

# Humvee Rollover Trainer

*An officer's quest to save lives in combat*

*By James Jennings*

**T**HE U.S. MILITARY PROCUREMENT SYSTEM does not normally work in favor of an individual soldier who has a good idea. Funding, building and fielding a new training device requires years of navigation through countless layers of bureaucracy. In this case, however, a young officer armed with exceptional persistence and an innovative spirit took a great idea from a back-of-the-napkin concept to operational testing in less than 7 months. The story of the Humvee egress assistance trainer (HEAT) is an extraordinary tale of a military officer's quest to save lives. The impact of the HEAT fielding is measurable. Military vehicle rollovers and associated fatalities in combat each dropped by more than 60% in the 2 years following the fielding of the trainer.

## Recognizing the Problem

The U.S. Army had a serious problem and no one quite knew what to do about it. It was 2005 and the Army's high-mobility, multi-purpose wheeled vehicle, the ubiquitous Humvee, was rolling over at an alarming rate during combat operations in Iraq. The problem confounded commanders, senior noncommissioned officers (NCOs) and military safety professionals: How to stop the rollovers or at least make the events survivable.

Chief Warrant Officer Three (CW3) Rik Cox had an idea, one that had been discussed by various military leaders and safety personnel, yet had never been aggressively pursued. What if vehicle occupants could experience a realistic rollover simulation in training? They could then know exactly how to react. The driver and gunner could be trained to recognize the feel of the 25° angle at which the top-heavy uparmored Humvee tips over. In addition, the occupants would recognize the value of using seatbelts, even in combat.

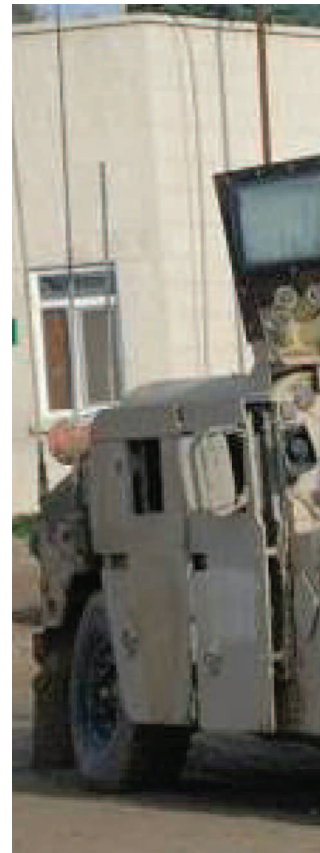
## What the Data Revealed

Cox was the lowest-ranking officer in the U.S. Army's Forces Command (FORSCOM) Safety Division, an office of military safety professionals 6,700 miles from the sands of Iraq. As the person who collected and analyzed daily casualty reports, Cox saw the same incident causation entry repeatedly: Humvee rollover.

The accompanying injury descriptions were predictable: fatal head injury, broken back, paralysis from broken neck. Gunners perched in the roof-mounted turrets had another repetitive entry: killed when thrown from vehicle. Another tragic fatality cause: drowned when trapped in overturned submerged vehicle. Ground vehicle simulation training had never advanced past the "good idea" stage. However, Cox decided to take the lead in the effort to develop a training device.

CW3 Cox was an officer in the U.S. Army Reserve and a member of the FORSCOM Safety Division's Army Safety Augmentation Detachment (ASAD), a 110-person organization comprised of trained ground and aviation safety officers. Since Sept. 11, 2001, ASAD has mobilized and deployed 60 officers and NCOs as individual augmentees to military staffs in Iraq, Afghanistan and Kuwait. With the exception of aviation units, the typical Army brigade was not staffed with a full-time safety professional in 2003. Although division and corps-level staffs

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had civilian safety managers, they tapped ASAD resources to manage the increased workload in a combat environment.

In fall 2003, Cox was assigned to manage thousands of casualty reports sent to FORSCOM headquarters in Fort McPherson near Atlanta, GA. He began to analyze the data in an effort to answer questions about accidental losses, causation and effective mitigation.

