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An APT Demining Machine

Andy Smith
Humanitarian Mine Action Specialist

AN **APT** DEMINING MACHINE

by Andy Smith [University of Genoa, Italy]

WWI demining machines.
All graphics courtesy of the author.

This paper introduces a new machine for use in support of humanitarian mine action. Developed under the EU FP7-TIRAMISU R&D initiative, the machine is reliable, easy to deploy, and has a low cost of ownership. It is designed to withstand anti-personnel (AP) mine detonations as it drives over an area preparing it for manual demining. Small and highly maneuverable, it can climb steeper inclines than other machines and drive over roads to deploy without an expensive transporter. With dual driver controls, it can be remotely controlled when working in hazardous areas. This article describes how it is appropriate and reports on its performance in testing/acceptance trials in Croatia. It also describes current plans to extend its utility as a C-IED tool.

Armored machines have been designed for military breaching of minefields since WWI and used to make relatively safe routes for soldiers or vehicles to pass through minefields. For many, these machines seemed a logical starting point for the development of machines suitable for use in post-conflict area clearance, so military flails, tillers, and rollers were adapted for use in demining. Generally expensive to buy, maintain, and use, these machines were not able to destroy all mines and ordnance as required to meet the clearance requirement in the International Mine Action Standards (IMAS), so they have never been suitable for stand-alone use.[1]

Purpose-designed demining machines are generally intended to withstand the detonation of anti-tank (AT) mines with repairable damage. This design aim adds greatly to cost, weight, and fuel requirements. Commercially available machines have tended to be heavily armored and designed to detonate the mines under their

Left, a blast damaged Aardvark flail in Libya and right, blast damaged demining machines in Angola.

A backhoe in Afghanistan, an articulated hydraulic mulcher arm on the back of a Werewolf mine protected vehicle (MPV) in Angola, and an Arjun raking excavator in Sri Lanka.

tool, not under their tracks or wheels. The tool will be damaged but is designed to allow fast repair. Some can withstand multiple detonations before the cumulative shock-wave damage necessitates an extensive overhaul. Thus, all the large demining machines are only more-or-less AT mine resistant. Their size and weight make the machines difficult to deploy, and their running costs, including fuel and repairs, are very high. Just importing them to the country of use can add significant costs and involve lengthy delays. Often oversold as clearance machines, many large machines are abandoned when the cost of repair and maintenance is too great to justify their continued use.

To reduce costs and avoid some of the deployment problems involved with larger machines, smaller variants have been designed specifically for use in mine action. Usually, designers seek to make these machines able to withstand an AT mine detonation. Extensive armoring and a large engine made the machines heavier than is ideal, and their weight limited the power available for them to climb hills or meet their design purposes with minimum damage to the environment. These machines invariably also need expensive transporters to move them around, so even the best purpose-designed smaller machines suffered many of the same problems of access and total cost of ownership that arise with larger demining machines. In terms of withstanding AT mine blasts, successful designs are limited in that any large detonation beneath a small machine will usually send it into the air, and severe damage will occur when it lands. Quietly acknowledging this, most designs are radio controlled so that risk to the operator is avoided.

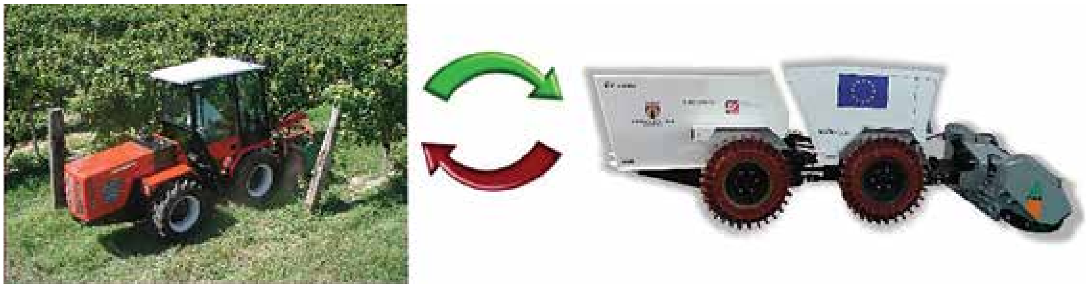
The fact that most machines fail to withstand AT blasts without incurring severe damage raises the question of whether it is necessary to try to withstand AT mine blasts. Based on existing plant and agricultural machinery, a range of machines have been made that do not enter hazardous areas until after they are processed. Their success are often largely ignored, because many are not commercially available.

