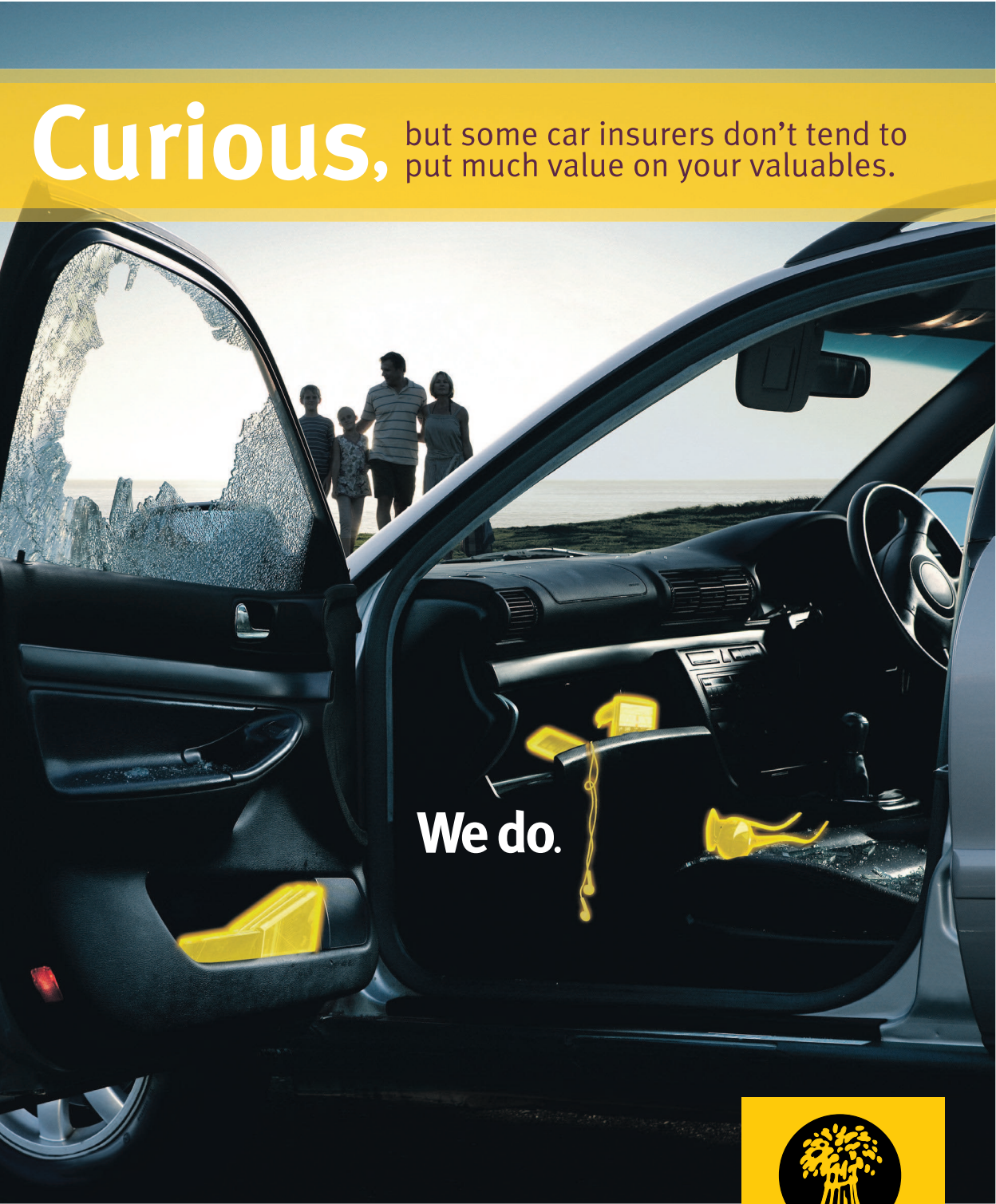


STAND ASIDE, SOLDIER, WE ROBOTS ARE IN COMMAND

Machines are already being used for surveillance and to disarm bombs in Afghanistan and Iraq, but a new generation is coming that will be armed and autonomous, says Mark Harris

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In a hidden testing ground somewhere on the outskirts of Boston, Massachusetts, machines billed as the future of warfare are being put through their paces. Inside the compound — accessed after rigorous security checks — are no-go areas, forbidden laboratories and stark warnings not to touch the equipment.

So it's a surprise to come face to face with the latest military hardware and discover that it's unarmed. The small unmanned ground vehicle (SUGV), with its tracked wheels and articulated sensor head, looks more like Wall-E, the cute robot in Disney's animated film of the same name, than the homicidal machines from the Terminator films.

The company that builds them is called iRobot, and it is America's biggest manufacturer of military robots. I am here to put some of its latest inventions through their paces. And despite the formality of the surroundings, I can't help having fun: directing the 30lb SUGV with a video game-style wireless controller is like playing with the world's best remote-control toy. A tap on a joystick and it darts forward instantly, blasting up slopes, rattling over rocks and even, with the aid of rotating flippers, climbing stairs. All the while, on-board cameras feed back live video to a pin-sharp head-up display, allowing me to zoom in with a 300x telephoto lens, flip into night vision or direct a laser range-finder onto a distant target.

