability to reduce the time required to remove blocking vehicles to less than one quarter of the time used by existing manual methods.



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Working in pairs, the bogies position themselves under the vehicle before lifting its wheels on rollers

Rolf Gebhardt was first detective superintendent with the German State Office of Criminal Investigation. In 1992 he was deployed to the Stuttgart State Office of Criminal Investigation within the Institute of Forensics, and has worked as an expert in IEDs since 1995. He has also chaired the German Association of IED experts.

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