The Groundhog area preparation machine made for a particular task in Burma.

The first such machine may have been an old tractor with a side cutter attached and some light armoring. This was used to cut undergrowth on road verges in front of manual deminers in Cambodia in 1997.[2] Around the same time, mine-protected military vehicles were converted to cut undergrowth in Angola, while converted backhoes were used in Afghanistan.[3] The excavator's bucket was later redesigned for vegetation removal and area preparation by an Indian INGO in Sri Lanka, where Arjun raking excavators were widely used until 2011.[4]

These machines, while armored, rely on the long reach of hydraulic arms to avoid having to drive over uncleared ground. Some, such as the Arjun, could withstand AP blast mines under the tracks, but none could have withstood AT mines. However, where there is no AT mine threat, it is efficient to drive the area preparation machine over the ground and so prepare a wide area. Avoiding risk to the operator is generally achieved by either using heavy armoring or a remote control system, but that has not always been the case.

For example, in 2014, it was impossible to get the Burmese government's permission to import any demining equipment at all. For a particular task involving small gelignite pressure mines, a small area preparation machine was made that removed the undergrowth and detonated some devices in advance of manual



The tractor and the conversion to a demining machine.

demining using the Rake Excavation and Detection System (REDS), a long-handled raking system.[5] This task-specific machine, only suitable for that threat on level ground, did the job well. The two-wheeled rice tractor on which it was based is back working in Burma's rice paddies now.

The converted rice tractor was appropriate for that task because the unusually small threat could be confidently predicted and the ground was relatively flat. For wider application, a more versatile machine would be needed. The ideal small machine should be able to follow narrow paths, climb steep inclines, and be radio controlled when working in areas with unknown hazards. It must be protected against AP blast and fragmentation mines but does not need to withstand AT mine detonations, if only because the evidence shows that this would be impossible to achieve anyway. In many post-conflict contexts, where armored machines were not widely used, the threat from AT mines is very low.[6]

AN APPROPRIATE SMALL MACHINE

At that time, the "Locostra" tractor was unfinished and unproven. Supported under the EU TIRAMISU Research and Development project, the design has been a collaboration between an Italian tractor manufacturer, Pierre Trattori, and the Engineering Department of the University of Genoa. Throughout the project, the design team was guided by end users and by staff of the Centar Za Testiranje, Razvoj I Obuku (CTRO - Centre for Testing, Development and Training) in Croatia.[7] Toward the end of the TIRAMISU project, the machine matured and received a bigger engine, more armoring and cameras, and a new name. Because the machine seemed singularly appropriate for its purpose, it became known as the Area Preparation Tractor (APT).[8]

The developers of APT do not pretend that it is a mine clearance machine. The APT will detonate some mines but, like all other demining machines, will also leave mines and almost all ordnance behind. It is designed to climb hills, maneuver around obstacles, and withstand AP mine detonations while preparing the ground for the thorough manual search and clearance that will follow.

The machine makes manual demining faster by removing the undergrowth and preparing the ground surface with a mulching attachment. When mines detonate as it works, that can help to identify the hazardous hotspots in an area. When tripwires are shredded and fuzes are broken from fragmentation mines, risk to the deminers is reduced. Most demining accidents occur when excavating an explosive hazard so loosening the ground surface reduces risk by making subsequent excavation easier.[9]

The APT is based on a popular and proven agricultural tractor that is widely used in Italian vineyards with steep inclines. Small, with a low center of gravity, the tractor is steered via wheels and an articulated chassis. The combined steering means that it can maneuver tightly around obstacles without having to leave a wide area unprocessed.