Army leadership at all levels, armed with data from FORSCOM and the U.S. Army Safety Center, recognized the tragic unintended consequences of the accelerated effort to provide armor plating for the Humvee, the workhorse of the military's wheeled vehicle fleet. Whether the Humvees were equipped with bolt-on armor plating or factory-installed ballistic protection, the vehicles were rolling over at an alarming rate. Although only 17 fatalities had been reported in association with 72 Humvee rollovers in the 5 years before global war on terror (GWOT) hostilities began in 2002, 90 sol-

diers had been killed and 159 injured in vehicle rollovers during the first 2 years following the invasion of Iraq on March 20, 2003 (U.S. Army Combat Readiness/Safety Center).

The addition of heavily armored gunner turrets to the roof raised the Humvee's center of gravity, increasing its rollover tendency. The prevailing "drive it like you stole it" mentality further exacerbated the problem. With the approval of their commanders, soldiers often drove faster than 80 mph to minimize exposure to insurgent-activated improvised explosive devices (IEDs), especially when the insurgency began in the late summer months of 2003. If they made rapid or abrupt movements of the steering wheel, the laws of physics were unforgiving. The moment arm during a roll was especially brutal to the gunner, who was unsecured and elevated above the cab.

In addition, the vehicle's two-point seatbelt, which the Army had been upgrading to a three-point system at a slow pace before the GWOT began, was too short to fit around a soldier wearing the newly issued body armor vest. It was poorly constructed and often fell apart. The Army had no effective restraint system for the Humvee and soldiers were paying the price.

FORSCOM was not the only group seeking a solution to the rollover problem. Many experienced military safety professionals were focused on developing a simulation training device. Statistical data from helicopter crashes clearly prove the value of egress training. Survivors of crashes are 250% more likely to safely get out of the wreckage if they have been previously trained on proper egress procedures (Foster, 2000).

Applying the same logic to Humvee drivers and crews, a simulated rollover during a controlled pre-combat training event would likely allow vehicle drivers to avoid the roll, turret gunners to drop down inside the cab before the roll began, and buckled-up occupants to survive the accident.

### Identifying a Solution

In March 2005, the FORSCOM Safety Office began aggressively pursuing a solution. At least two sister Army commands were reviewing design concepts by contractors, some priced at more than \$1 million. Others were seeking to find a Humvee chassis to serve as a prototype to minimize cost. The Department of Defense has a program to reuse old material and equipment, including damaged vehicles. The Defense Reutilization and Marketing Office (DRMO) has locations throughout the world, including in Iraq, Kuwait and Afghanistan. Ironically, DRMO's stateside efficiency caused a problem: There were no disabled Humvees or so it seemed.

However, Cox's thorough search uncovered a

**Photo 1:** Adding protective armored plating and a turret raised the Humvee's center of gravity and created an extremely top-heavy vehicle.

**Photo 2 (inset):** One soldier was killed in this Nov. 17, 2005, Humvee rollover in northern Iraq near Tal Afar. He was not wearing a seatbelt.

**Abstract:** Humvee rollovers were an ongoing concern for U.S. Army leadership, particularly as combat increased in Iraq. This article shares the story of the development, testing and fielding of a Humvee egress assistance trainer, and how its success has helped decrease the number of injuries and fatalities associated with vehicle rollovers.



wrecked chassis at DRMO's Montgomery, AL, facility. Thanks to some timely assistance from a transportation office at Fort Benning, GA, the chassis was moved to Fort Gillem near Atlanta. Gillem is home of the Army Reserve's 81st Regional Readiness Command Equipment Concentration Site 43 (ECS 43), a maintenance outfit comprised of military technicians. These technicians are mechanics who are federal employees during the week and Army Reserve soldiers for weekend drill periods.

Al Martelly, ECS 43 manager (and Sergeant Major Martelly in the Reserves), recalls seeing Cox keep driving by his maintenance yard. Cox finally stopped in, introduced himself, described the rollover trainer project and asked for a place to temporarily store the Humvee cab. Not wanting any distractions with the war escalating and mechanics behind on scheduled projects, Martelly's shop foreman initially said no. But Martelly eventually relented. He even said that some of his mechanics might help when things were slow and perhaps he could spare the forklift now and again. Cox had his Humvee cab and maintenance support, even if it was tenuous.

