ON A ROLL

How the Penn alumnus behind Humanistic Robotics, Inc. is saving the world one landmine at a time—and making money doing it.

By Kathryn Levy Feldman

Ten days before Christmas 2012, Samuel J. Reeves W'05 found himself in front of the British Airways ticket counter at Philadelphia International Airport doing a quick cost/benefit analysis: the excess-baggage fee he was being asked to hand over for his third suitcase versus the value of its contents, an essential—but duplicate, and very heavy—piece of mechanical equipment.

Reeves paid the not-unsubstantial fee, which turned out to be money well-spent. When he arrived at his destination—a UN peacekeeping mission in Juba, South Sudan—he discovered that the equipment he'd sent separately by freight container had never arrived.

Reeves' suitcase held a coupler that his company, Humanistic Robotics, Inc. (HRI) had custom-designed for the UN to attach the landmine roller to an armored peacekeeping vehicle. As it was, despite months of planning and specifying, the coupler still needed to be modified in the field to make it fit. But at least they *had* a coupler and, in the end, it did fit.

ILLUSTRATION BY RYAN GRABER

Reeves has become a master at fitting the pieces together in the decade or so since he and industrial designer Josh Koplin co-founded Philadelphia-based HRI, which designs rollers for clearing landmines and improvised explosive devices (IEDs); creates vehicle remote-control systems; and develops engineering solutions for government agencies, non-government organizations (NGOs), and commercial clients. Though HRI works alongside and for many nonprofits, Reeves' goal was always to create a *business* that would solve a global problem. "We are not a charity; we are a functioning business here to make a profit," he emphasizes. "Our contribution to society is our mission. Our contribution to the world is what we do."

The seeds of this dynamic—often referred to as *social entrepreneurship*—were planted in Reeves' consciousness in a class taught by Wharton's Ian MacMillan, the Dhirubhai Ambani Professor of Innovation and Entrepreneurship and director of the Sol C. Snider Entrepreneurial Research Center. "When you generate positive inflow, what you put into motion is a virtuous cycle," MacMillan explains. "The more money you make, the more people are helped. It is often a more sustainable model than a charity. At least in some cases, you can solve problems by helping people become self-sufficient."

These ideas prompted Reeves to start "rethinking what I really wanted out of my career," he says. "I realized I wanted to start a business with an altruistic end goal."

What that business would be, exactly, began to come into focus when Reeves teamed up with Koplin, then a master's-degree student in industrial design at the Pratt Institute. The two met through their parents. Koplin's father, a business colleague of Reeves' dad, was entrusted with hospitality duty when Reeves entered Penn. The offspring quickly recognized a synergy between the idea guy and the business guy and were off and running.

Seeking to create "a business that would save the world," Reeves eventually fixed on a concept in Koplin's sketchbook for a pressure sensitive, robotic landmine-clearing system. That was the "one [Reeves] couldn't stop talking about," Koplin, now HRI's chief technology officer, recalls. "I wasn't sure it was a business as much as it was an idea to give the world for free, but Samuel just started working the phones." Once Reeves discovered there was a substantial market for such an enterprise, he was all-in. (In fact, the market is huge: according to *The Economics of Peace and Security Journal*, in 2003 the UN alone received more than $40 million for demining.)

Today, says Reeves, HRI is recognized as "the world experts in roller technology" and a leader in the "super niche" of landmine clearing. How Reeves, Koplin, their team of engineers, and village of Penn connections got there—through Afghanistan, Croatia, Thailand, Bosnia, Cambodia, and most recently, South Sudan—is a story of persistence, passion, and self-professed naïveté.

"Basically we were proposing to start one of the more difficult businesses we could start," Reeves says with a laugh.

"A certain amount of naïveté is good," seconds Koplin. "We had no idea it couldn't be done."