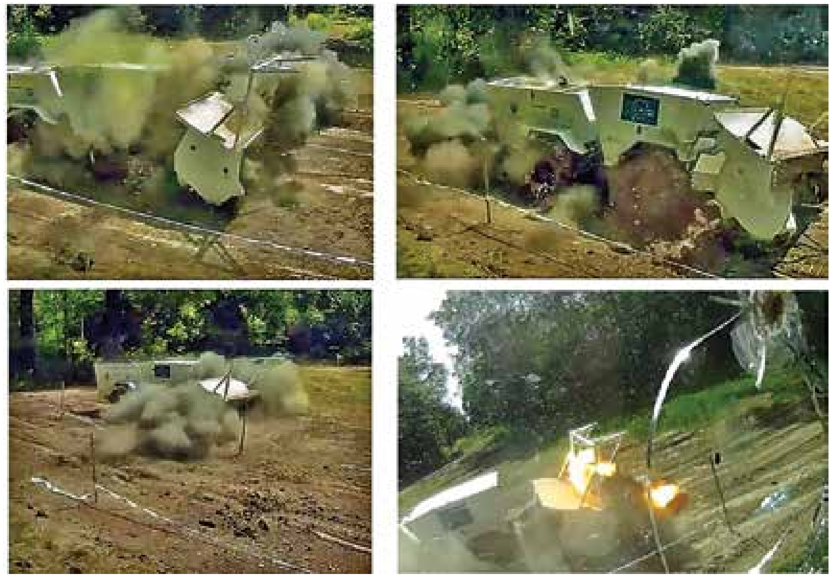
The machine has innovative blast-resistant wheels that successfully absorb the energy of AP mine detonations without the shock wave damaging the bearings and chassis. Its engine, hydrostatic drive, and articulated chassis have proven robust and reliable in years of hard agricultural use. The radio control system is also robust and has proven reliable over several years in the construction sector.

Its hydrostatic drive means that it can move forwards and backwards with the same ease and speed, allowing the user to choose the best approach for a specific use. For example, it can make sense to cut breaches into undergrowth and then return along the same path, processing the area a second time.

With dual radio and manual controls, the top of the cab armor lifts off so that it can be driven conventionally over roads to the working area, then radio controlled to work in hazardous areas. This allows the total cost of ownership to be low because it need not include an expensive transporter. Its ability to deploy itself also avoids a common problem with large machines when the combined weight of the machine and its transporter causes damage to roads, bridges, and culverts.

The APT can be fitted with a wide range of other tools and tow a trailer carrying its blast-resistant wheels, demining equipment, water, and other base-camp essentials.[10]

In May 2015, the first complete prototype APT machine was shown at the 2015 CTRO Symposium in Croatia. After the symposium, it was subjected to a series of independent explosive tests at the CTRO test site. Multiple blast and fragmentation mines were detonated beneath the wheels and the working tool in "worst-case" positions without any impact on the machine's ability to perform.[11] In later analysis, there was no evidence of shock wave transfer to the bearings or chassis.[12] Having performed well in the explosive tests, the same machine was later field tested by CTRO over five days. Testing took place on abandoned agricultural land and in a forest that was a suspected hazardous area (SHA).[12,13]



Stills from a video of the testing using real mines.[14]

Side-to-side area preparation was augmented by cutting breaches through the heavily vegetated area. Dense vegetation was cut, and the ground surface was processed. The work included testing deployment approaches and operator training materials. The testing was successful and a CTRO accreditation certificate was issued.[13] Minor refinements that are planned include reshaping the armor for easier removal and access to the engine, as shown in Figure 1.

Stills from a video of APT during field trials.

The University of Genoa has extensive experience in robotics and has plans to develop a lifting C-IED platform that includes a dozer blade, large manipulator arm, small manipulator arm with disrupters, winch, and extra cameras. APT C-IED's generous power (more than 100 horsepower) allows it to carry and power multiple devices electrically, by direct rotation power take off (PTO), or hydraulically. This means that proven or preferred manipulator arms and disrupter devices can be used.

The C-IED platform can simply replace the mulcher on a demining APT or can be fitted to a dedicated C-IED APT with upgraded (rifle resistant) armor and refined decontamination features.[15]

