The MARCbot:
The Army Program that Revolutionized Robotics for Patrol Warfighters

by William J. Cohen and Ken Zemach

Introduction

In Iraq, sometime during 2003, the threat of Improvised Explosive Devices (IEDs) used against U.S. and coalition forces began to grow significantly and resultant deaths and injuries became frequent. IEDs became the most common and effective tool of the insurgents and, for a moment, we were surprised. There was nothing fancy about the tactics and nothing particularly advanced about the technology, but insurgents leveraged an effective way to kill and injure warfighters. The stories are myriad: IEDs in boxes, trash, gas cans, dead animals — laying there in the road and triggered in various ways. Initially IEDs were made from old artillery shells that were easy to procure in the immediate post-invasion Iraq. The types of IEDs continuously evolved throughout the U.S. combat involvement in Iraq to include homemade explosives and horribly effective EFPs (explosively formed penetrators). IEDs were the first truly asymmetric, evolving, effective, and enduring threat of the Iraq conflict with enormous associated human and capital costs.

This article is about the Multi-function, Agile, Remote-Controlled Robot (MARCbot) introduced as an inexpensive, mission-specific robotic platform developed for the inspection of suspected IEDs or suspicious materials throughout the urban and rural environments of Iraq. It was developed with the intention of providing route clearance, patrolling, and convoy warfighters an asset that could improve positive identification of IEDs at a time when that need was both critical and generally unaddressed. The resulting benefits provided warfighters with standoff from potentially deadly devices, the ability to summon specialty bomb disposal personnel with a greater certainty as to the need, and allowed patrols and convoys to push forward with their critical missions. Over 1000 production MARCbots were manufactured by Exponent, Inc. for use in Iraq, and later, in Afghanistan.

The Role of the U.S. Army Rapid Equipping Force

In 2002, the Vice Chief of Staff of the Army, GEN John M. Keane, heard that warfighters were sometimes exploring caves in Afghanistan with a rope tied around their waist, the same thing many "tunnel rats" did in Vietnam. He asked Army COL Bruce Jette to lead a response to this allegation and perhaps identify some sort of robot that could do the job instead, thus exposing warfighters to less risk.

To help mitigate this problem, Exponent was asked to create a theater-capable wearable computer with helmet mounted eye piece display to control the robot and support the mission. In less than two months, Exponent engineers and Army personnel were exploring caves in Afghanistan with robots. Because of the success of this mission, GEN Keane initiated the creation of the U.S. Army Rapid Equipping Force (REF). Its mission is to provide warfighters with critically needed capabilities in the shortest possible time frame. Exponent became the REF's main engineering partner to help assess capability gaps and provide engineering prototyping both in and out of theater for nearly eight years.

A New Mission to Combat IEDs

By 2004, REF had established an in-country presence in Iraq with Exponent labs. As the IED threat in Iraq increased, so too did the horrific stories about soldiers dying while investigating suspicious objects in the road (be it an old tire, dead dog, burlap sack, or even a hole that was the scene of a previous IED blast). Exponent began to engage with warfighters on their operational problems, and kept hearing the same thing. When asked why they would just walk up to something they suspected might kill them, warfighters would often respond, "What else are we supposed to do?"

The choices at the time were very limited. If you suspected that something was an IED, you could: walk up to it and inspect it; drive by it slowly and inspect it; drive by it quickly and hope it didn't blow up; shoot at it and see what happened; or use binoculars to view it — all of which were either dangerous or ineffective. The other option was calling the Explosive Ordnance Disposal (EOD) to investigate it with their specialty robots or other methods. However, at that time, EOD response times were often measured in hours, during which the road had to be closed, and insurgents could freely set up attacks using mortars and rockets. For warfighters on patrol whose job it was to keep the roadways open and safe for travel, none of these options were sufficient or particularly safe.

Robots for Route Clearance: A New Concept

In the early days of the Iraq war, the average patrolling unit did not think that they could get access to any sort of remote detection device. The now much-utilized Buffalo vehicle consisted of a fleet of two, and it took years to assemble enough Buffalos to service the need. This led Exponent and the REF to repurpose the iRobot PackBot Scout robots from Afghanistan to Iraq for use by everyday patrol units. In early 2004, 22 of these robots were made available in Iraq for investigative purposes.

The rules for usage were simple: non-EOD personnel were not allowed to "mess" with suspect devices. However, using a robot to visually inspect a suspicious object often allowed warfighters to confirm that it was not a threat, and the mission could proceed. In the case when an IED was found or at least still suspected, then EOD would be called. This, in turn, greatly decreased the quantity of calls to EOD, freeing them up to handle more likely threats, and reducing their response time.

