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U.S. Humanitarian Demining R&D Program: Emerging Technologies

The Humanitarian Demining (HD) Research and Development (R&D) Program is continually innovating and applying new technology to demining. Through these changes, the goal of worldwide mine clearance is within reach.

by Sean Burke, Tom Henderson and Roger Cresci, RDECOM CERDEC NVESD

Introduction

Afghanistan, Angola, Mozambique, Rwanda, Thailand, Cambodia—these are only a few of the many nations suffering from a severe landmine problem, and seven of over 20 nations that have received assistance through a robust U.S. R&D program designed to help solve dettaels.

The U.S. HD R&D Program focuses on the development, testing, demonstration and validation of technology for immediate use in HD operations and environments around the globe. The U.S. Army's Research, Development and Engineering Command (RDECOM) and the Information and Electronic Sensors Directorate (NVESD) executes this program for the Office of the Assistant Secretary of Defense for Special Operations/Low Intensity Conflict (OASD SO/LIC).

The R&D Program develops new technology that will improve the overall safety and efficiency of existing HD operations at a minimal cost. This is accomplished through the adaptation of commercial off-the-shelf equipment, the integration of mature technologies and the leveraging of current R&D technology developments within the NVESD Countermine, Science and Technology mission areas. The primary goal of the program is to enhance existing technology that can be used for mine detection, wide area surveys, mechanical mine clearance and vegetation clearance, mine neutralization, individual deminer protection and individual deminer tools. This article will focus on the most recent R&D mechanical mine clearance and vegetation clearance technology developments.

The Annual Humanitarian Demining Requirements Workshop

The primary challenge facing the R&D Program each year is the process of gaining a thorough understanding of the most serious problems facing deminers around the world. This is necessary so that the program can focus on technology developments that will achieve the greatest results in the shortest possible time.

We address this challenge in two ways. The first is to bring representatives from governmental mine action centers (MACs) and demining-related non-governmental organizations (NGOs) together in an informal workshop environment with the purpose of extracting their most critical technology needs.

The R&D Program Manager hosts the Annual Humanitarian Demining Requirements Workshop each year in the Washington, D.C. area to update the technology requirements of the demining community. This workshop is one of the most important events of the program because it documents the required capabilities that truly represent current demining needs.

The second way to address the challenge is to perform site assessments. During these in-country site assessments, the R&D Program engineers and logisticians travel to minefields in host nations to gain firsthand knowledge of deminers and the physical and environmental challenges they face while performing demining operations. Site assessments are discussed in greater detail later in this article.

The R&D Program decides where to focus its development efforts as the conclusion of the Annual Humanitarian Demining Requirements Workshop. The Program Manager then structures a program execution plan for the upcoming fiscal year and submits it to OASD SO/LIC for approval. Once the plan is approved, the design and development of prototype technologies immediately begins. This is accomplished using three methods:

1. Awarding external contracts to industry.
2. Conducting in-house developments utilizing highly experienced and skilled personnel from the NVESD Prototype Fabrication Facility.
3. Leveraging from existing NVESD Countermine developmental efforts.

International market surveys are also conducted to help identify commercially available items that could be used or adapted for HD applications.

All prototype technologies undergo extensive developmental testing to ensure all design requirements are met. If test results identify engineering modifications that will improve the system's performance, changes are made and the system is retested. Successful developmental testing provides confidence that a system is ready for use, but the one test in the evaluation done in actual field environments in the host nations, which are referred to as Operational Field Evaluations.

Operational Field Evaluations

The Operational Field Evaluation is one of the most important aspects of the HD R&D Program because the new equipment is tested in real minefields. Operational Field Evaluations are extremely beneficial to the HD effort. These evaluations allow the host country to use and evaluate equipment for a predetermined period of time to determine if it is useful, cost-effective and efficient. There is no better method for testing the effectiveness and suitability of prototype technologies. It also provides the R&D Program with important "lessons learned" information that may result in system improvements for future evaluations.

The Operational Field Evaluation process begins with a host nation request to OASD SO/LIC. If approved, OASD SO/LIC directs the R&D Program personnel to conduct an in-country site assessment. The in-country site assessment team, which includes engineers and logisticians from the HD R&D Program, assists the requesting nation in determining the most appropriate prototype equipment for each specific area of operation. Many factors are considered, including terrain, weather and variety of landmines. The assessment process ends with a recommendation for the most suitable technology that could fulfill the defined mission and a decision by OASD SO/LIC to support an Operational Field Evaluation. Evaluations typically last from six months to one year.