According to Freedom Fields USA, a Carmel based non-profit "dedicated to the humanitarian removal of landmines in war-torn countries," there are roughly 70 million landmines in at least 90 countries around the world, most of which are no longer at war. Landmines kill or injure approximately 15,000 to 20,000 people each year, the majority of them children. Mike Croll, whose books on the topic include *The History of Landmines* and *Landmines in War and Peace*, puts it this way: "Around every 22 minutes, one person somewhere in the world is killed or injured by a landmine."

As explosive devices, landmines date back to the 14th century, but they did not feature regularly in warfare until the second half of the 19th century. During the US Civil War, the Confederate Navy developed floating mines, designed to explode on target. These early "torpedoes" were responsible for sinking 29 ships and damaging 14 others, Croll writes. US Brigadier-General Gabriel J. Rains first experimented with land-based explosive "booby traps" while commanding troops against the Seminole Indians in Florida in 1840. By 1862, he had devised artillery shells that could be exploded by pulling trip wires or by being stepped on. On May 4, 1862, a scout on horseback, near Yorktown, Virginia, became the first person killed by a pressure-activated landmine. Rains' landmines, used extensively during the Civil War, were so powerful that when five landmines with his signature fuses were discovered in 1960, their powder was "still quite dangerous," Croll writes.

The British adopted the technology during their African campaigns in the 1880s. Ironically, in 1884—shortly before he and his fellow defenders would perish in the Siege of Khartoum—British General George Gordon wrote: "Landmines are the thing for defense in the future. We have covered the works with them and they have done much execution."

But it was during the First World War that landmines became a staple of war, designed to counter the new tanks. Anti-tank and smaller anti-personnel mines were ubiquitous in World War II, which also saw the introduction of non-metal landmines (harder-to detect), first encountered by American soldiers in Lorraine, France, in 1944.

In 1945, the US Army attributed 2.5 percent of combat fatalities and 20.7 percent of tank losses in the war to landmines. Many of the large minefields laid across North Africa remain today, often buried under decades of shifting sands, and in Europe World War II minefields are still being cleared in Holland and France.

Ever since, the proliferation of landmines has "run out of control," says Croll. "The face of the earth has been scarred with more than 400 million mines since 1939, with 65 million of these laid in the last 20 years." Korea, Vietnam, Angola, Mozambique, Cambodia, Afghanistan, Israel, Syria, Bosnia, Kosovo, Burundi, South Sudan—this is just a partial list of the countries where landmines still kill and maim people, often while they are carrying out everyday chores. Their presence makes land unusable for farming, schools, or general living, hindering the economic and political growth of countries struggling to rebuild. Those who survive landmine accidents usually cannot return to the workforce. The cycle of destruction and despair continues.

The International Campaign to Ban Landmines—headed by activist Jody Williams, who won a Nobel Peace Prize for her efforts—was successful in drafting the 1997 Convention on the Prohibition of the Use, Stockpiling,

Production and Transfer of Anti-Personnel Mines and on their Destruction, known as the Ottawa Treaty. The treaty went into effect in 1999, and today 161 countries have signed it. China, Russia—and the US—remain hold-outs, although the US State Department Office of Weapons Removal and Abatement's website states that it is "proud to be the world's single largest financial supporter of humanitarian mine action."

Aircraft and artillery can lay a field of landmines in minutes that can take years to remove. The first problem is identification. The most common method remains manual demining with prodders, metal detectors, trained dogs, and, believe it or not, extremely large rats. Deminers are heavily trained by the NGOs, charities, or commercial mining companies that hire them and are paid well for their efforts, according to Reeves and Koplin. "In Afghanistan, for example, deminers earn double the average daily wage and the work is considered to be prestigious," Koplin notes. They live in tented camps near the sites. Needless to say, the process is extremely slow and tedious—and remains very dangerous.