Cox has an undergraduate degree in English and a master's in Biology, so he had not spent much time in mechanical engineering classes. "What you need is a metal frame to set this thing on," advised CW4 Art Jordan, one of the most experienced maintenance technicians in the Army who was stationed at Fort Gillem. "You have to find a steel frame." Jordan is also a race car enthusiast and has a nuts-and-bolts familiarity with metallurgy. He estimated the weight of the modified Humvee cab that was to be rotated on a shaft to be about 2,500 lb. "But that's just an estimate," he warned.

So, Cox's next mission was to find a steel frame. Contemplating that task as he sat at a stoplight in McDonough, GA, a few days later, Cox glanced to his right and saw a junkyard filled with metal scrap. Moments later, the junkyard attendant saw a curious sight. A uniformed military officer strode over to him through the mud and asked, "Can I walk around your junkyard and look for steel?" For the next 3 days, Cox searched for metal. He eventually found a 6.5 ft-wide steel frame with three A-frame supports welded to the base. It was perfect for supporting the rollover trainer.

### **A Design Takes Shape**

Although not an engineer and still unsure of the final design, Cox knew that the wrecked Humvee had to be substantially modified. All portions of the vehicle to the front and rear of the cab had to be removed. There were 93 in. between the vertical support braces on the metal frame; the passenger compartment could be trimmed back to 87 in. in length.

At the same time Cox began to dismantle the Humvee, the ECS 43 manager sent three mil-techs to help dispose of fuel remaining in the cab's fuel tank. Staff Sergeant James Jett, Sergeant Mickey Hill and Specialist Christopher Whiting arrived with a heavy-duty Army wrecker and a 5-ton truck. They quickly saw Cox needed more robust tools to cut the

chassis and balance it on the metal frame. Over the next few months, the three men trimmed, cut and modified the cab. They mounted it on a shaft without the aid of computer-assisted design programs or sophisticated engineering tools.

On Sept. 29, 2005, Jett left Cox a voicemail. "Chief, right now I'm suspended upside-down in a Humvee. Give me a call." "Finally!" Cox thought. The rollover trainer cab was mounted on its frame and rotated 180° for the first time.

Materials began arriving to support the growing effort. Humvee seats came from Marine Corps Logistics Base in Albany, GA. Seatbelts appeared one day, a gift from FORSCOM G-4/Logistics. Fort Polk donated fiberglass doors. Many items were donated, and some had to be purchased. But one critical item was proving nearly impossible to obtain. Designed to absorb the blast of an IED, uparmored Humvee doors weigh 300 lb each. Rollover survivors, especially those who had escaped from a vehicle submerged in an Iraqi canal, consistently spoke of the need to ensure that occupants know how to open the heavy doors. A true simulation of how difficult it is to exit an upended uparmored Humvee, not always neatly positioned upside-down, meant armored doors had to be mounted. That was proving especially difficult.

In response to the escalating IED threat, the Department of Defense energized military contractors to dramatically escalate uparmored Humvee production and to retrofit existing vehicles with add-on armor kits. Although production lines were operating around the clock to meet the demand, no one was willing to part with four armored doors bound for a combat zone where soldiers continued to operate vehicles with canvas doors. Cox could not find the right leader or manager who had the latitude to weigh the value of a realistic rollover trainer as an incident prevention tool and make the decision to divert doors to Fort Gillem. The FORSCOM Sergeant Major went to work and, in late August 2005, four armored doors arrived at the ECS 43 maintenance building.

Once the crew cab was mounted on the shaft, mechanical engineering expertise was needed to develop a method to rotate the device. The U.S. Army Corps of Engineers dispatched two engineers from the local office who quickly solved the problem. A properly positioned hydroelectric motor could rotate the cab in a controlled manner, allowing the operator to stop the trainer at any angle. The FORSCOM Command Sergeant Major quickly provided funding for the motor. The brake system symbolized the cost-driven ingenuity that was the hallmark of the project. Instead of reinventing the wheel, the team modified a hydraulic brake system from a commercial forklift. The Corps of Engineers support proved invaluable for another reason. Since both men were registered P.E., there was no questioning the design's soundness and safety.