An important aspect of the R&D Program is the opportunity for NGOs and governmental MACs from the supported demining nations to participate in the development of a specific technology from its initial design through its Operational Field Evaluation. The host nation's NGO/MAC has the opportunity to participate as a user in the development cycle when a new development is determined to be the best technological solution that meets its needs. The NGO/MAC is kept up to date on the system's development progress and is participated in meetings and observe developmental testing. In return, the host nation agrees to conduct an Operational Field Evaluation once the system development is complete.

HD Program: Mechanical Technologies at Work

Mechanical mine and vegetation clearance was identified as a top-priority requirement by the international demining community during the recent Annual Humanitarian Demining Requirements Workshop. This is primarily due to the variety of different environmental conditions and types of terrain that challenge the international demining community. Therefore, environmental considerations and terrain types are taken into consideration when developing new technologies.

The R&D Program has focused its efforts on developing a cost-effective and efficient mine clearance and vegetation removal technology that can be used in several different environments. In fact, NVESD's Prototype Fabrication Facility has proven to be one of the most capable organizations for mechanical mine clearance and vegetation clearance design and development. If industry cannot provide an equipment solution, NVESD's Prototype Fabrication Facility can build one. Many of the most successful technology solutions in the field today have been designed and built under the R&D Program's guidance at the NVESD Prototype Fabrication Facility.

One of the key requirements in achieving this goal is to provide standoff protection for demining equipment operators. This is accomplished by utilizing tele-operated and semi-autonomous platforms whenever possible. As of yet, there is not one single technology that can overcome all of the challenges faced by the different demining communities.

However, technologies developed by the R&D Program confront specific environmental challenges and are making a positive impact in the process to rid the world of mines.

Mine Clearing Cultivator

The Mine Clearing Cultivator (MCC) is a remote-controlled mechanical system that uproots and removes AT mines from unimproved roads and large open areas without creating the berms that other commercial devices produce. The system consists of a large, lightweight, hydraulically powered auger integrated onto a commercial 200-hp-class bulldozer. Operationally, the tiller armcultivates the soil and lifts AT mines and other large objects to the surface. Then, the hydraulically powered auger disburries the mines to each side of the tractor for subsequent neutralization. One major advantage of the system is the tiller arm's breakaway design. This allows the system to be fully reversible in the event of an inadvertent mine detonation. The MCC is currently operating in minefields in Angola.

Mine Clearing Sifter

Since the MCC is designed for AT mine clearance only, a solution for AP mine...
clearance is also required in some areas. The Mine Clearing Sifter (MCS) is designed to do just that. The Mine Clearing Sifter is a remote-controlled mechanical device that sifts through the previously culverted soil and removes any remaining AP mines and other large objects. It mounts on the same 200-ton-class bulldozer as the MCC. The MCS consists of a shear blade that lifts everything in its path, down to 35 cm deep, onto a sloped conveyor belt assembly. Any objects less than four cm in size fall through the conveyor belt and fall back onto the ground. The remaining objects are transferred onto a perpendicular side-loading conveyor belt, which then deposits the mines and other material to the side of the ground. The remaining objects are sifted and sorted through the previously cultivated soil. Clearance is also required in some areas. The MCS is being used in everything in its path, down to 35 cm deep, objects less than four cm in size fall through, and any other large objects. It mounts onto the same bulldozer as the MCC. The MCS does not create a berms as other commercial dozers do. The free-floating linkage, remote control, and modular design are all technological improvements over current military plows and commercial blade. These improvements ensure operator safety and have decreased the amount of training required to operate the system. The MCS was deployed to the U.S. Naval Base at Guantanamo Bay, Cuba, in 2001, where it assisted the U.S. Marines in quality assurance/mine clearing operations of the last remaining U.S. controlled minefield.