It also doesn't always work. While millions of square meters of land in more than 60 countries around the world have been identified as "suspect" and diligently cleared by the international demining community, much of this work has not yielded mines. In many cases, cumbersome operator-driven machines outfitted with "flails" (rotating cylinders with chains that churn up the ground) and massive rollers have torn up farmland, placed the drivers of the machines in extreme danger, and sometimes even left mines behind or thrown them outside of the cleared area. "No method of mechanical demining is 100 percent effective," explains Reeves. "There are so many variables that it always requires two methods of clearance. What becomes most important is to be quick and to be economical."

According to Reeves and Koplin, landmines cost as little as three dollars to produce but as much as $3,000 to remove. It is difficult and expensive to transport conventional mine clearing equipment to developing countries, and then get them where they need to be in places where the necessary infrastructure may or may not exist. The machines are complicated to maintain, and spare supplies are not easy to come by. "[Mine clearance] is a rule of thumb industry that grew up with fast and loose requirements," explains Reeves. All of which suggests that finding a faster, safer, and more cost-effective way of detecting and disarming minefields would be of significant benefit to the demining community—which is where HRI comes in.

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Back in 2004, while Koplin was figuring out a way to integrate the construction of a prototype of his landmine-clearing design into the requirements for his Pratt master's thesis, Reeves submitted their idea to Wharton Entrepreneurship's Venture Initiation Program, designed to help Penn students create their own businesses. Once accepted, Reeves began drafting a business plan for the company, which he and Koplin called Humanistic Robotics from Koplin's original concept of a robotic landmine-clearing roller.

"You have to have a certain amount of self-confidence to get past those people who are skeptical about a 22-year-old starting a business," Reeves allows. But it certainly helped to have the support and advice he received from his "world-class" Wharton professors, who never once discouraged him from pursuing this idea. "I cannot say enough about the Wharton faculty. It was super-supportive."

Koplin feels equally indebted to Penn for "adopting" him. "People at Penn were all about 'How can I help?'" he says. "Samuel was so fortunate to be in a place that let him have the latitude to be what he wanted to be."

MacMillan acknowledges that, while he thought what Reeves was doing was "admirable," he wasn't sure he could pull it off. "But Samuel had this vision of starting a business doing demining and he hacked away at it for years. God bless him."

An essential part of that "hacking away" was talking to anyone who knew anything about landmine clearing, anywhere in the world.

Reeves "really impressed me as someone who could make connections with partners who could join him in moving Humanistic Robotics forward," says Karl Ulrich, CBIC Endowed Professor of Operations and Management and vice dean of innovation at Wharton. Ulrich, who was faculty director and founder of Weiss Tech House from 2003-2008, taught Reeves in his course on product design. "He established relationships with governments, companies, and individuals, even as an undergraduate," Ulrich remembers.

While the campus entrepreneurial community was squarely behind them, Reeves and Koplin did not lack for discouragement from other quarters. They were convinced that their concept for a smaller, cheaper, easier to maintain and transport roller was better than anything on the market, but no one believed them. Everywhere Reeves turned, he encountered naysayers in the industry, who said rollers didn't work.

But then one of those skeptics, Alex Griffiths—at the time a program officer at the Geneva International Center for Humanitarian Demining, an international think tank that researched landmine clearance—called him back. "He told me they didn't actually know if rollers worked, and they were putting together a study to find out what did," Reeves recounts. And, oh, by the way, the center was hiring consultants to do this research, and would they be interested?

Which is how Reeves and Koplin wound up taking some time off from their respective academic programs to travel all over the world to research the most effective method of landmine clearance. With funding from the Geneva think tank, the partners traveled to Thailand, Cambodia, Bosnia, Croatia, Canada, and Afghanistan in the summer and early fall of 2004, and submitted their findings at the end of the year.

Besides lots of valuable data, the experience gave them legitimacy and credibility.

"When we're talking with people who've been in the military for years and have cleared mines, we can say, 'We were in Afghanistan too,'" Reeves said in a 2005 *Gazette* story reporting on HRI's winning the $5,000 grand prize in that year's PennVention competition sponsored by Weiss Tech House ["Gazetteer," July|Aug 2005]. Not only that, notes Koplin, "it was like peeling an onion. Standing in the field, we could see we were righter and righter. In the middle of Bosnia, we could see opportunities."