### **From Design to Operation**

On Oct. 24, 2005, less than 7 months after Cox was given approval to pursue the project, the first HEAT

was operational. The entire project, not including thousands of volunteered man-hours, generosity by suppliers and reclaimed materials, cost less than \$14,000. The HEAT was capable of seating four combat-equipped soldiers with their weapons, ammunition cans and other cargo. All occupants were secured in place with the same seatbelts being used in Iraq.

The hydroelectric motor and brakes allowed the operator to rotate the cab 25° on either side to demonstrate the tip-over point. The trainer could be rotated to any angle and safely stopped in place. Laden with standard combat kits weighing more than 50 lb and their assigned weapons, occupants struggled mightily as they released their seatbelts, collapsed into an ungainly upside-down heap, and dealt with disorientation, three other sets of kicking feet, and the daunting task of opening the armored doors.

At the Nov. 17, 2005, FORSCOM Commander's Conference, the HEAT was introduced to senior leaders of the 750,000-man command. Cox and his three ECS 43 mil-techs placed the HEAT in a nearby parking lot, where it immediately attracted attention. Ironically, the biggest fan was from another service, Air Force Major General Lee McFann, commander of the USAF Safety Center and a guest speaker at the conference. After McFann emerged from his simulated rollover in the HEAT, he turned to the officer and NCO accompanying him. "Figure out how to buy these," he ordered. Cox smiled. There was no procurement process or fielding plan.

### **A Fielding Plan Takes Shape**

Colonel John Gallagher was the Coalition Forces Land Component Command (CFLCC) Reserve Affairs Liaison Officer. The day after the commander's conference, he was completing his mid-tour leave and was scheduled to fly back to CFLCC's Kuwait-based headquarters the next day. As Gallagher and his wife walked near FORSCOM headquarters, he caught a glimpse of the HEAT. "I didn't know we had any uparmored Humvees state-side," he thought. He led his wife toward the odd-looking contraption, thinking he would show her the Army's newest combat vehicle upgrade.

Cox was putting all comers in uniform into the HEAT. Other than warning occupants to brace themselves against the roof to prevent neck injuries when unbuckling while upside-down, he gave no instructions. "I was trying to give them the same preparation that our soldiers were receiving in Iraq," Cox explains, "Which was none at all."

Gallagher wanted to know about the trainer. Cox strapped him in and rolled the HEAT 180°. Like many occupants, Gallagher took nearly 5 minutes to unbuckle, orient himself, open the armored door and exit the vehicle. As always, Cox, Jett, Hill and Whiting were standing by prepared to help, but Gallagher wanted to experience the realism of an unassisted egress.

When he finally clamored out, he was sold. "Give

me everything you've got on this, Chief. We need it in Kuwait as soon as possible." The HEAT now had a high-ranking champion in Kuwait, where all soldiers bound for Iraq are trained before crossing the border northbound into combat.

Lieutenant General (LTG) Steven Whitcomb, the CFLCC Commander, would soon share Gallagher's enthusiasm. Armed with Cox's plans and with money to spend, CFLCC engineers and safety professionals built a HEAT trainer in 6 weeks. CFLCC's HEAT improved on the original design and was mounted on a trailer. It added platforms for easy access to the cab and rails on the sides of the platforms.

### **Word Spreads Quickly**

A team of engineers and safety professionals produced a prototype for a January 2006 Safety Stand-Down Day. They put LTG Whitcomb inside and rolled him over. Like Gallagher, Whitcomb was hooked. "Make this happen," he said. "I want every soldier who goes into Iraq to receive this training," he directed. Within 3 months, HEAT training was a mandatory event for all soldiers before heading into combat in Iraq.

Word of the trainer spread quickly. Fort Polk, Fort Drum and U.S. Army Europe built HEATs. Following an April 2006 rollover incident in Mosul, Iraq, near Forward Operating Base (FOB) Diamondback, Lieutenant Colonel Ron Green, Commander of the 142nd Corps Support Battalion, asked the safety officer investigating the incident what he could do to prevent future rollovers.

Within hours, Cox's now-popular engineering drawings were in his hands. Green handed them to his senior maintenance warrant officers and NCOs. Two months later, on June 14, at the FOB Diamondback Army Birthday Cookout, Green unveiled the first HEAT built in Iraq.