Rotary Mine Comb

The Rotary Mine Comb is a mechanical device used to clear AP mines from large open areas with minimal vegetation. The device operates very similar to a kitchen "sifter." At the front of the vehicle, a rotating ring of pins is extended into the soil. These pins rotate at high speed, cutting through the soil and breaking the AP mines. As the pins move, they cut through the soil and break apart the mines. This process continues until all the mines are removed. The Rotary Mine Comb has several advantages over other mine clearing systems. It can work in hard-packed soil, it can work in hard-packed soil, and it can work in wooded areas. The Rotary Mine Comb also has the ability to clear AP mines from deeply buried mines, which is a significant advantage over other systems. However, this system is limited to clearing AP mines and cannot be used to clear other types of mines. The Rotary Mine Comb is ideal for clearing large areas of land quickly and efficiently. It is a cost-effective solution for mine clearance operations.

Survivable Demining Tractor and Tools

One of the greatest success stories of the HD R&D Program is the Survivable Demining Tractor and Tools (SDTT). The SDTT is a commercial tractor fitted with amber-plated and optional steel wheels used to support various demining operations in heavily vegetated areas. Although the tractor can be survivable against AP mines, it is specifically designed to operate in areas containing AP mines since it can survive the direct effects from these mines without damage to the system or its components. The SDTT offers deminers the flexibility to choose from a variety of specialized implements that best suit their environmental conditions, accomplishing missions ranging from area preparation to quality assurance. These implements include backhoe buckets, grapples, and other standard attachments that allow the system to operate in the most conventional construction role. Also, the four-wheel drive, four-wheel steering platform maximizes maneuverability and allows for operation in less than ideal terrain with minimal environmental impact.

PM-CCS Berm Sifter

The U.S. Army's Program Manager for Mine Clearing Systems (PM-CCS) is providing two modified U.S. Army front loaders to the U.S. Army in Southeast Asia in support of Operation Enhancing Freedom. An urgent need identified by the Department of Army and the U.S. Army's Training and Doctrine Command initiated a three-year (PM-CCS, HD R&D Program and the NVEES Prototype Fabrication Facility) effort to rapidly identify and modify two U.S. Army front loaders. The cab and chassis were armored, the pneumatic tires were replaced with solid rubber SETCO tires, and a COTS Rotor sifting bucket was integrated to sift soil and separate mines in suspected areas in Afghanistan. All of the work and integration was completed at the NVEES Prototype Fabrication Facility, once again proving the HD R&D Program's claim of "if it doesn't exist, we can build it." The Army is deploying the systems to Afghanistan in the fall of 2003. The PM-CCS Berm Sifter is an excellent example of how leveraging, outstanding teamwork and the quick reaction capability of the HD R&D Program can contribute to successful technology development.
standard bucket parallel to the minefield. It then makes a second pass where the lifting “forklike” bucket is inserted into the bottom of the minefield trench wall and operated in such a way that it collapses a small section of the wall back into the existing trench. Finally, a third pass is made with the COTS Rotor sifting bucket attachment. The Rotor sifting bucket is used to scoop up and lift the collapsed soil to remove mines and large debris at a separate location. Although it is a time-consuming process, testing has shown this system to be very promising. Deployment to Honduras is scheduled for November 2003.

Tempest

The Tempest is another great example of an HD R&D Program success story. The Tempest was specifically designed to be an affordable remote-controlled mechanical system for clearing medium vegetation, neutralizing crispwires and removing metallic debris on the surface of AP minefields. It utilizes interchangeable vegetation-clearing components (rail, mulching mower), and it integrates mowers to prepare the land for follow-up detection technologies, i.e., V-shaped chains and hardened sacrificial wheels enabling it to survive AP minefield threats. The latest version of the Tempest, the M5X, is capable of cutting 900 sq m of two-m-tall vegetation per hour. It has been deployed in Cambodia, Thailand and most recently Mozambique to undergo Operational Field Evaluations. In the first five months of operation in 2003, one Tempest cleared 54,600 sq m of land in three separate minefields in Mozambique for the United Nations Accelerated Demining Program (UNADP), while another continues to be an integral part of TANAC's mine action program.