Winning that PennVention prize "was huge for us," says Reeves. Weiss Tech House gave the partners space, tools, and support to work on the design for over a year. "Samuel made the best possible use of Penn resources, taking advantage of funding and space from the Weiss Tech House and the Wharton Entrepreneurial Programs," Ulrich notes. At the time, other mechanical de-miners cost as much as $250,000. HRI's version came with an estimated price tag of under $100,000, although they had only built a prototype, not the real thing. (Depending on the level of sophistication needed, the company's current products cost $70,000, $85,000, and $95,000.)

By 2006, both partners having earned their degrees, Koplin had set up shop in a rented 10 foot by 10 foot motorcycle bay he found on Craigslist for $150 a month, while Reeves took a part-time job at the Wharton Small Business Development Center and continued to work the phones. His persistence garnered them $100,000 from the research and development arm of the Department of Defense, which was curious enough about their concept to offer to build it for them. All they needed were engineering drawings.

The Penn network went into overdrive. Karl Ulrich connected Reeves and Koplin with his brother, Nathan Ulrich ENG'87 GEng'89 Gr'90, a world-renowned designer and inventor of award-winning products (the robotic Penn hand, the Xootr line of kick scooters, the Voloci electric motorbike, and the iDrive power-assisted wheelchair, to name a few). From the beginning, it was a fortuitous connection.

"My overall impression is that clearing mines is an especially difficult technical problem, and that current systems are not adequate in many respects, exactly as you had explained in our meeting," Nathan Ulrich wrote in a 2006 email to Reeves. "I agree that there is an excellent opportunity (and need) for an effective low-cost system." The inventor agreed to generate the engineering specs.

The Army built and welded the frame at the prototyping facility at Picatinny Arsenal in New Jersey. "But they didn't make the arms or wheels or assemble the rest," says Koplin, who ordered the rest of the parts made at a machine shop. He and Reeves realized they had outgrown the motorcycle bay. They needed to hire engineers, and they needed a larger facility in which they could assemble their product.

Enter Congressman Patrick Murphy, an Iraq War veteran elected in 2006 to represent Pennsylvania's Eighth Congressional District who would serve through 2011. The partners had met Murphy and told him about their project during his campaign. When they—not coincidentally—set up shop in a former textile mill in his district in Bristol, Pennsylvania, Murphy became their champion. During his time on the House Armed Services Committee and later on the Appropriations Committee, Murphy helped HRI secure a series of government contracts that increased from $400,000 to $1.6 million to $3.2 million in 2010.

At Karl Ulrich's suggestion, Reeves and Koplin also reconnected with some engineers they had met in the PennVention contest: Erik de Brun GEng'06 and Stephen Ahnert, who had started their own design firm, Ripple Design, and agreed to take them on as clients. What began as assembly work continued with research and design until HRI was able to hire its own engineers.

"We were emotionally invested in the product from the beginning and it has been incredibly exciting to be there from the beginning and watch them grow," says de Brun. As a result of the initial involvement with HRI, his firm has continued to be significantly involved in landmine-clearing technology, he adds. "It is fair to say that because of Samuel and Josh, between 25 and 40 percent of our business is in humanitarian demining. It is a life changing business to be a part of."

The team spent several months testing their machine in the factory and in the field at an army testing range in Michigan, burying mines at different depths, varying the speed of the machine, adding weight, and tinkering with the design. "We simulated land fields of different terrains (sand, dirt, gravel), and we practiced on the hardest types of (inert) landmines to hit, Chinese Type 72, lent to us by the Canadian government," Reeves notes. "By the fourth generation of rollers [they are currently on their sixth], we had achieved 99.6 percent detonation rates over 1,300 mines buried as deep as 10 centimeters. No one else could claim that rate of success."