This version was mounted on a flat-rack and could be transported by an Army palletized loading system truck. At Green's direction, the Mosul HEAT had been built exclusively with parts with national stock numbers so all components were available in the U.S. government supply system. The price tag for the Mosul HEAT was \$15,000.

### **Results Bear Out the Effort**

The real test of the device's effectiveness would be whether it reduced rollovers and associated fatalities and injuries. A key indicator was the influx of testimonials from soldiers who survived a rollover. The first positive report came from an unusual source, soldiers from the Army of the Republic of Georgia, an American coalition partner with forces deployed in Iraq. On March 29, 2006, newly arrived Georgian soldiers were trained in the HEAT as part of CFLCC-run precombat exercises at Camp Udairi, Kuwait. The following day, a Georgian crew rolled a Humvee. The April 12, 2006, issue of *Desert Voice*, the Army's military magazine in Kuwait, printed the success story.

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Learning how to react in extreme circumstances saved the lives of Georgian soldiers. During a training exercise, a Georgian gunner and his crew walked away with minor injuries from a HMMWV [Humvee] rollover accident April 1, 2006, at Udairi Range. Georgian Forces received the [HEAT] course the day before the accident and credit the training for the lack of fatalities in the accident.

"We did what we were trained to do to survive," said Georgian Cpl. Levani Lomtadze, HMMWV gunner. Traveling on the counter-improvised explosive device lanes, Lomtadze's HMMWV hit a hill and turned over. The vehicle did a complete 360° rollover.

Lomtadze said he and his crew felt the vehicle turning and immediately assumed the correct supportive positions to survive. The HEAT provided the Georgian troops with knowledge that helped save their lives,

Lomtadze said. "If we didn't take the class we wouldn't have known what to do," he added.

HEAT training was saving lives and not only in Humvee rollovers. On Dec. 4, 2006, Sergeant Erin Paynter and Private Lekeisha Hawkins, petroleum supply specialists assigned to Forward Support Troop, 1st Squadron, 7th Cavalry Regiment, 4th Infantry Division, completed a night combat refueling mission near Taji, Iraq. As they were driving a high mobility expanded tactical truck back to the base, they encountered a downhill slope.

Despite the assistance of night vision devices, poor depth perception in the darkness caused Hawkins to lose control of the vehicle. The tanker, nearly full of fuel, rolled over a small cliff. Both soldiers immediately reacted as they had been trained in the HEAT and emerged unscathed.

Said Hawkins, "If we hadn't been wearing our seatbelts there's no telling how we would have landed. The cabs of these trucks have a lot of space and

## Photos Tell the HEAT Story



Photo 3: Identifying, procuring and transporting this wrecked Humvee cab were the first critical steps in the development of the trainer.



Photo 4: This scrap metal frame was found in a McDonough junkyard. It would become the base for the first rollover trainer.



Photo 5: Jett, Hill and Whiting mounting the Humvee cab on the steel frame in an ECS 43 maintenance bay.



Photo 6: The HEAT starts to take shape.

there's a lot of room that you could bounce around in. All the training we had helped to prevent our getting hurt" (Multinational Corps Iraq, 2006).

Cox also received some testimonials. After a rollover near Sharana, Afghanistan, on April 27, 2007, Command Sergeant Major Charles Turner wrote a personal letter to Cox:

We were on patrol visiting soldiers in our CJOA [combined/joint area of operations]. As we were driving on a mountain road, a van crossed the median and T-boned us, knocking us off the road. I knew immediately that he was a suicide bomber, but for some odd reason his explosives did not detonate.

Right then and there is when the HEAT training took over. The van hit us so hard that it had us up on two wheels as we flipped over the side of the road and fell about 15 ft down into a wadi. I remember stating "Sh\*\*, here we go!"

I reached behind me and pulled the gunner down. At the same time, I screamed, "Roll-over, rollover!" Everyone braced for impact as we landed on the top of our M1114 [Humvee]. We always rehearse our TTPs [tactics, techniques and procedures], which include rollover drills and safety belts being worn during our patrol briefs, which paid big dividends on this particular mission. Thanks, again, CW3 Cox for what you and your soldiers do each and every day!