MAXX

The MAXX system is a small, remote-controlled mechanical system designed to clear medium vegetation in various environments. It incorporates several COTS tools (muckers, cutting blade, sifting fork and commercial bucket) mounted on a small commercial platform. It is ideal for clearing vegetation in hard-to-reach areas and around obstacles. The MAXX design places interchangeable heads at the end of a 360-degree rotating articulating arm providing a ‘reach in’ capability to clear vegetation ahead of the machine. This mode of operation allows the system to operate from cleared areas, reducing the risk of damage if a mine is detonated. MAXX was recently deployed and is operating in Rwanda on an Operational Field Evaluation. Early results are very promising.

Conclusion

The U.S. HD R&D Program is making steady progress towards achieving its goal of making demining safer, faster and more efficient than current methods. Mechanical clearance equipment currently undergoing Operational Field Evaluations has helped clear over 500,000 sq m of land in just the first six months of 2003. The HD R&D Program is conducting new site assessments and is planning for new Operational Field Evaluations in FY04. The results of the 2003 Annual Humanitarian Demining Requirements Workshop have been analyzed and the program execution plan has been developed for FY04. The project engineers, logistics and technicians working on the program have an extensive range of expertise and experience, and continue to increase their understanding and knowledge of the HD environment. The HD R&D Program continues to be proactive and anxious to contribute as much as it can to help solve the global landmine crisis.

*All photos courtesy of the author.

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The R&D Requirements Workshop

It doesn’t take more than a day with deminers in a minefield to realize the challenges they face. You quickly discover they are dedicated to what they do, they are passionate about it, and they are extremely vocal about what they think they need to do a better job. A group of dedicated engineers and developers have been carefully listening to what they have to say.

by Joe Lokey, RDECOM CERDEC NVESD

For the past seven years, the U.S. Department of Defense Humanitarian Demining (HD) Research & Development (R&D) Program at Fort Belvoir, Virginia, has reached out to global experts in demining to find out what they need to better their tools, techniques and technologies. The positive results can be found in Thailand, Cambodia, Central America, Africa, and the Middle East. These improvements and innovations in tools, technologies and machines all start with an annual requirements workshop, in which deminers from the field are invited to bring their ideas and problems to a group of specialists to solve these very problems.

The concept is simple: gather useful and effective suggestions of the experts in the field on their most critical needs. Then use the resources made available by the U.S. government to adapt solutions to those ideas to off-the-shelf technologies or local solutions to improve mine detection, mine clearance or personnel protection. The results are then tested and evaluated in a live minefield where more data is collected and mines are cleared.

The NVESD Process

What the Night Vision and Electronic Sensors Directorate (NVS or NVESD) does is simple. They find out what needs determining and create solutions. They then fund, develop and field test prototype equipment and technologies. Not all output is from pure research. For example, RIDCOM CERDEC NVESD takes an existing piece of equipment and modifies it, tests and conducts field trials in a variety of “live” conditions. The cost to the host nation that requests these operational tests is minimal since all they fund are essentially the daily operations costs. Thus, the host country does not have to absorb the huge expense of development and engineering.

During the test and evaluation, performance data is collected on the technology. This information is used to change the configuration, make improvements or even change the specifications to get the optimal benefit to the deminer from the innovations being fielded. It is this continuous path of process improvements that results in a better, less expensive, more efficient, safer path to a mine-free world.

Of course, there is always paperwork involved, but a letter to the U.S. Embassy, a letter of request and a phone call to the right office is all it takes to start the process of testing these technologies. Once approved, a team of specialists is dispatched to assess the demining situation and lay the foundation for future action. The tests and in-country evaluations are normally set up for six months to a year. The host country then decides whether or not that particular technology or equipment should be acquired on a permanent basis.

At the end of the evaluation, everyone benefits. The NVESD receives feedback on performance and suggestions to improve the product or technology. The host nation's minefields are cleared or mines are detected with the technology or equipment on loan. The operators on the ground get hands-on experience and training with new and updated technologies. The company or manufacturer of the technology collects invaluable marketing and performance data for future sales of more appropriate and affordable tools targeted to address the landmine problem.

Inside the Workshop

The workshop has evolved over the years and now advanced in participation. The number of countries supported by the United States is well over 40 and representatives from most of these countries have, at one time, attended one or more of these workshops. The past few years have averaged attendance from 16 to 18 various country demining programs. Others have also attended as guests from countries, such as the People's Republic of China. The mix of attendees is also critical to the success of the workshop. In addition to all the major non-governmental organizations (NGOs) involved in demining, there are many military