The game is deadly serious, however. Robert Gates, the US defence secretary, recently announced that SUGVs would form a key part of the military's multi-billion-dollar Future Combat Systems modernisation programme, deploying to every brigade in the army. They will be used for everything from searching hostile buildings and caves to disarming bombs. The SUGV's predecessor, the PackBot, has been in Afghanistan since 2002 and Iraq since 2003. The US army claims it has disarmed more than 10,000 improvised explosive devices.

iRobot is at the vanguard of a drive towards a remote battlefield, where humans are replaced with autonomous and semi-autonomous drones and robots. According to PW Singer, an American defence analyst and author of *Wired for War*, the number of unmanned systems on the ground in Iraq has gone from zero to 12,000 over the past five years. He argues that this is only the start and that military officers acknowledge new prototypes will soon make human fighter pilots obsolete, while the Pentagon is developing insect-sized robots to carry out reconnaissance work.

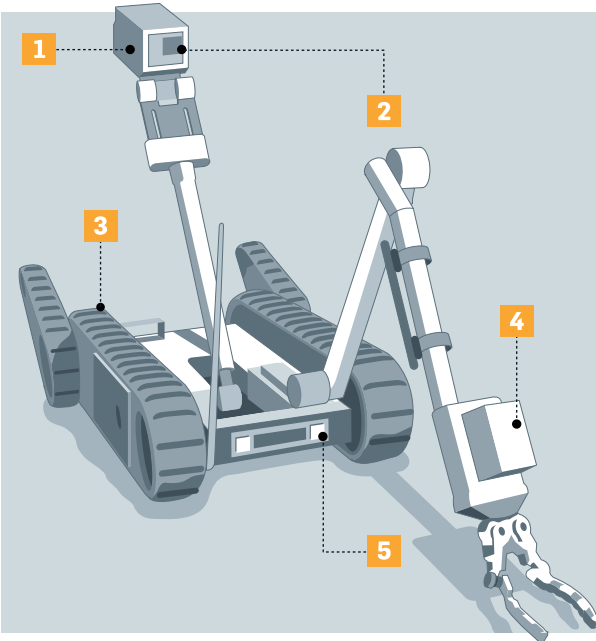
Suddenly companies such as iRobot are finding themselves in hot demand. It has already delivered 2,400 PackBots, which cost \$100,000 (£63,000) each, to the US army and about two dozen to the Ministry of Defence in Britain. It was founded by engineers from Massachusetts Institute of Technology, NASA's Jet Propulsion Laboratory and Disney.

Less than 10 years ago, iRobot was struggling to find a market for such products as My Real Baby, an animatronic infant that could move its eyes and lips and gurgle. Unfortunately, it looked less like a real baby than a creepy newborn Arnold Schwarzenegger covered in plastic, and did



Daniel Byrne

The SUGV is built by iRobot, whose founders include engineers from Disney, creator of Wall-E, top right. Not all robots are a success — the US army dropped plans to deploy the gun-carrying Talon Swords, bottom right, in Iraq



The i Robot family

- 1 The camera features zoom and on some models night vision capabilities
- 2 Operator can "see" through the robot's camera eyes, navigate round obstacles and manipulate its arm using a laptop screen from a distance of up to 1,000 metres
- 3 Tracks enable negotiation of rugged terrain and give the robot a top speed of 5.8mph
- 4 On some models a 42in arm is equipped with a powerful gripper and camera that enable the robot to identify, lift and carry small objects. Future models could be equipped with weapons including a machinegun or grenade launcher
- 5 LED lights allow operation in low light



not sell well. Then there were the toys such as the robot dinosaur, the robot tractor and the robotic webcam that could follow you around a room. None took off until the company came up with the Roomba, a robot vacuum cleaner that accounts for around half the global home robotics market. It is the demand for warrior robots, however, that has really catapulted the company into the big time.

Both the PackBot and SUGV require human operators today, but iRobot plans to upgrade their hardware and software in the future to give them some self-sufficiency. "Real autonomous robots as Hollywood views them are still 30 years or 40 years into the future," says Joe Dyer, president of iRobot's military robotics. "When we talk about autonomy, we're talking about a machine that can navigate without continuous operation, operate tracks and arms without bumping into itself, and that, if you lose communications, will go back to where it could talk the last time."

Even if its robots are not yet intelligent, they are gaining other abilities. Chris Jones, iRobot's research programme manager, reveals details of a shape-shifting spy robot that could have been inspired by the liquid metal cyborg from Terminator 2. "We're building robots that don't have motors, wheels or anything rigid in them. They don't even have batteries, they run on chemical power," he says. "They're made of new materials called dielectric elastomers, which are extremely flexible and can change shape by applying electric or magnetic fields. Ultimately, we will build a robot that is completely squishy and that can squeeze through a hole the size of a 10 pence piece."