In addition to individual stories, Cox was able to track the dramatic decrease in rollover incidents and associated fatalities in Iraq. In 2005, 384 rollovers, which caused 74 fatalities, were reported. During 2006, the numbers dropped to 169 rollovers and 40 fatalities. By 2007, when HEAT training was mandatory before soldiers entered Iraq, there were 147 rollovers and 26 fatalities. The Multinational Corps-Iraq Safety Office (2008) reports rollovers decreased



Photo 7: On Oct. 24, 2005, CW3 Rik Cox conducted the first operational test of the HEAT at Fort Gillem.



Photo 8: The trailer-mounted CFLCC version of the HEAT is fielded in Kuwait. Note the flip-down access platforms and safety guards.



Photo 11: A soldier experiences a typical ungainly exit from an upended HEAT.



Photo 12: A soldier suspended by his seatbelt prepares to unbuckle as the HEAT rotation is stopped at the 180° point. Most soldiers have great difficulty during their first rollover in the HEAT.

62% and fatalities dropped 65% from 2005 to 2007. The U.S. Army Safety Center's 2006 year-end report highlighted leadership emphasis on vehicle safety and the HEAT as the two most critical factors in the drastic reduction in fatalities.

### The HEAT Today

Less than 3 years after this project began, HEAT construction, fielding and unit training are part of a fully funded and centrally managed Army-level program. Specially trained and qualified contractors operate the devices at most stateside military installations, including Army National Guard installations in most states. Units schedule predeployment HEAT sessions months before deployment.

The larger operating bases in Iraq and Afghanistan have rollover trainers and HEAT training remains mandatory. A CFLCC training guide outlines crew egress drills in day and simulated night conditions. Advanced HEAT training requires all occupants to exit using the same door or while assisting a simulated wounded crew member.

Starting in 2009, the U.S. Army and U.S. Marine Corps have 53 HEATs in operation, including units in Japan, Korea, Europe, Kuwait, Iraq, Afghanistan and the U.S. "Without the dedication, determination and drive of Chief Rik Cox, the Army would not have a rollover trainer today," says former FORSCOM Command Sergeant Major Carl Christian, now retired. "He took this project and made it a personal quest. As a result, there is no doubt in my mind he has saved the lives of our soldiers."

Today, CW3 Cox's dream is a reality and the success of the HEAT is one of the Army's most enduring good-news stories. The success is backed by solid statistical data and universal acclaim from soldiers, marines and leaders at all levels.

Cox's 4-year quest, taking the idea from concept to Army-wide fielding, is a tribute to his professionalism. It all began with a crumpled Humvee hulk, a rusty steel frame and an officer's burning desire to save soldiers' lives. ■



## The Next Generation

The success of the HEAT was not lost on the Army and Marines when the Humvee's replacement rolled off the production line in 2007-08. The Mine-Resistant Ambush-Protected (MRAP) vehicle is designed to absorb the blast of IEDs and protect occupants. However, its V-shaped hull and high profile has not mitigated the rollover problem and the armored gunner's turret exacerbates the center of gravity issue.

Engineers, contracting officials and military planners ensured the MRAP Egress Trainer (MET) was designed, funded and fielded within a few months of the arrival of the MRAP in Iraq and Afghanistan. The MET integrates the variety of upgrades added during the evolution of the HEAT, including a covered turret and internal video monitor. But the key indicators of success are a reduction in rollovers and increased survivability.

In the first 28 months of MRAP fielding, there have been 243 rollovers, which have resulted in 13 fatalities and 276 injuries. This record—especially the relatively low number of fatalities—is a very positive indicator of successful training.

As of March 2010, there are 14 METs in Iraq (some returning stateside as forces reduce), five METs in Kuwait and nine in Afghanistan. The Army and Marines have four METs in the U.S. and the planned total for all four armed services will be 84. The validation of rollover training for military vehicles, proven 5 years ago by the HEAT, continues with the MRAP Egress Trainer.



(From top) Photo 13: The MRAP has a very high profile and center of gravity.

Photo 14: The MET can be rotated and stopped to show roll angles and tipover points.

Photo 15: Soldiers ready for rollover simulation.

Photo 16: Occupants practice exiting vehicle through all available means. This soldier is climbing out of the turret opening with a foam-padded rifle mock-up.

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