The HRI Mine Roller is modularly constructed so that it can be easily assembled and refitted, easy to maintain, efficient to transport, cheap enough to use over and over again. It was proven to be more safe, reliable, and effective than its competitors. It finds mines more accurately than any roller has done in the history of the technology.

In 2011, the UN approached HRI about custom-designing anti-tank mine rollers for peacekeeping missions in South Sudan. The UN forces wanted mine rollers to attach to their armored vehicles when they were traveling throughout the country. HRI designed, manufactured, and delivered to the UN 25 such custom rollers in 10 weeks, which then eventually made their way—or failed to, in the case of the coupler mentioned earlier—via cargo shipping through security hurdles and various special clearances to their destinations. Late last year Reeves, Koplin, chief roller engineer Justin Dodd, and Paul Collinson, their UK-based field-operations specialist, went to South Sudan to oversee a five-day training course. Two days were devoted to assembling the roller and learning how to maintain it, and three days to practicing driving the armored vehicle while pushing the roller. It was the first time the custom roller had been tested in "real life" and according to Reeves, it was "an eye-opening experience."

"Afghanistan seems more developed than South Sudan, which has been at war with itself for about 40 years," says Reeves. "There are no utilities—everything runs off of generators, and water from the Nile is pumped into tankers that deliver it to villages. Just upstream from where they were pumping the water into the tanks, women were bathing and doing their laundry."

Reeves, Koplin, and Dodd stayed in what was called "River Camp," essentially a compound of shipping containers that have been converted into hotel rooms. "They called them VIP containers," Reeves says. Relatively speaking, the accommodations were more than adequate, with air conditioning, running water (from the Nile), flushing toilets, and mosquito netting. "The camp was filled with a lot of people like us doing State Department or embassy work," he says. "We got a chance to explain our machinery and talk about our company, so it ended up being one part marketing and one part making sure we did what we said we would do." Reeves and his crew stayed until the rollers were up and running and the peacekeepers knew how to maneuver them. To date, the feedback has been positive (though much is classified).

HRI's success with its Mine Roller may finally enable Reeves and Koplin to return to the robotic side of the business. "Our first vision for the company was to create a small, cheap robot to clear landmines," says Reeves. "We became a roller company because we didn't have enough money to explore robotics. It took us eight years to get back to the beginning."

One of the products they have already developed is the Open Integration Platform (OIP) for robotics, a remote-control system to transform commercial, off-the-shelf vehicles into robotic ones. The OIP has implications beyond landmine clearing—for example, in construction and forestry. "The person controlling it can be miles away; a camera on the roof sends data to the operator, who can view the operation on an android device," explains Reeves. "Any industry in which it is safer for the operator to be removed from the vehicle can make use of this product." There are other robotic control systems in the pipeline, not all with military applications—although, as Reeves notes, "There are plenty of landmines left to clear."

Since the company's start, "we went from struggling, to making several million dollars, [to] becoming a prime defense contractor," says Reeves. "We have 12 to 15 people who work for us, on and off, and we are starting to look like a real organization."

Few have been more proud of this success than Ian MacMillan, who recently invited Reeves to address his class of would-be social entrepreneurs.

"Honestly, Samuel's was one of my high-anxiety cases," he says with a laugh. "He poured years of his life into this project with no guarantee that it was going to work. But it was his innovative thinking and talent that helped make it happen. If it was easy, it would have happened long before Samuel thought of it."

Nathan Ulrich has been similarly impressed. "Startup companies are always risky, and I applaud Samuel and Josh for their dedication to such a meaningful endeavor, one that doesn't have glamor or a huge potential financial reward," he notes. "It's gratifying to see them realize their original goals. I'm proud to have worked with them in the early stages of their company."

"We were so fortunate that Penn was the place where our business was literally incubated," Reeves says. "They helped us with research funding, we had access to world class professors, we were incredibly privileged. I truly feel that we have a responsibility in the world to do something good and impactful. And I've learned that you can do that while making a profit."◆

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