Creating the First Small Robot for Patrol Soldiers

By the middle of 2004 it was clear that small robots could be useful, but the price tag, limited inspection capabilities (no elevated camera), and limited availability of other appropriate robots made it an unlikely and insufficient bulk purchase. At the request of the REF, Exponent prototyped a small remote controlled device for the mission. The final product had very high reliability rates in theater, and was purpose-built for the threat and environment. The idea was that, when the heat was on, a warfighter could deploy the robot in under one minute.

These initial few robots, placed with the units who had the need and mission, were tremendously successful. For instance, the very first prototype was reported to have confirmed over 30 IEDs on the notorious Airport Road between the Baghdad Airport base complex and the Green Zone. IEDs proved to be one of the most dangerous and disruptive tools in the insurgent's arsenal and every day in Iraq, dozens of IEDs continued to disrupt convoys, destroy Coalition assets, and maim and kill U.S. troops. The MARCbot immediately proved to be an extremely critical tool in this fight. The 2nd REF Director, COL Greg Tubbs, decisively initiated the notion of small robots for patrols and ordered the first large batch to be distributed throughout Iraq as well as negotiating their repair and support by the Robotic Systems Joint Project Office.

Applying In-Theater Technology Experience to Shape Military Product Development

By 2004 Exponent had worked with and supported a number of robotic platforms. In-theater development and supporting technology proved critical in the development of the MARCbot, driving several design principles that were essential for the MARCbot's success:

- Design the robot to do only one task, and that task must be something that is repeated often. Any

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functions that broaden the range of capabilities outside of the core mission only serve to add complexity, reduce overall system reliability, add unnecessary cost, and increase user training requirements and potential confusion under pressure. A user must be able to find the robot in its box and successfully operate it in less than a minute.

- Specifically do NOT design in other features, systems, and capabilities that are only tangential to the mission. For instance, GPS was specifically rejected as an option due to Exponent's in-theater experience with the GPS system, capabilities, and issues with other robotic platforms.
- Absolutely reject any control system that has buttons or controls that are not central to the primary mission of the robot (e.g., a laptop).By the time of design, Exponent had several years of in-theater experience supporting several types of robots that were controlled by both wearable computers, and later by laptops. The use of computers to control robots resulted in roughly three times the number of support issues over and above the support of the various robots themselves.
- Use standard systems. In this case, the use of military-standard x90 batteries was required because warfighters nearly always have access to them.
- Absolute minimization of technology and components for reduced system maintenance and lower costs.

Benefits of the MARCbot as an Asset to Patrol Soldiers

Over the next few years, additional features were added to improve the performance of these robots. Remote antennas allowed warfighters to operate the robot from within the armored environment of their vehicle and to see what the robot sees from safe distances. The simplicity of the system allowed a warfighter to receive the robot and, without complex training, be able to fully operate it nearly immediately. This proved enormously helpful during a time when warfighters in need were scattered around Iraq, but trainers were not. The MARCbot was also the first military robot asset to run exclusively from military batteries, and runtime topped almost six hours from a set. Since the fielding of the MARCbot, both the Packbot (iRobot) and Talon (QinetiQ) EOD robots have been upgraded to ensure that they operate on military standard x90 batteries as well.

Estimates from the field indicated that the MARCbot was used successfully on thousands of patrols, making determinations about hundreds of suspicious items, and saving the lives of U.S. warfighters. In the end, Exponent and the REF proved that with the MARCbot on patrol, there was never a reason that a warfighter ever had to "kick the box" again. Q

Dr. William J. Cohen *is a Principal in Exponent's Technology Development Practice. His consulting practice in Industrial Engineering specializes in the design, adaptation, and implementation of technology to solve operational problems for the U.S. Military. This work involves evaluation of capability gaps for deployed soldiers, technology assessment and testing, and iterative product design. Over the course of a year, Cohen was chief proponent for the design, testing, training, repair and fielding of the MARCbot—culminating in the delivery of nearly 1000 of these proven, life-saving devices to the U.S. Army.*

Dr. Ken Zemach *has spent over two years overseas, working in both Iraq and Afghanistan solving problems for the U.S. military. Zemach was one of ten recipients of the U.S. Army's Greatest Inventions award for 2003. Solutions include a preferred passive under armor cooling method, a down-well imaging system, a remote monitor and power solution for a weapon mounted thermal imager, a wearable antenna system, a power supply solution for a high end thermal imager for base security, an inexpensive method for foreign phrase translation, and a practical method for harvesting untapped energy in military batteries for long duration missions. Currently, Zemach's scientific consulting practice specializes in the application of appropriate technology to solve current problems for both the Military and consumer marketplace.*