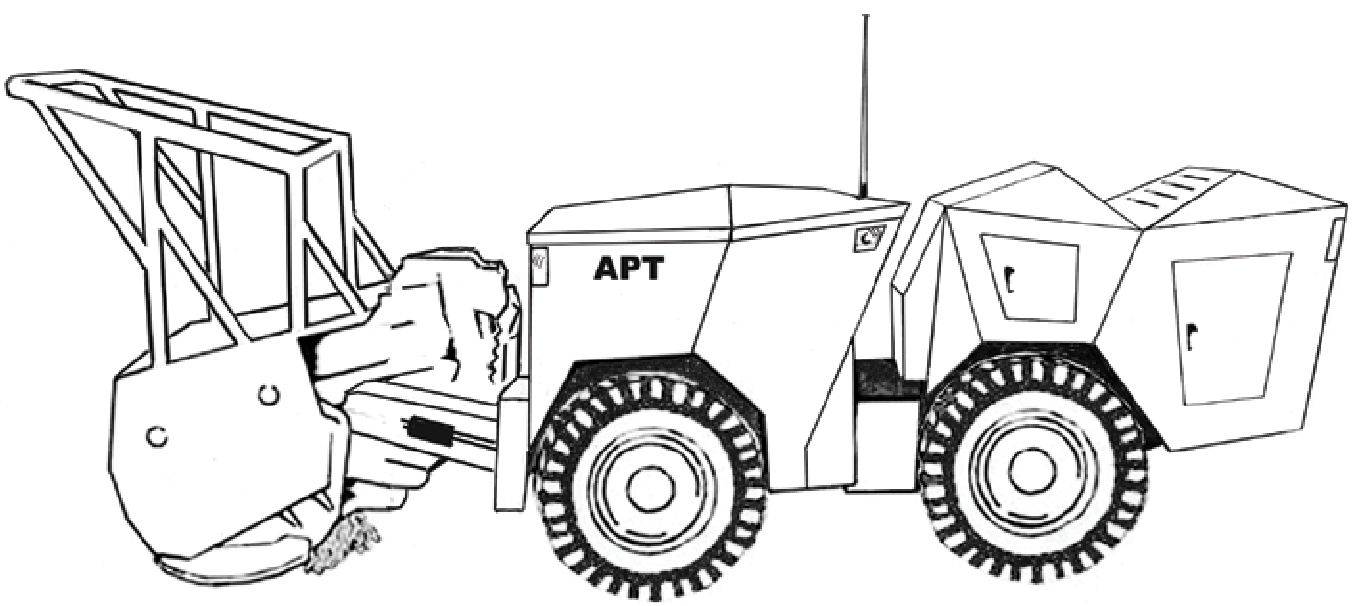


Figure 1. Sketch showing the shape of the refined armor.

In close collaboration with a leading provider of C-IED training to humanitarian mine action organizations, the C-IED APT will be developed to be able to

- move rubble and obstructions aside (delicately when appropriate),
- conduct a rapid camera survey of an area, producing accurate map records,
- investigate suspicious objects either robustly or delicately,
- collect ordnance that may not be considered safe to move by hand,
- disrupt potential IEDs with either a water charge, frangible or solid projectile: each of three disrupters feature three pre-loaded barrels (25.4 mm and 40 mm),
- fire a closed grapnel and line that can then be used to pull the target,
- place explosive charges to disrupt or destroy IEDs,
- attach hooks and a winch cable to drag heavy items to another place,
- deploy cutting equipment able to cut an additional entry into a vehicle/container,
- deploy a commercial off-the-shelf freeze neutralizing kit,
- gain safe entry to a vehicle for internal camera inspection,
- carry a multichannel (selective) wireless signal jammer to prevent wireless initiation systems being used in the vicinity,
- carry and place smaller robots when access through small openings is required.[16]

One advantage it has over all other similarly sized C-IED machines is the ability to be driven by an on-board operator to the area of need. Its small footprint and maneuverability allow it to drive over sidewalks when traffic is gridlocked following an incident. It can push or lift debris aside to access an area, and its flexible chassis and ground clearance allow it to move over rubble to get where it is needed.

See endnotes page 67

For more information about the Demining APT, contact andrew.vian.smith@edu.unige.it at the University of Genoa. For more information about the C-IED APT, contact Matteo Zoppi at zoppi@dimec.unige.it.

Andy Smith
DIME, University of Genoa, Italy
www.nolandmines.com
www.ddasonline.com

A.V. Smith (AVS, Andy Smith) works part-time with the University of Genoa in Italy as a research assistant and is currently working on munition disruption systems in Palau. He has worked in demining for twenty years, starting as a personal protective equipment (PPE) designer in 1996 and rapidly becoming a deminer/surveyor and then a Technical Advisor, trainer, program manager and UNDP country CTA. The founder and keeper of the Database of Demining Accidents (DDAS), he has also developed and put into production the most popular PPE used in HMA. His work during 2016 included writing extensive field risk management training materials for GICHD.

ENDNOTES

MediaWiki: Supporting IMSMA Documentation by Kontotasiou and Cottray [from page 5]

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