Experts in everything from origami and flexible electronics to the mathematics of Venus fly trap movement are working on the project, and Jones expects to have a working, slithering prototype within a year. "We've already had sub-systems that we've shown to

move. Now we're looking at how to pull it all together."

If providing surveillance and saving soldiers' lives were all that military robots were doing, it would be easy to dismiss Hollywood's merciless kill-bots as mere science fiction. However, the PackBot is a modular system, in which cameras can be augmented with a gripper, sensors for chemical weapons or a Taser X26 stun weapon. The next generation of iRobot's machines, the Warrior, will go further still. This larger (285lb) robot will be able to travel over rough terrain at 9.5mph, drag a fully laden soldier and sport a multi-barrel Firestorm electronic gun shooting high-explosive rounds.

The combination of high firepower and low intellect sounds sinister but it doesn't worry some experts, such as Patrick Lin, professor of robotic ethics at California Polytechnic State University. "Robots don't inherently have emotions, and can't act out of hate, anger or fear," he says. "We don't want robots to think for themselves. If they just follow orders and remain within rules of engagement they would do a better job than people in this narrow, military context."

Experiments with autonomous armed robots — machines that are capable of choosing and engaging targets without human control — have not always gone well. In South Africa in 2007 a robotic anti-aircraft gun began firing at random during an exercise, killing nine soldiers and wounding 11 more. Then, last year in Iraq, the US army cancelled plans to deploy machinegun-equipped Talon Swords robots, with the manufacturer citing unexplained "technical issues".

Despite this, the rush to arm androids is speeding up. The Pentagon has at least four programmes involving development of armed, autonomous robots including one that proposes using a team of cyborgs to track down and capture enemy personnel. More than 40 countries, including China, Russia, Pakistan and Iran, are also developing military robots, and few are squeamish about putting metal fingers on triggers. At least two countries, South Korea and Israel, have already deployed sentry robots along their borders.

"Eventually, these weapons will proliferate," says Lin. "Our enemies will also have robots. It's not a matter of if, it's a matter of when."

While the most complex and capable robots, such as

the Warrior, are very expensive — around \$300,000 (£189,000) each — smaller, simpler robots can be almost as dangerous, while being much cheaper to construct.

At iRobot, I am shown a tiny tracked robot, code-named Ember, weighing just 1lb and costing so little to make that it is virtually disposable.

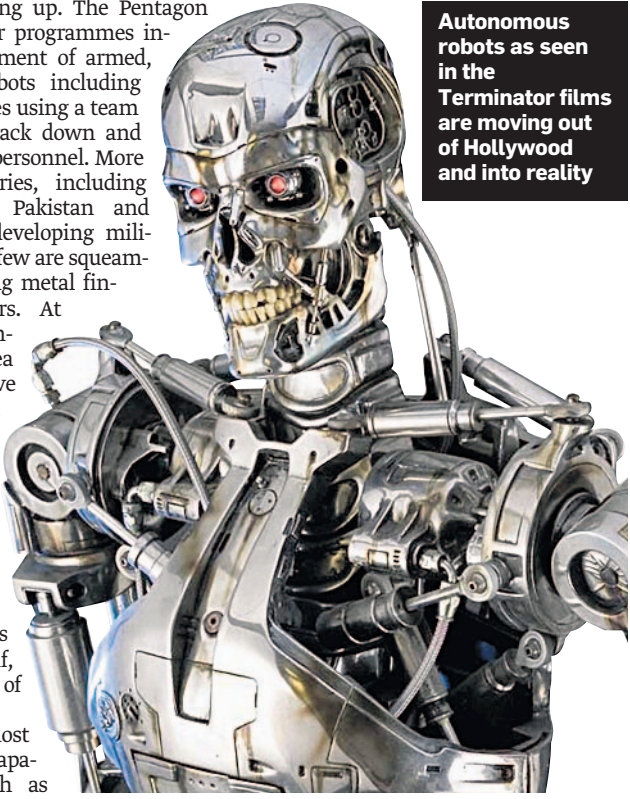
Ember moves at walking pace, can right itself when it is turned over and is controlled by a simple touchscreen application on an Apple iPhone. iRobot's version is designed to boost radio communications and capture video footage but it does not take much imagination to envisage similar devices packing various weapons and explosives. Suddenly, the PackBots and

'Ultimately we will build a robot that is completely squishy and can squeeze through a hole the size of a 10 pence piece'

SUGVs zipping around iRobot's assault course seem a little less fun and a little more dangerous.

At least iRobot's Joe Dyer does have a few pointers in case you should ever find yourself facing a rogue robot: "It's not unlike us: if you hit the right place, you kill it but there are other places where it'll keep on working."

And where might those right places be? "I could tell you," he says. "But then I'd have to have one of my robots kill you."



Autonomous robots as seen in the Terminator films are moving out of Hollywood and into reality